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3.3.2 Number of books and chapters in edited volumes/books published and papers published in national/ international conference proceedings per teacher during last five year

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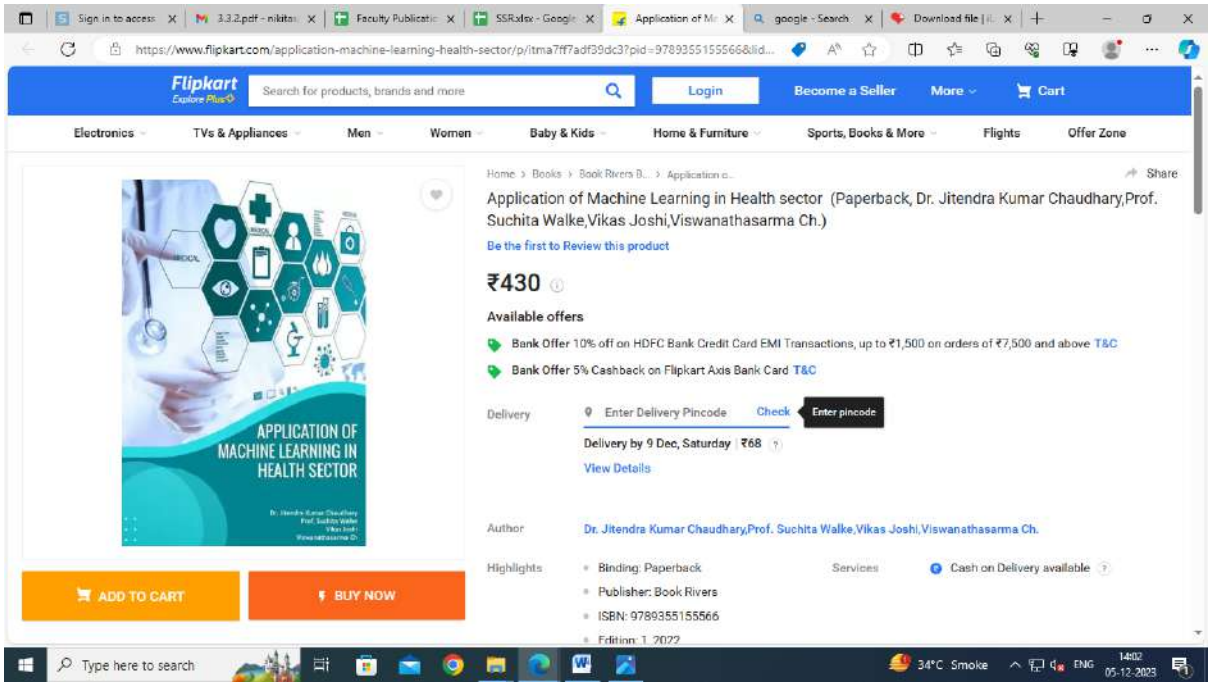
2. prof. Suchita Walke



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Vertical Axis Wind Turbine with Inverter

[1]Akshay A Karande, [2]Saroj J Patil, [3]Swaroop P Patil, Ms. Pooja Kulkarni

*[*1,2,3,4]Department of Electronics & Telecommunication Engineering,*
Pillai HOC College of Engineering and Technology, Rasayani University of Mumbai

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Abstract

One of the major issues in this fast-moving world is to meet the demand for energy in the most economical and environment-friendly way. This research focused on designing a Vertical axis wind turbine (VAWT) that gives a solution that is comparatively a cheap alternative to renewable energy. When there is enough wind to rotate the windmill, magnetic coupling between the rotating and stationary coils causes the windmill to produce energy. The work demonstrates a vertical rotating prototype of the windmill. The wind turbine can charge up to a 12V battery. The advantage of this design is that it works without any consumption of fossil fuel and works efficiently inappropriate weather conditions with- out being closely monitored and the battery charges automatically without any harmful emissions or drawbacks. The work presented in this paper is an example of how natural resources like wind energy can be used efficiently to produce electricity.

Keywords: *Arduino uno, Invertor, Renewable energy system, vertical axis wind turbine, Battery*

I. INTRODUCTION

Wind power has emerged as one of the most cost-effective renewable energy sources in recent years. Wind turbines that generate power nowadays use tried-and-true technology and offer a reliable and sustainable energy supply. The first known wind turbine created for electricity production is built by inventor Charles Brush to provide electricity for his mansion in Ohio. A wind turbine is a device that converts wind's kinetic energy into electrical energy. The costs of producing wind energy have reduced by 80 percent since the last century. Today, wind energy is regarded as the least expensive renewable energy source. On the market today, wind turbines are useful. Vertical-Axis wind turbines happen to be the most popular and widely coveted turbines. It is also more practical, reliable and cost effective, it also has the best longevity and durability features. Therefore, we will be able to use efficiently over a long haul.

1.1 Literature Review

Today, wind energy is thought to be the most affordable type of renewable energy. Currently available wind turbines serve a purpose. Their analysis indicates that the vertical axis wind turbine can be able to attain the air from all the direction and produces the power of 1 kilowatt for a movement of 25 m/s. D.A.nikam et al. analysed that the generation of electricity is affected by the geometry and orientation of the blade in the wind turbine .He analysed the blade plays critical role in the performance and energy production of the turbine. Altab hossain et al. analysed that the power production will increases when the velocity is high. Parth Rathod et al. study of a combined vertical axis wind turbine review. The experiment is conducted to increase the power production and efficiency of a wind turbine. The outcome suggests that a turbine's efficiency is always dependent on the wind speed and weather. Piyush Gulve et al. analysed the design and construction of vertical axis wind turbine. He conclude that the vertical axis wind turbine is more efficient than horizontal axis wind turbine because it requires compact room for making the same amount of electricity while making less noise.

1.2 Problem definition

The electricity we get today in our homes is generated from nuclear energy or any other atmosphere destroying ways. For both large-scale and small-scale and distributed power generation applications, wind power is a desirable and alternative energy source. One of the most important advantages of wind energy is that it is modular and scalable. A wind turbine is a machine that transforms wind's kinetic energy into electrical power. The main rotor shaft of a vertical axis wind turbine (VAWT), which can take wind from any direction, is one form of wind turbine. The primary objective of this research is to design and model a small-scale VAWT, which can be used to meet the power for low demand applications.

Research Article

IoT Based Condition Monitoring for Railway Track Fault Detection in Smart Cities

Shridhar Padhi, Mansi Subhedar, Saikiran Behra & Tejesh Patil

Published online: 09 Dec 2022

Abstract

The railways have the busiest and biggest networks in the world and play a key role in

Original Research | Published: 29 August 2022

Performance Evaluation of Multiband Embroidered Fractal Antenna on Human Body

Shruti Gite & Mansi Subhedar

SN Computer Science 3, Article number: 459 (2022) | Cite this article

Abstract

Several recent technologies are emerging that integrate the wearable system with antenna

Antennas in Airborne Applications

Publisher: IEEE

Aamir Shaikh ; Manjusha Joshi All Authors

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II. Dynamics of UAV

III. Antennas

IV. Airborne Applications

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This paper gives an overview of various types of antennas used in airborne applications such as delivery using UAVs, defence, disaster management. Antenna characteristics are very sensitive and must be used before implementing in airborne applications. Because of different nature of aerial body on which antennas are mounted, different antenna positions will result in variations in the radiation pattern. In recent studies, researcher considers antenna positioning with respect to azimuth and elevation angles. Effect of aerial body on antenna, its signal strength and radiation pattern is observable. Cross polarization discrimination occurs due to polarization mixing of communicating channels.

Published in: 2022 IEEE Bombay Section Signature Conference (IBSSC)

Date of Conference: 08-10 December 2022

Date Added to IEEE *Xplore*: 14 February 2023

ISBN Information:

INSPEC Accession Number: 22645477

DOI: 10.1109/IBSSC56953.2022.10037463

Publisher: IEEE

Conference Location: Mumbai, India

Harmonic Elimination with Multilevel Inverter Based Hybrid Filter Using Artificial Intelligence Approach

Publisher: IEEE

Pranita Chavan ; B. R. Patil **All Authors**

Abstract

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II. Description of the Proposed System and Control Method

III. Simulation Result and Discussion

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Harmonics in the distribution system are caused by the fast growth of nonlinear loads based on power electronics. Harmonics reduce the quality of the power and the effectiveness of the power system. As a result, getting rid of it is crucial. This study evaluates a hybrid filter based on a cascaded H-bridge multilevel inverter for decreasing source current harmonics in a high-voltage system. The hybrid filter topology includes a double-tuned passive filter and a cascaded H-bridge MLI-based active filter in a shunt at the point of common coupling. To lower the compensation cost, the shunt passive filter suppresses low-order dominant 5th and 7th harmonics, whereas the shunt active filter eliminates high-order harmonics. To increase system performance, an approach based on artificial intelligence is employed to create compensation current and DC link voltage control. Switching pulses for cascaded MLI are produced using a multiband hysteresis current controller. The harmonic distortion in source current (THDi) is measured under different compensation methods. The system response is observed for steady state and dynamic state. The system is developed and evaluated using MATLAB/Simulink.

Published in: 2022 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)

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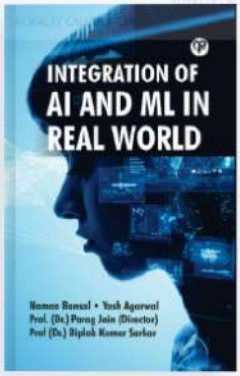

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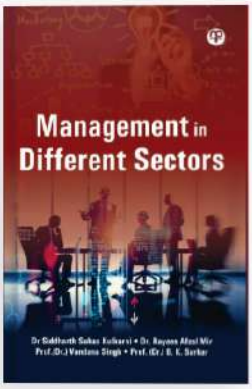

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Dr Siddharth Suhas Kulkarni, Dr. Rayees Afzal Mir, Prof (Dr.) B. K. Sarkar, Prof. (Dr.) Vandana Singh

A crucial aspect of human behaviour is learning. The process of gaining new information, skills, behaviours, beliefs, attitudes, and preferences is called learning. Living is learning in its purest form. From the moment of birth until the moment of death, everyone is engaged in a constant learning process. We are all actively involved in learning activities to strengthen our capacity for adaptation to the demands of the ever-changing environment. Through the construction or reconstruction of experiences under the influence of emotional and instinctual dispositions, a person continues to learn throughout all phases of life. However, there are other elements that are addressed below and have an impact on a student's learning:

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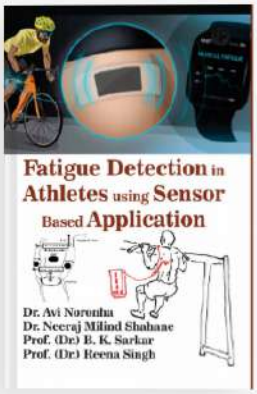

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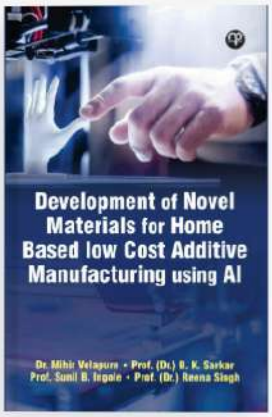

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Development of Novel Materials for Home Based low Cost Additive Manufacturing using AI

Dr. Mihir Velapure, Prof. Sunil B. Ingole

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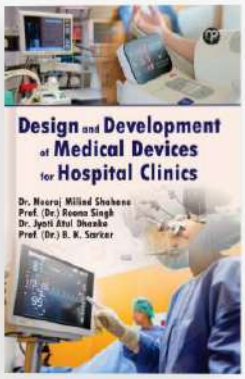

Design and Development of Medical Devices for Hospital Clinics

Dr. Neeraj Milind Shahane

Medical devices have a significant negative impact on the environment. The waste generated from medical devices has environmental as well as cost implications. While single-use devices are responsible for rising quantities of medical waste and inventory costs for hospitals, reused devices tend to get involved in cases of reinfection and are more expensive to develop for manufacturers. Beyond the benefits and risks of single use and reusable devices, the imperative for a less wasteful healthcare system in the United Kingdom lies in the Climate Change Act, which mandates the reduction of greenhouse gas emissions by 80% from the 1990 baseline.

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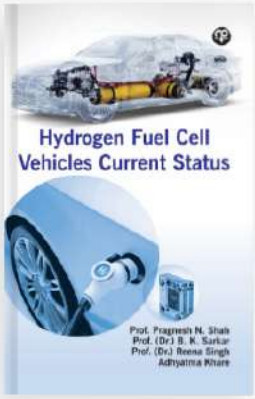

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Hydrogen Fuel Cell Vehicles Current Status

Adhyatma Khare, Dr. B. K. Sarkar, Dr. Reena Singh, Pragnesh N. Shah

The hazardous effects of pollutants from conventional fuel vehicles have caused the scientific world to move towards environmentally friendly energy sources. Though we have various renewable energy sources, the perfect one to use as an energy source for vehicles is hydrogen. Like electricity, hydrogen is an energy carrier that has the ability to deliver incredible amounts of energy. On-board hydrogen storage in vehicles is an important factor that should be considered when designing fuel cell vehicles. In this study, a recent development in hydrogen fuel cell engines is reviewed to scrutinize the feasibility of using hydrogen as a major fuel in transportation systems. A fuel cell is an electrochemical device that can produce electricity by allowing chemical gases and oxidants as reactants. With anodes and electrolytes, the fuel cell splits the cation and the anion in the reactant to produce electricity. Fuel cells use reactants, which are not harmful to the environment and produce water as a product of the chemical reaction. As hydrogen is one of the most efficient energy carriers, the fuel cell can produce direct current (DC) power to run the electric car. By integrating a hydrogen fuel cell with batteries and the control system with strategies, one can produce a sustainable hybrid car.

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Cyberattack Detection System using Machine Learning

Dr. B. K. Sarkar, Dr. Kirti Mahajan, Dr. M. Bheemalingaiah, Dr. Reena Singh

Within the ever-growing and quickly increasing field of cyber security, it is nearly impossible to quantify or justify the explanations why cyber security has such an outsized impact. Permitting malicious threats to run any place, at any time or in any context is a long way from being acceptable, and may cause forceful injury. It particularly applies to the Byzantine web of consumers and using the net and company information that cyber security groups are finding it hard to shield and contain. Cyber security may be a necessary thought for people and families alike, also for businesses, governments, and academic establishments that operate inside the compass of world network or net. With the facility of Machine Learning, we will advance cyber security landscape. Businesses these days are gathering immense amounts of user information. Information is at the heartbeat of any business-critical system you'll be able to think about. This co-jointly includes infrastructure systems that are being implemented these days. Today's high-tech infrastructure, that has network and cyber security systems, is gathering tremendous amounts of data and analytics on almost all the key aspects of mission-critical systems. Whereas people still give the key operational oversight and intelligent insights into today's infrastructure, machine learning and AI are gaining pace and gathering immense momentum in most of the areas of today's systems, whether or not it's positioned on premise or within the cyber security house.

Keywords: Machine Learning, cyber security, k-means, Random Forest, SVM etc.

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Blockchain Mechanism, DLTs, CBDC, Smart Contracts and NFTs

Dr. B. K. Sarkar, Dr. Reena Singh, Mr. Vikas Garg, Vandana Singh

We examine the connection between fundamental blockchain component of cryptographic forms of money and its distributional attributes. Notwithstanding cost, we stress on utilizing real block size and block time as the functional elements of cryptos. We utilize distributional attributes like Fourier power range, minutes, and quantiles, worldwide we desired states, as well as the actions for long haul conditions, chance and commotion to sum up the data from crypto time series. With the speculation that the blockchain structure makes sense of the distributional attributes of cryptos, we utilize trademark based ghastly bunching to bunch the chose cryptos into five gatherings. We investigate these groups and find very that the bunches of cryptos share comparative system like beginning of fork, trouble change recurrence, and the idea of block size. This paper furnishes crypto makers and clients with a superior comprehension toward the association between the blockchain convention plan and distributional qualities of cryptos. A blockchain is a decentralized, dispersed, and frequently open, computerized record comprising of records called blocks that are utilized to record exchanges across numerous PCs so that any elaborate block can't be changed retroactively, without the modification of every resulting block.

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Cyber Security using Machine Learning

Dr. B. K. Sarkar, Dr. M. Eheemalingaiah, Dr. Reena Singh

Within the ever-growing and quickly increasing field of cyber security, it is nearly impossible to quantify or justify the explanations why cyber security has such an outsized impact. Permitting malicious threats to run any place, at any time or in any context is a long way from being acceptable, and may cause forceful injury. It particularly applies to the Byzantine web of consumers and using the net and company information that cyber security groups are finding it hard to shield and contain. Cyber security may be a necessary thought for people and families alike, also for businesses, governments, and academic establishments that operate inside the compass of world network or net. With the facility of Machine Learning, we will advance cyber security landscape. Businesses these days are gathering immense amounts of user information. Information is at the heartbeat of any business-critical system you'll be able to think about. This co-jointly includes infrastructure systems that are being implemented these days. Today's high-tech infrastructure, that has network and cyber security systems, is gathering tremendous amounts of data and analytics on almost all the key aspects of mission-critical systems. Whereas people still give the key operational oversight and intelligent insights into today's infrastructure, machine learning and AI are gaining pace and gathering immense momentum in most of the areas of today's systems, whether or not it's positioned on premise or within the cyber security house.
Keywords:Machine Learning, cyber security, k-means,Random Forest, SVM etc.

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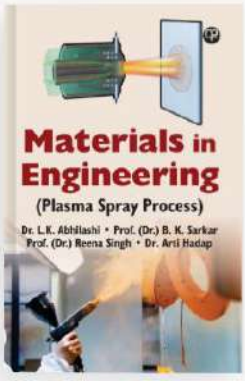

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Digital Technology in Agriculture

Dr. B. K. Sarkar, Dr. J.W. Bakal, Dr. Reena Singh, Dr. Surinder Waznie

Rural creation is the foundation of food security, sustenance security, supportable turn of events and neediness lightening in India. The
agribusiness area contributes around 18% of the absolute GDP (Gross domestic product) and practically 40% of all out NDP (Net Homegrown item). Almost 64% of the absolute labor force is utilized in agriculture or agribusiness-based organizations. However, there is still a ton of potential in farming that hasn't been diverted. In India's provincial regions, ranchers are delivering the greater part of the nation's food. However, they are falling behind a direct result of a bunch of difficulties that they face, because of both inward and outer variables. Provokes, for example, restricted admittance to innovation, market imposing business model, occasional movements, biased data stream, and the sky is the limit from there, that are influencing their general development. Tech may very well be the answer for all ranch issues. New innovation in agribusiness could assist ranchers with estimating environment all the more precisely, lessen water use, increment returns and lift their net benefits. According to a gauge, the utilization of new innovation in Indian horticulture canhelp in saving $2 billion in a year with each rancher saving $16 each. The

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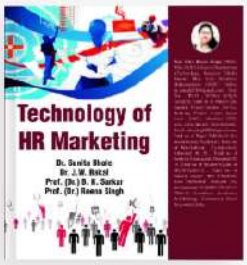

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Technology of HR Marketing

Dr. B. K. Sarkar, Dr. J.W. Bakal, Dr. Reena Singh, Dr. Sunita Bhole

Human asset showcasing (HRM) is centered on the making of occupation position while including all significant boundaries like work determination, wage, and sufficient correspondence of a proposition for employment. Wage is feasible to comprehend as how much cash got as well as a wide range of remuneration for the work that has been finished. Types of staff renumeration have gotten more interest during the last 10 years, particularly with respect to directors and the idea of industry 4.0. Proposition for employment depictions help to track down appropriate candidates for explicit administrative positions. The fundamental goal of this paper is to express the connection among orientation and the picked factors (work sources). For this reason, there was an acknowledged poll review, zeroed in on HRM in the business climate in the Czech Republic. The example populace for the review comprised of 522 individuals, however criticism was just gotten from 185 members (a return pace of 35.44%). To deal with the information, we utilized Pearson's chi-square test for freedom and bunch examination.

Graphical plan was made utilizing a ROC bend (Beneficiary Working Trademark). As per the outcomes got, there were characterized connections among orientation and occupation servers as occupation sources, and among orientation and informal communities as occupation sources. This reliance is upheld by the ROC bend, which shows the assumptions for wage salaries as per the work-insight of the representative.

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Digital HR Marketing

Dr. B. K. Sarkar, Dr. Balan E Mon, Dr. Reena Singh, Dr. KAPIL KAPOOR /

This study combs through relevant literature, adopts a combination of typical sampling and random sampling, collects three big data technology-driven interactive marketing e-commerce companies in a specific period of Sina Weibo sample data for research,

obtains historical information and data, and constructs a model. Through relevant analysis to eliminate invalid variables, we creatively selected three variables of Internet hot words, activities, and micro topics as independent variables and used marketing effects as dependent variables to carry out empirical analysis and study the marketing innovation of three representative companies based on big data technology. We discussed the use of self-media in interactive marketing e-commerce and the situation of marketing innovation based on self-media, focusing on the interactive relationship between marketing innovation and internet word-of-mouth (brand image). Through research, we have derived the three-force model, which is the biggest result of this research, and provided a reference model for interactive marketing e-commerce companies to carry out follow-up marketing innovation based on the media. Limited to the level of research and ability, there are some deficiencies in the research, such as barrage marketing, big data marketing, and emotional computing, that have not been analyzed in depth. This article fully considers the dependence of small and medium e-commerce companies on e-commerce platforms in the era of big data and conducteddetailed market research on their precision marketing strategies in the era of big data. This will be a new field that does not come from media marketing. This articleintends to summarize a series of experiences and laws from special to general, from individuality to generality, so as to give full play to the role of personalized marketing in increasing website traffic and order conversion, in order to personalize the use of data by other e-commerce companies with marketing provides some valuable experiences and methods

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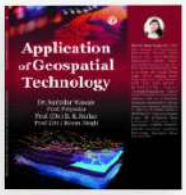

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Application of Geospatial Technology

Dr. B. K. Sarkar, Dr. Reena Singh, Dr. Surinder Wasule, Prof. Priyanka

Geospatial innovation (otherwise called geomatics) is a multidisciplinary field that incorporates teaches like studying, photogrammetry, remote detecting, planning, geographic data frameworks (GIS), geodesy and worldwide route satellite framework (GNSS) (PunCheng, 2001). As per the U.S. Division of Work, geospasial industry can be viewed as "a data innovation field of training that obtains, makes due, deciphers, coordinates, shows, dissects, or in any case utilizes information zeroing in on the geographic, fleeting, and spatial setting" (Klinkenberg, 2007). Another coordinated scholarly field has a different scope of uses (Konen, 2002). The uses of geomatics are in the fields of accuracy cultivating, metropolitan preparation, offices the executives, business geographics, security and knowledge, robotized planning, land the board, ecological administration, land organization, telecom, mechanized machine control, structural designing etc. Indeed, even utilizations of certain gadgets like PDAs, RFID (radio recurrence recognizable proof) labels and video observation cameras can be viewed as a component of geospatial innovations, since they use area data (Klinkenberg, 2007).

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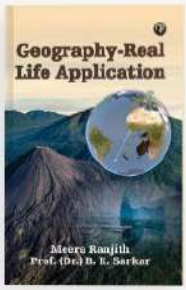

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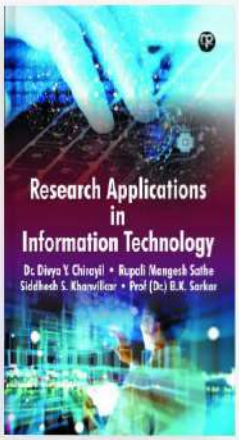

RESEARCH APPLICATIONS IN INFORMATION TECHNOLOGY

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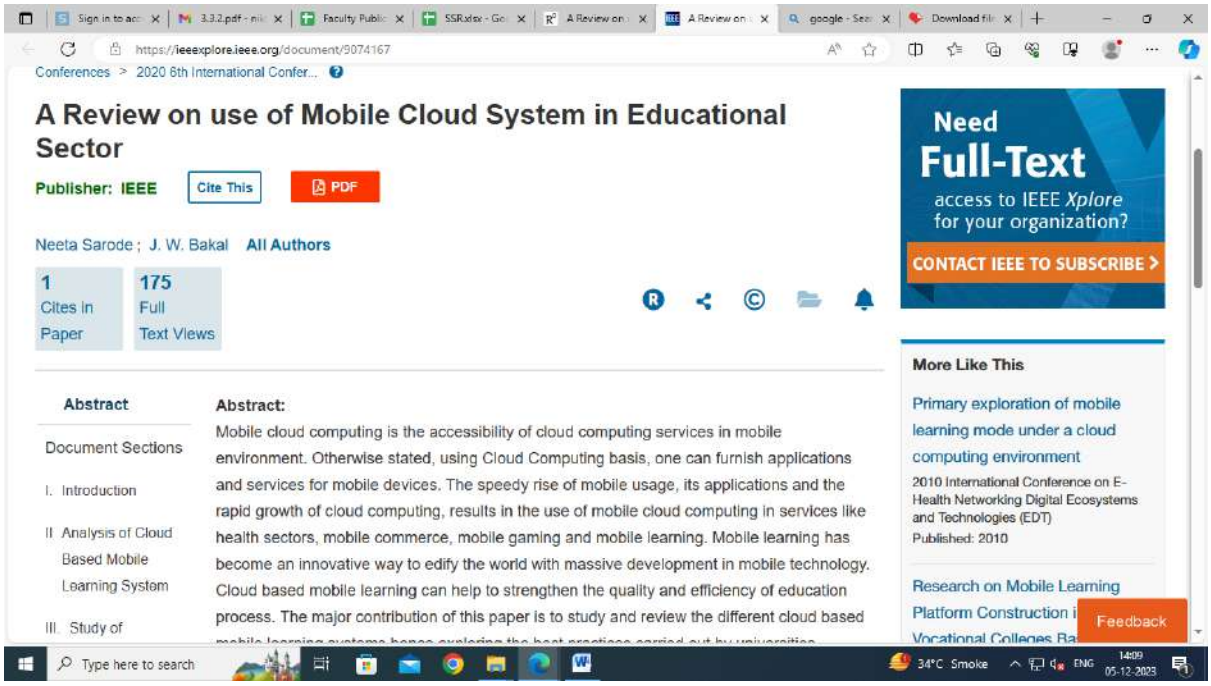
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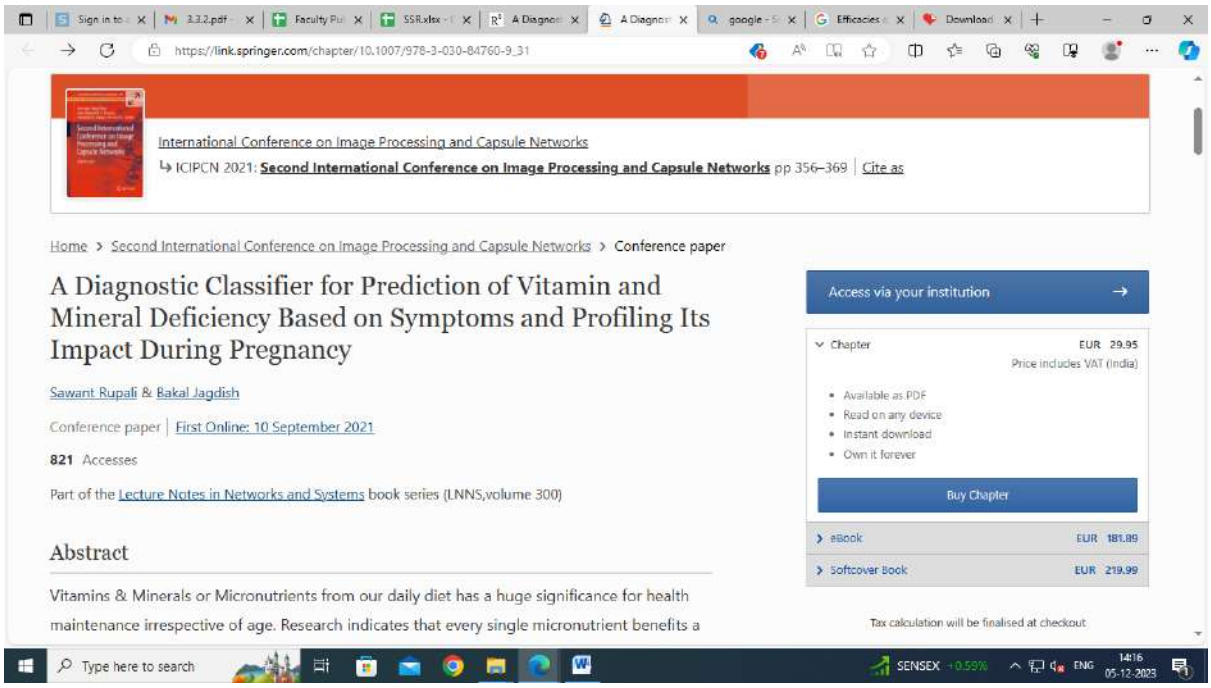
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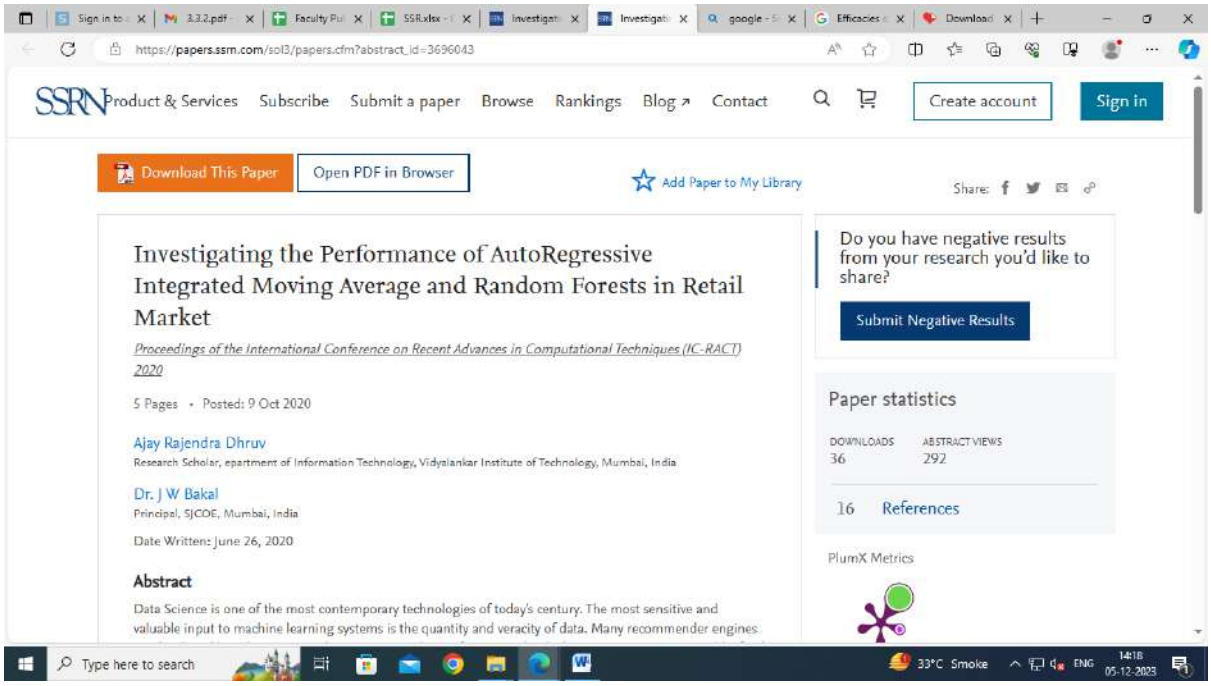
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Dr. J W Bakal
Principal, SJCOE, Mumbai, India
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Ajay Dhruv & J. W. Bakal
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Abstract
The world is growing smarter with technology-driven applications in assisting lifestyle of humans. Machine learning has predominantly helped businesses in continuously learning and evaluating human likes and dislikes. Today, deep neural networks have grabbed the attention of many researchers in developing highly complicated yet effective models for prediction and data analytics. Recommender systems being one of the applications of machine learning has caught customer attention especially in the retail and hospitality sector. After a recommendation engine is built, it is evaluated in different tangents like accuracy, recall, etc. However, there is a serious need to shift the research focus to the user experience and design aspect while using such recommender systems. This paper conducts a survey and based on
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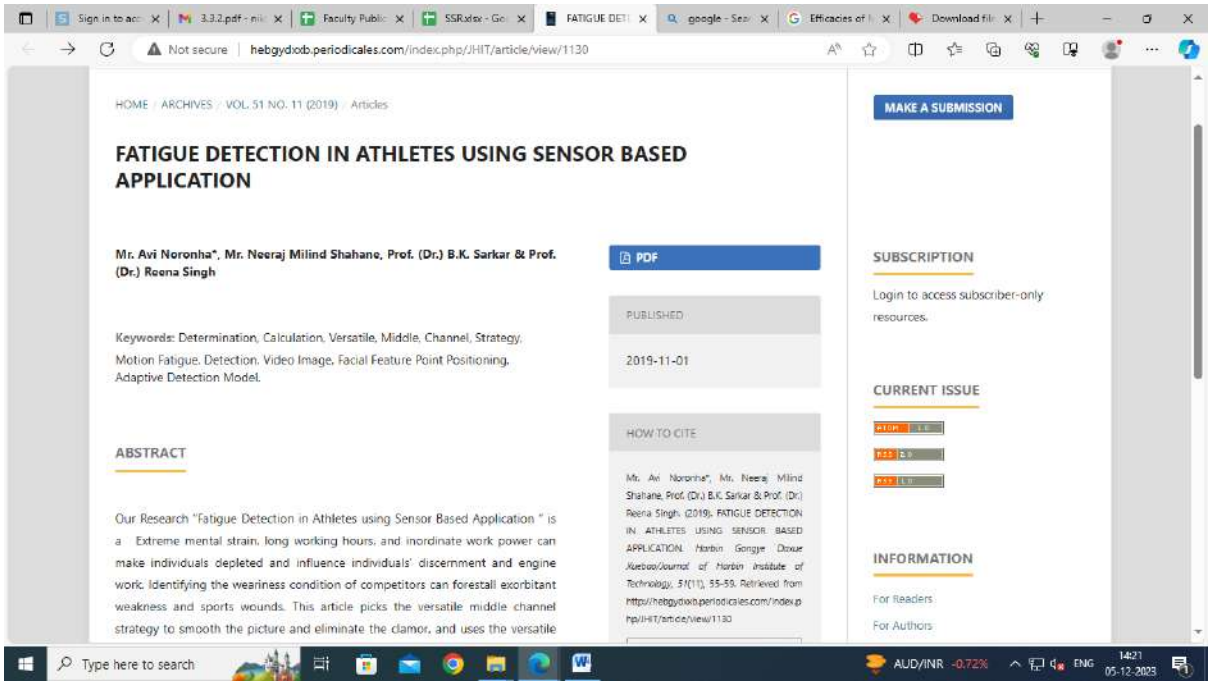

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FATIGUE DETECTION IN ATHLETES USING SENSOR BASED APPLICATION

Mr. Avi Noronha*, Mr. Neeraj Milind Shahane, Prof. (Dr.) B.K. Sarkar & Prof. (Dr.) Reena Singh

PDF

Keywords: Determination, Calculation, Versatile, Middle, Channel, Strategy, Motion Fatigue, Detection, Video Image, Facial Feature Point Positioning, Adaptive Detection Model.

PUBLISHED

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ABSTRACT

Our Research "Fatigue Detection in Athletes using Sensor Based Application " is a Extreme mental strain, long working hours, and inordinate work power can make individuals depleted and influence individuals' discernment and engine work. Identifying the weariness condition of competitors can forestall exorbitant weakness and sports wounds. This article picks the versatile middle channel strategy to smooth the picture and eliminate the clamor, and uses the versatile

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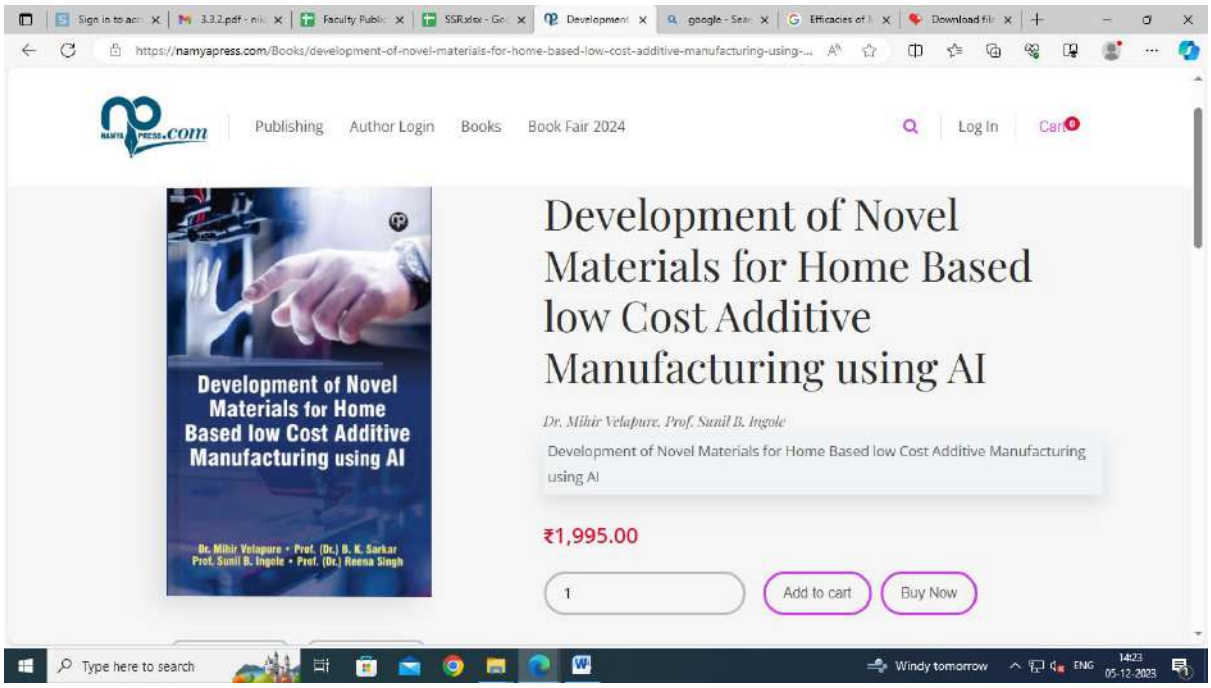

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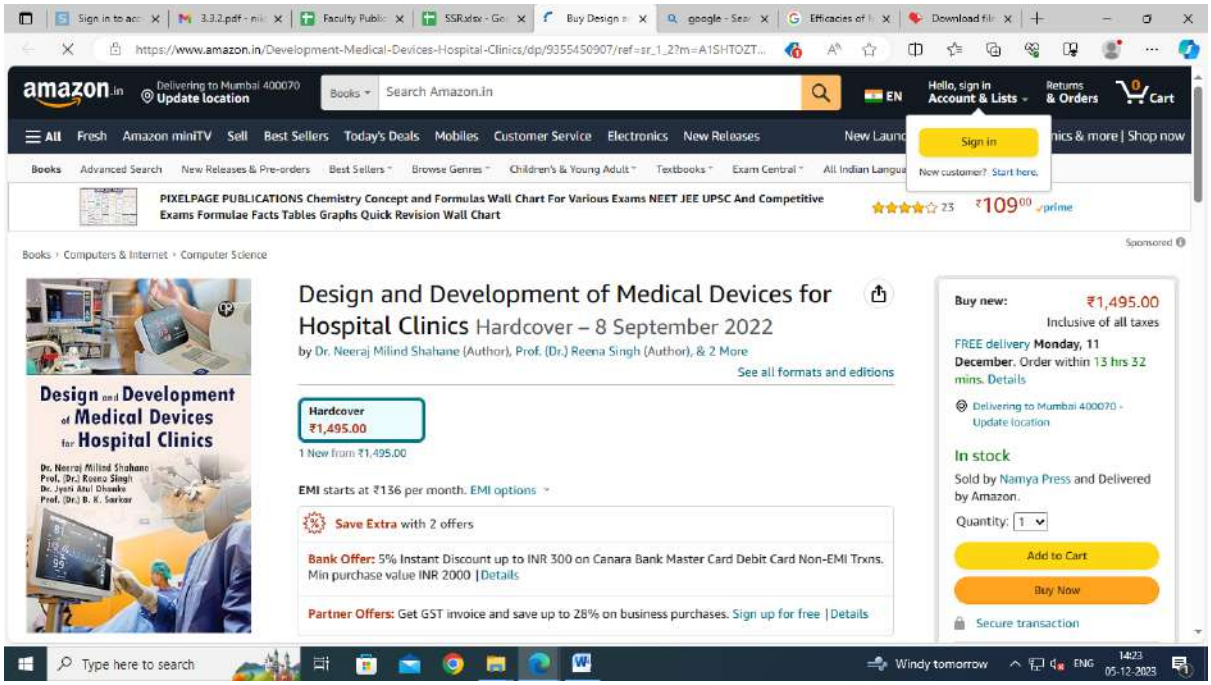
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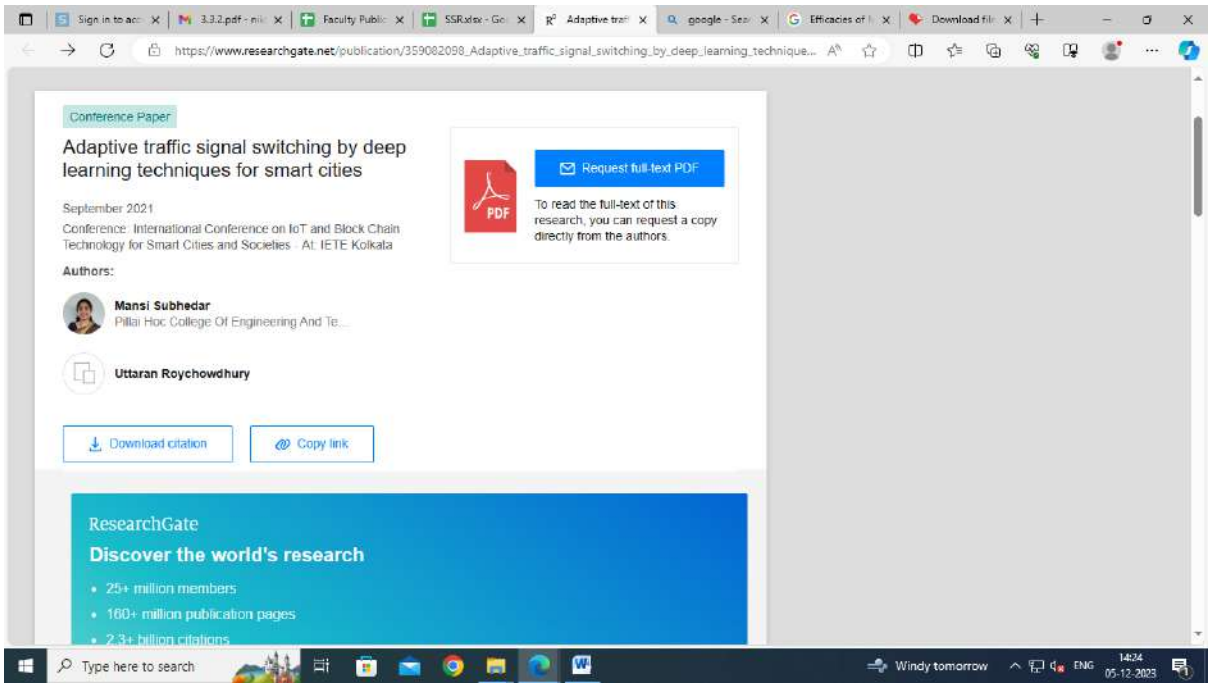
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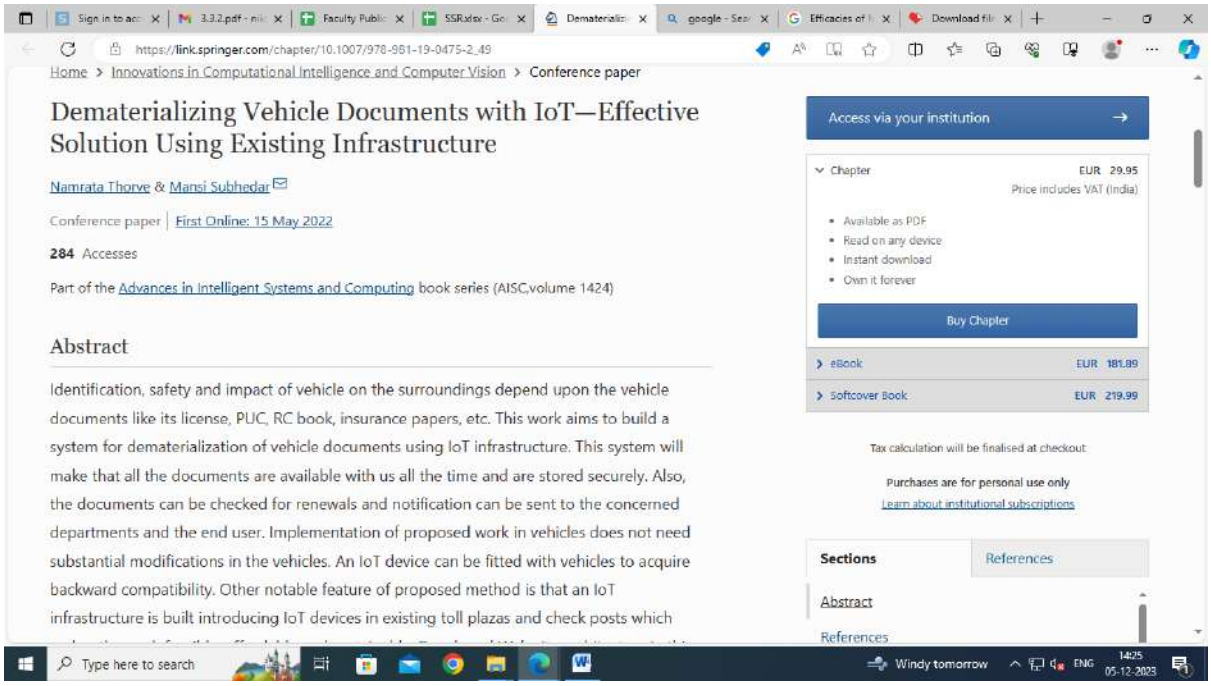

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Dematerializing Vehicle Documents with IoT—Effective Solution Using Existing Infrastructure

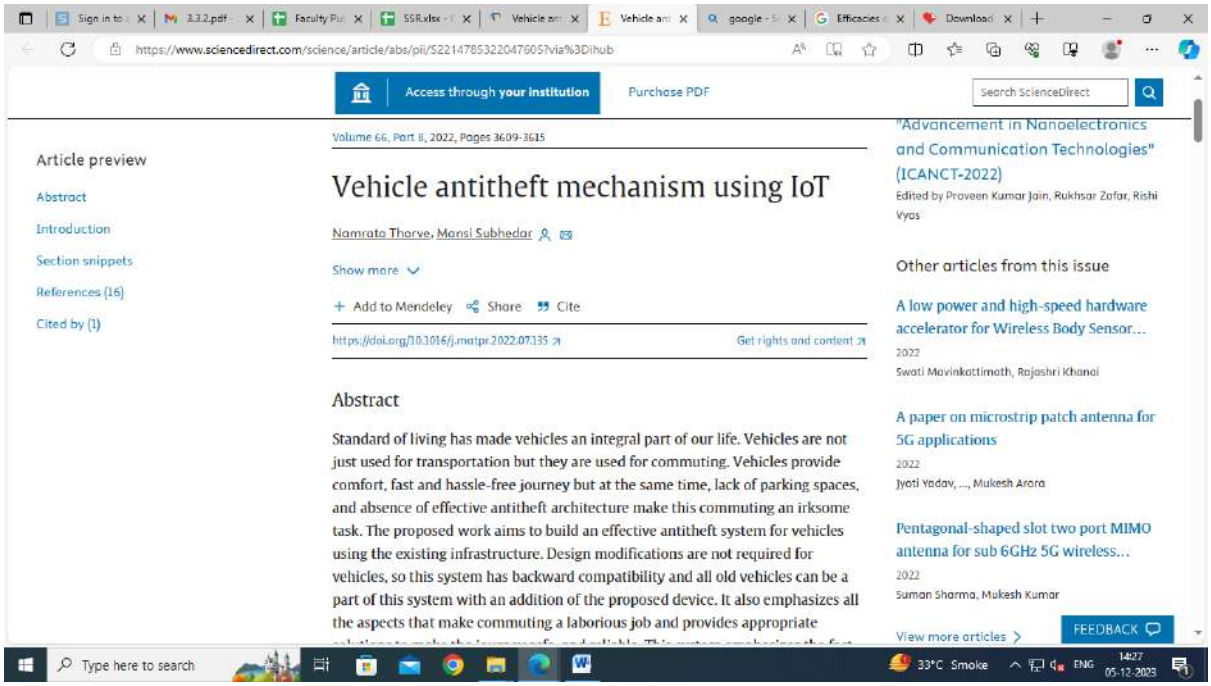
Namrata Thorve & Mansi Subhedar

Conference paper | First Online: 15 May 2022

Part of the Advances in Intelligent Systems and Computing book series (AISC,volume 1424)

Abstract

Identification, safety and impact of vehicle on the surroundings depend upon the vehicle documents like its license, PUC, RC book, insurance papers, etc. This work aims to build a system for dematerialization of vehicle documents using IoT infrastructure. This system will make that all the documents are available with us all the time and are stored securely. Also, the documents can be checked for renewals and notification can be sent to the concerned departments and the end user. Implementation of proposed work in vehicles does not need substantial modifications in the vehicles. An IoT device can be fitted with vehicles to acquire backward compatibility. Other notable feature of proposed method is that an IoT infrastructure is built introducing IoT devices in existing toll plazas and check posts which



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Volume 66, Part 8, 2022, Pages 3609-3615

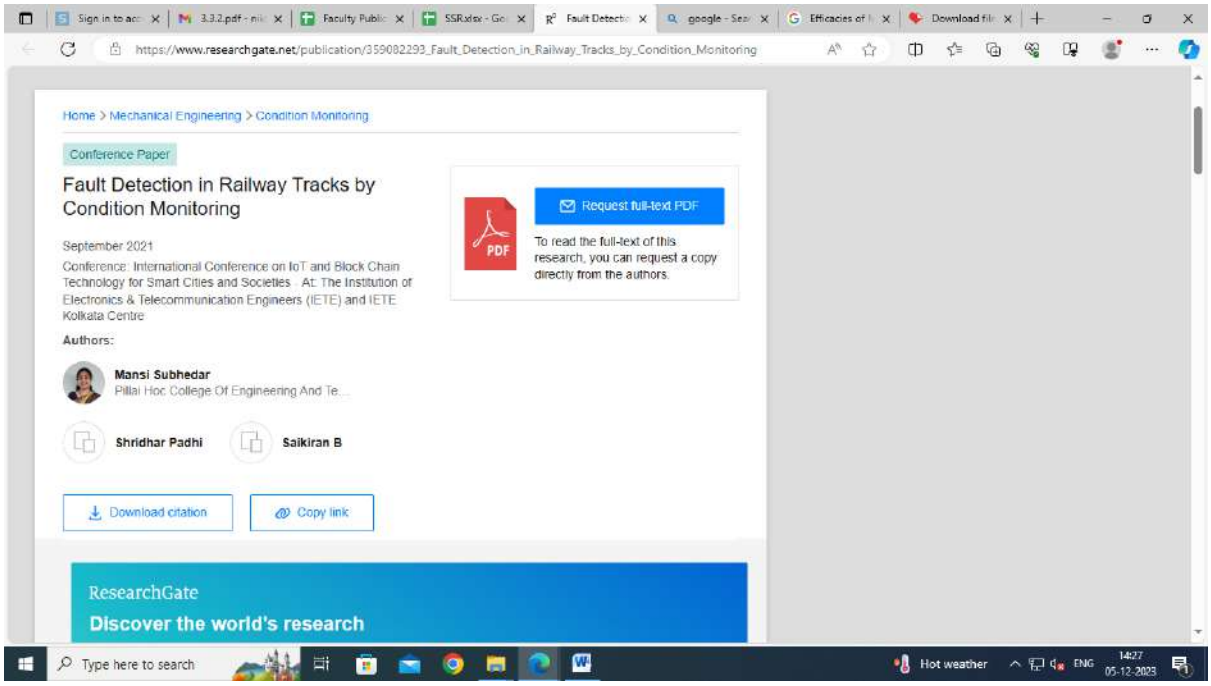
Vehicle antitheft mechanism using IoT

Namrata Thorve, Mansi Subhedar

https://doi.org/10.1016/j.matpr.2022.07.135

Abstract

Standard of living has made vehicles an integral part of our life. Vehicles are not just used for transportation but they are used for commuting. Vehicles provide comfort, fast and hassle-free journey but at the same time, lack of parking spaces, and absence of effective antitheft architecture make this commuting an irksome task. The proposed work aims to build an effective antitheft system for vehicles using the existing infrastructure. Design modifications are not required for vehicles, so this system has backward compatibility and all old vehicles can be a part of this system with an addition of the proposed device. It also emphasizes all the aspects that make commuting a laborious job and provides appropriate



Positive reinforcement in virtual learning systems through gamification of adaptive MCQ test

Original Article | Published: 07 January 2021

Cover selection technique for secure transform domain image steganography

Mansi S. Subhedar

Iran Journal of Computer Science 4, 241–252 (2021) | Cite this article

Abstract

In image steganography, an appropriate cover selection offers the least detectable stego image thereby assuring the security of covert communication. In this paper, a new framework is proposed for the optimal choice of cover from the image database based on statistical texture analysis. Texture analysis using a gray level co-occurrence matrix (GLCM) and run-length matrix (RLM) helps to identify the heterogeneity of images. Textural features were extracted and a non-linear support vector machine was employed to classify a suitable cover from image database. This can further be used as a host image to carry the secret message for the image steganography scheme. To justify the validity of the proposed cover selection technique, image steganography algorithm based on double density dual tree DWT (DDDTDWT) and LU decomposition is also proposed in this work. Performance measures like imperceptibility, robustness, and steganalyser's inability to detect the stego image were employed to check validity of the proposed schemes. Better imperceptibility, strong robustness to stego attacks, and poor detection accuracy by steganalyser confirms the efficacy of proposed cover selection and transform domain image steganography techniques.

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Automatic Onion Transplanter

SUYOG RAJESH KORDE[1], DEEPAK KUMAR RAMMILAN VERMA[2], SATYAM MANGESH SAWANT[3]

[1, 2, 3] *Pillai HOC College of Engineering and Technology*

Abstract- Agriculture has always been the backbone of India for a long time. The states like Maharashtra, Punjab, Kerala and Assam are highly involved in agriculture. It all started due to the impact of, \Green Revolution" by means of which farmers came to know about the various techniques involved in farming and the advantages in it. In Modern world, Automation robot is used in many of the _elds such as defense, surveillance, medical _eld, industries and soon. As centuries passed, certain modern techniques were invented in agriculture due to the progress in science. Agro-Technology is the process of applying the technology innovation occurring in daily life and applying that to the agriculture sector which improves the e_ciency of the crop produced and also to develop a better Mechanical machine to help the agriculture _eld which reduces the amount and time of work spent on one crop. Hence in this work of project we decided to design a better mechanical machine which is available to the farmers at a cheaper rate. The main purpose of our project is to provide a_ordable, compact, multi-purpose solar based robot to farmers for their agricultural use. It is battery based Multi-tasking Robot which performs various operations such as digging, transplanting and pesticides spraying in farms. Its controlling is done by wi_ module which makes it user
friendly as well.

I. INTRODUCTION

An automated transplant an agricultural machine used for transplanting to the soil _eld. This is very important as it reduces the time taken to transplant (when compared to manual transplanting), thus allowing more time for harvesting. it also reduces the use of manual energy. Transplanting and planting vegetables in traditional way, is of hard job and ine_-cient activity. In addition, harvesting of prior crop and preparation of the substrate and transplantation should be done in a period of short time in doubled planting which by doing conventional way of transplantation, it would be hard. These factors show the need for mechanization of transplantation even more than before. Labour costs and the di_erence in depth of planting seedlings are of other factors that make the mechanical transplanting of vegetables seeding necessary. The introduction of the modular seedlings in greenhouse trays makes it possible to produce good quality uniform seedlings in an orderly array that could possibly be set in the _eld by machine. Modern farms are expected to produce more yields with higher quality at lower expenses in a sustainable way that is less dependent on the labor force the idea of applying robotics technology in agriculture is very new. In agriculture, the opportunities for robot enhanced productivity are immense and the robots are appearing on farms in various guises and in Automatic Onion Transplanter increasing numbers. This battery based multitasking agricultural robot is capable of doing multiple task such as digging, bowing, sowing, spraying pesticides. It uses 12V batteries to power the vehicle movement as well as to the motor. The grass cutter motor, digging motors and even a motor to which a water tank is connected are interfaced with Arduino UNO which controls the working of all the motors. To stabilize the whole agrobot for unequal ground we have _tted suspensions on four wheels. We are using WiFi module by which the vehicle is commanded to Go Forward, Backward, Left and Right,to dig the soil, transplanting onion. The robot is highly capable to do all its work in the e_cient manner by reducing many work times and hard labor.

II. PROCEDURE FOR PAPER SUBMISSION

Agricultural robot is a modern requirement in research area. As today educated people should devote for agriculture and implement technology development. In agricultural sector, more labors are in need. But there are not su_cient workers for this sector. Hence the landlords face problems in the agricultural sector and moves towards the industrial sector causing for

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TRACKING BOARD FOR UNSAFE ACT

Dinesh Balakumar[*1], Tejas Rane[*2], Abhishek Patil[*3],
Pratik Vibhandik[*4], Prof. Pratik Mhatre[*5]

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ABSTRACT

This paper is based on various applications of Industrial automation where the Safety of Workers and danger through industrial appliances are imminent nowadays. So, here we are proposing our project which is Making a Tracking Board that detects smoke, LPG, temperature, Tilt which prevents any Major accidents in industries and gives alerts to the Supervisor within a moment via an SMS when there is a problem causing environment and accordingly use the components necessary to limit the dangerous situations in a workplace. The main component we use here is a NodeMCU ESP8266 and connecting our project to IoT applications. Using IoT applications, data can be obtained directly from the website, and accordingly, decisions can be made.

Keywords*:* automation, safety, tracking board, accidents, NodeMCU, sensors, workplace, Blynk App, data, decision.

I. INTRODUCTION

Out of 100%, Unsafe Acts contribute to 61% of accidents, and the remaining 39% of accidents are due to Unsafe conditions in India. The higher number of accidents reported by the safety department due to unsafe act behaviour[2] has occurred as a general issue, which contributes to 48% of the accident in India. We come across various incidents in life which can't be helped and few other incidents which are human errors. We are built like that as a human being like a 50-50 Measure. Unsafe acts occur anytime when an employee fails to abide by the safety rules and protocols. We here are talking about human safety where you need a guarantee that you need to be safe and secure and this system is a Security system that helps the industry or a workplace to be safe and secure in every measure. This study aims to identify the root cause that contributes to Unsafe Act behavior and further analysis in the implementation of control risks on Unsafe Act behavior at industries. Few of the Unsafe Acts include Operating equipment without Authority, disregard of instructions that are followed in industries, removing safety devices, using defective equipment, working in an unsafe posture, absent-mindedness/ awareness, working under the influence of alcohol/drugs, failure to understand instructions, etc.

The fact that people make errors in situations that require judgment and problem solving, these are those kinds of situations where we can't help ourselves. It's natural and happens so often but needs to be minimized. So, here our system is a Board that can track the problematic situations in the industry especially smoke, Gas[5], temperature change, Tilt measure and gives you alert and side by side can prevent any injuries too by actually switching on/off the required components to limit the cause of panic in a workplace. In this way, safety is provided in every aspect.

II. METHODOLOGY

The hardware part of this project consists of two modules. The first one is a protection module and the second one is detection module. NodeMCU[4] esp8266 module and four types of sensors namely smoke sensor, LPG sensor, temperature sensor[3], and tilt sensor are key elements in the board that we are making in this project.

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ACCIDENT IDENTIFICATION & ALERTING SYSTEM

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[*1,2,3,4]BE Students, Dept. of EXTC Engineering, PHCET College, Rasayani, Maharashtra, India

[*5]Professor, Dept. of EXTC Engineering, PHCET College, Rasayani, Maharashtra, India

ABSTRACT

As nowadays, the number of vehicles are increasing rapidly, the number of accident happening due to vehicles are also get increased. Most of the accident happened because of increased traffic as well as high speed, drunk & driving, overstress, diverting minds and due to use of electronic gadgets. The proposed system ensures by making emergency facilities available to the accident victim as early as possible by giving emergency message to relatives, hospitals or rescue teams letting know the accident location with the help of system embedded in the vehicle. This paper discuss about a system which can automatically detect an accident happened and can alert the hospitals, ambulance, family members, police station or rescue teams which are nearest one. The system uses the Accelerometer to detect an accident. The microcontroller continuously monitors the output of accelerometer. The accident location of the vehicle can be tracked by using GPS module which is installed in the system. Once accident occurs, the accident location is sent through the GSM modem used in the system.

Keywords: Accident, Emergency, Microcontroller, MEMS, Accelerometer, Gyroscope, GPS, GSM

I. INTRODUCTION

In today's era, vehicles are the important part of the human's daily life. The usage of vehicles have increased rapidly over the past decades. The major reason for the death rates over the world is due to the road accidents. The appearance of vehicles impacts on the human life. The increasing number of vehicles has also increased not only the road accidents but also traffic hazards. Preventing deaths and serious injuries in road accidents is becoming an important goal for the governments around the world. The main reasons for the accidents are high speed driving, lack of sufficient sleep, drunk and driving and also the use of electronic gadgets while driving. To recognize the location of the accident and to find the accident location automatic accident identification and alerting system is very useful. For an accident victim, every second is important to save the victim's life. Hence, it is important to provide medical services on a time to the victim of the accident. In the arrival of ambulance if there is delay, there will a probably loss of life. Near about 1.2 million people are died every year and 50 million people injured every year worldwide due to road accidents.

The most likely reason of individual's death after accident is lack of first aid because emergency services cannot reach on time at accident location. Analysis shows that if we decrease only 1-2 minutes of accident response time that can increase the chances of saving person's life upto six percent. Hence, emergency services should reach on time at accident location. Therefore, the main goal of the accident identification system is to detect an accident and automatically send the message to the registered numbers such as emergency services along with the location. Real time geographic location of the vehicle is informed by the system by using preinstalled sensing accelerometer equipment. The output of an accelerometer is given input to the microcontroller, this input data is continuously monitored by the microcontroller unit. The vehicle can be tracked in all weather conditions. GPS and GSM technologies are used in the proposed system to provide all the data to the registered number or the remote server. The information received is used to provide services to the individual at the time of emergency.

The output of the accelerometer is continuously monitored and processed by the microcontroller. When an accident occurs, there is a sudden change in the acceleration or the roll-off in the car's axis. The accident is detected with the help of the microcontroller. The microcontroller sends an alert message automatically to the relatives as well as nearby police station and emergency medical services through the GSM module. The geographic location of the vehicle is acquired by the GPS module. The alert message includes the geographic coordinates, time in which accident has occurred. Incase if there is false detection of accident or a minor accident happened and there is no medical facility required a switch is provided to the user to terminate the ongoing emergency message. The switch has to be pressed by the user within specified time which is 1 or 2 minutes. Hence with help of this project we can detect the location of the vehicle where the accident has occurred so that we can provide the first aid to the victim as early as possible.

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Main Reasons of Accident

Everyday, thousands of road accidents happen across the world. Main reasons of accidents are because of human errors or human mistakes while driving vehicle. Road accidents occur due to variety of reasons. Often, drivers are distracted while driving, taking their focus away from the road. In some cases drivers get tired after spending more hours in driving vehicle. In some cases accidents occur in multiple reasons like bad visibility and unsafe road design.

Some of the common reasons which causes accident are Over-speeding, Drunken driving, Distraction of driver, Red light jumping, Bad road conditions, Drowsy driving, Animal crossing, etc.

II. LITERATURE SURVEY

There are various research had done in order to minimize the accidents and to save more lives of an injured victims in an accidents. There are many ways to detect accident of an vehicle as well as the location of vehicle. Many methods mostly used GPS and GSM systems to track the location of the vehicles.

In the paper [5], the author proposed accident detection and alert system which uses the arduino and a vibration sensor to detect an accident. The system was well designed. Only the disadvantage of that system is vibrations are common in vehicles so that many times system may give false detection of accidents.

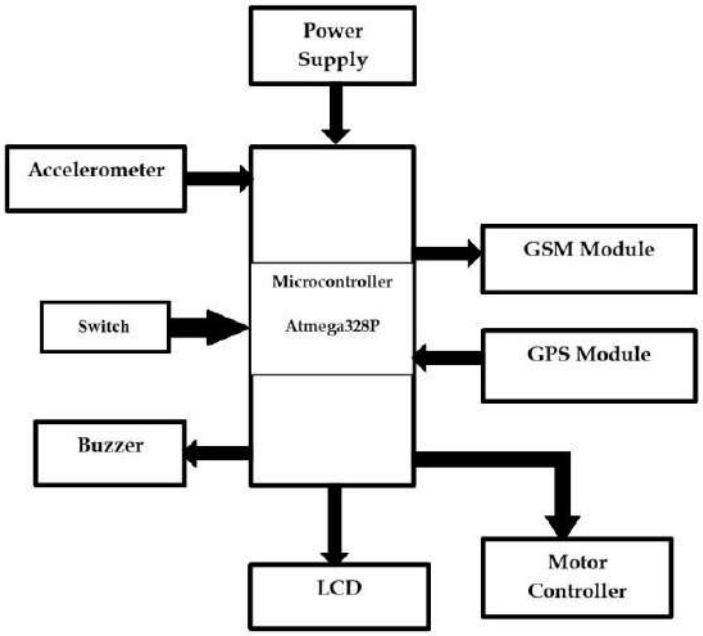
In proposed paper [10], the research includes disaster management system using smartphone which is cloud based accident detection system. Cloud based accident as well as disaster management system can face problems like latency and bandwidth limitation.

In [9], authors proposed a mobile application for automatic accident detection and multimodal alert. It uses accident detection algorithm. eCall system is used by this proposed system to automatically detect the accidents of vehicle along with collisions and roll over.

The other existing system also uses the IOT and Cloud computing technologies. IOT based system monitors the vehicles using magneto resistive sensors. But for IOT system installing in vehicle, the system should be internet connected at all time.

III. METHODOLOGY

a) Block Diagram



The ATmega328P is the heart of the system. The power supply of output voltage 5-6V is sufficient for the system to work. The output of the accelerometer is given input the microcontroller. The GSM module is connected to the microcontroller through which the emergency message will be sent to the registered numbers. The GSM module is connected to the input of the microcontroller which will provide GPS location of the vehicle. The switch is provided to terminate the ongoing alert message if it is necessary. And it also contains LCD, Buzzer, Motor controller, etc.

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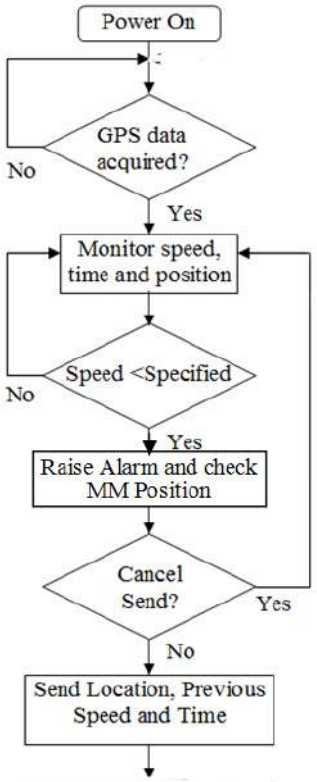
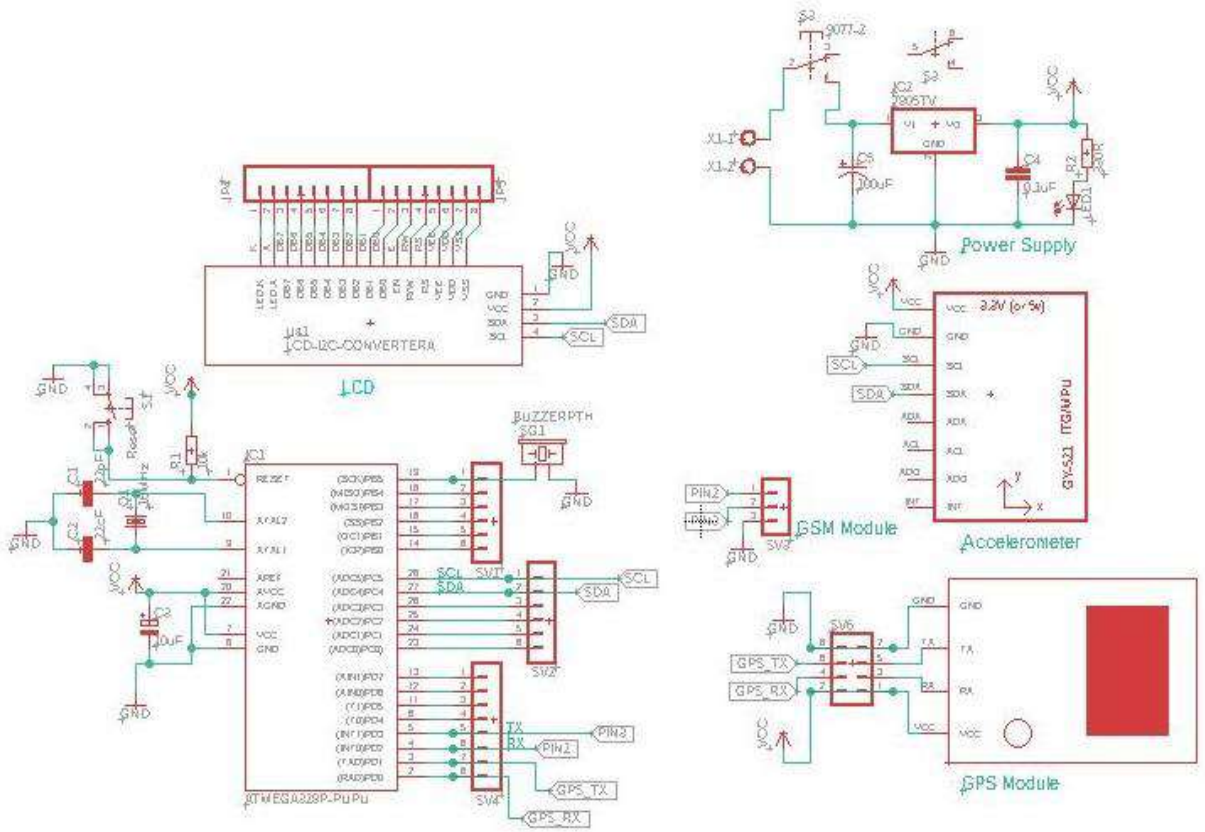
b) Flow Chart



The above figure shows the working flowchart of the system.

c) Circuit Diagram



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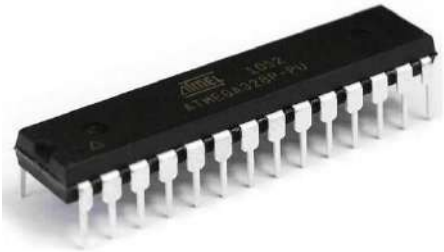
IV. WORKING

When the vehicle will start moving, the accelerometer sensor installed in the system will continuously monitor the acceleration as well as the axis of the vehicle. If there is sudden change in the acceleration as compared specified reading or if there is roll-off in the car's axis the accident get detected by the microcontroller. The buzzer present in the system will start beeping indicating the accident is detected and system is now activated. The GPS detects the latitude and longitude coordinates of the vehicle which is necessary to locate the position of the vehicle to provide medical facility. The emergency message will sent to the phone numbers which saved in the system. The numbers can be changed by the user. Finally the alert/emergency message is sent to the registered numbers having location and time of accident of the vehicle.

If there is false detection of accident or there is minor accident and no medical or emergency is required the driver can press the reset button within specified time which is 1-2 minutes to terminate ongoing emergency message.

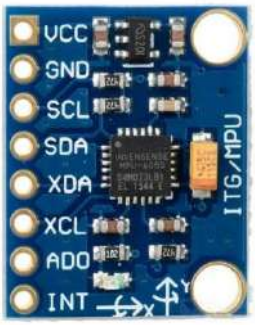
V. HARDWARE DETAILS

a) ATmega328P



It is the high performance microchip picoPower 8 –bit AVR RISC microcontroller contains 32KB ISP flash memory with read-while-write capabilities. The microcontroller has 14 digital I/O pins and 6 analog input pins.

b) Accelerometer



MPU6050 is a complete 6-axis motion tracking device. It combines of 3-axis accelerometer and 3-axis gyroscope and digital motion processor. It helps us to measure acceleration, velocity, orientation, displacement, etc.

c) GPS Module

It is used to determine the ground position of an object (vehicle). Neo-6m is the high performance u-blox 6 positioning engine. This is very flexible and cost effective receiver offer numerous connectivity option in a very small package. It consumes very low power makes it ideal for portable devices.

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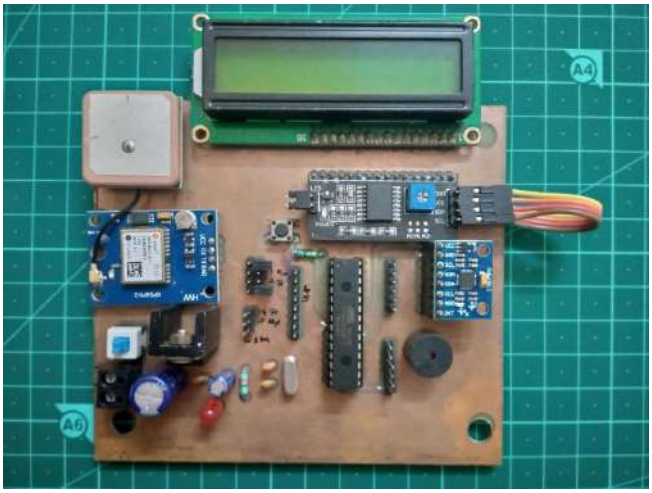
d) GSM Module

The GSM technology is most widely used cellular technology used in the world. It is the digital cellular technology used for transmitting mobile voice and data services. It is highly economical and less expensive.

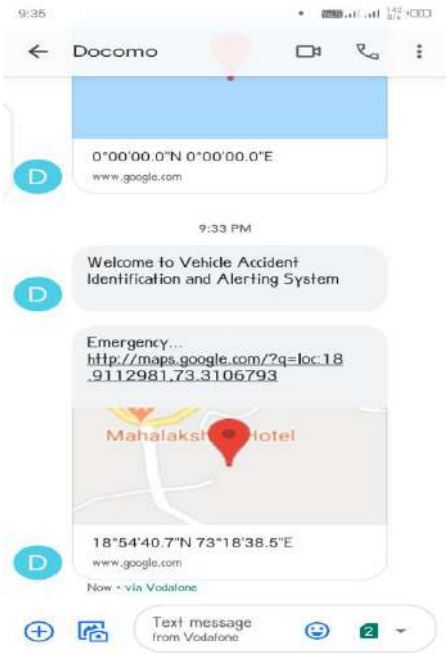
VI. RESULTS

a) PCB Board



The above figure is the PCB board of the proposed system.

b) Alert Message



IOT Based Early Flood Detection and Avoidance

M. SHOYEB SAYYAD[1], POOJA SURVE[2], NAZIM SHAIKH[3], MANSI GHARAT[4], PRIYA TAMBE[5]
[1, 2, 3, 4] *Student, Pillai HOC College of Engineering and Technology, Rasayani*
[5] *Assistant Professor, Pillai HOC College of Engineering and Technology, Rasayani*

Abstract- ***Flooding is a natural phenomenon which has attracted global attention as a result of its negative impact on the society. Developing nations such as India have been predicted to experience increased flood occurrences in the coming decade. The events of flooding are unlikely to change, however, its impact on our society can be very well reduced. There are some places that are more prone to flooding than other places, the implementation of flood alert systems near any major water area or body of water provides critical information that can protect property and save lives.***

Hence we are designing this project to inform the people about the upcoming flood by making use of the concept of Internet of Things. For that purpose we are going to use an android Application to intimate the users. This Project focuses on providing early detection of flooding and the measures to minimise and avoid floods. The system involves the deployment of sensor nodes at specific flood vulnerable locations for real-time flood monitoring and detection. Flood events relating to flash flooding and run-off water or overflow are successfully monitored in real time which saves individuals plenty of time to prepare against predicted flood occurrence, saving them from the aftermath of flood disaster.

Indexed Terms- Arduino, Android, BLYNK IOT, ESP8266 Wifi Module, Moisture Sensor, Ultrasonic Sensor

I. INTRODUCTION

In India, the rainy seasons occur each year from June to October. Early rainfall is usually in June with full commencement in July, and stops in the months of October each year, with a few showers in November. Flooding is a natural phenomenon which attracts global interest. It results in tremendous environmental destruction and loss of lives. Flooding is a result of substantial rainfalls, structural failures and a large number of human factors. Floods rely on precipitation amounts and rates, topology, geology, land use, and antecedent moisture condition.

In the year 2018 Severe flooding affected Indian state of Kerala due to unusual high rain during monsoon season. It was the worst flooding in Kerala in nearly a century. In which over 374 people died within fortnight. Thirty-five out of 42 dams within the state open for the first time in history. Kerala received heavy monsoon rainfall on the mid evening of August and resulting in dams filling to capacity in the first 24 hours of rainfall the state received 310 mm of rain.

The events of flooding is unlikely to change, however, its impact on our society can be very well reduced. Efficient forecasting and early warning systems can help mitigate the effects of flooding. The concept of Internet of things can be used to collect Real time information from a wide range of environmental phenomenon.

To develop A Real Time Solution to Flood detection and avoidance Using IoT and Sensor Network, we proposed a flood detection and avoidance model which requires attention to three basic factors: Data collection via water level sensors, data processing, and the dissemination of flood warning information. While automated flood warning systems are often surprisingly expensive to implement, the primary factor determining cost for any such system is the number of Sensor site locations.

To tackle the problem of detection of the flooding, we are using the Y89 Moisture sensor's which will act as the water level sensor. Where the resistance value will be proportionate to the moisture in the soil.

The HC SR04 Ultrasonic sensor will be used to monitor the water level in a body which stores water which can easily be water dams in our case.

Computational Intelligence pp 765–775 | Cite as

Sustainably Nurturing a Plant (SNAP) Using Internet of Things

Akshayee Bharat Dhule & Divya Y.Chirayil

Conference paper | First Online: 16 February 2023

320 Accesses

Part of the Lecture Notes in Electrical Engineering book series (LNEE,volume 968)

Abstract

Plants are of great importance to us and are a vital factor in human existence on this earth. We cannot imagine a life without plants. Rapid development in economy, industries, and cities has led to an increase in the rate of deforestation. In order to have balance, the "Plant a tree" initiative is taken at the institutional level, community level, and government level. This initiative has not succeeded in a true sense as most of them just plant the trees but forget to nurture them as there is a lack of communication, feelings, and emotional quotient in people for the plants. The following paper presents a prototype that personifies the plant, helps them to create emotional quotient using IoT, monitors their health, and nurtures them. The sensor values are monitored on LCD, Cayenne dashboard, and also in the mobile app. The prototype posts customized messages on various social media like Facebook, Twitter on certain threshold values of sensors thereby personifying the plant. Moreover, the huge dataset created by the sensors lay the foundation to build algorithms in machine and deep learning, which will help to make tailor made conditions to nurture a plant and also enhance the expressions of plants

Sections References

Abstract

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Particle Swarm Optimization-Based Neural Network for Wireless Heterogeneous Networks

Divya Y. Chirayil

Conference paper | First Online: 31 March 2022

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Part of the Advances in Intelligent Systems and Computing book series (AISC,volume 1420)

Abstract

The heterogeneous wireless network aims to maintain improved mobility and communication among the wide area network always. Therefore, VHO is very much required. This proposed work introduces vertical VHO that is context-aware in heterogeneous sector. Better handover is generated from an enhanced determination of handover points. Particle swarm optimization

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Use of IoT - Internet of things

DR. ARPIT JAIN, Prof (Dr.) Ratna Raja Kumar Jambi, Prof (Dr.) B. K. Sarkar , Pro (Dr.) Vivek Kumar

Namya Press USA, 31-May-2022 - Technology & Engineering - 185 pages

The developing peculiarity of the Internet of Things (IoT), which is that any thing equipped for being associated with the Internet will be, presents a remarkable chance for organizations. Utilizing a broad writing audit, the flow research analyzes the critical change in showcasing techniques that need to happen to focus on the millennial age of as they embrace IoT. Most examination characterizes the Millennial age as those brought into the world from the mid 1980s to the mid 2000s. As people in this age become older, there More »

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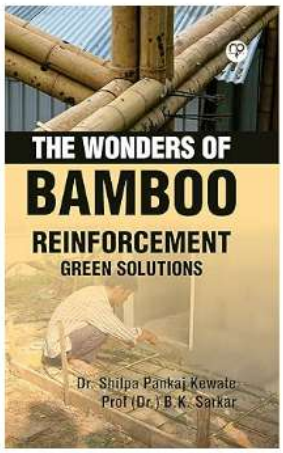

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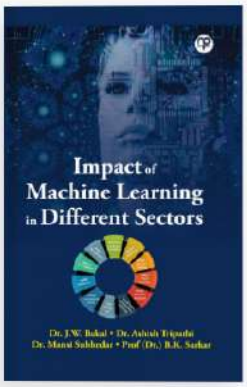

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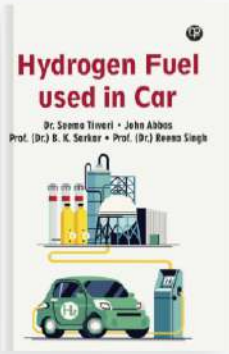

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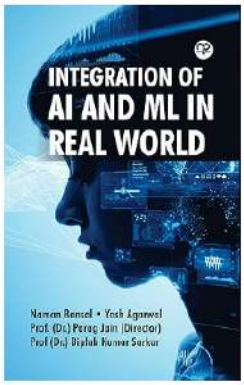

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Mechanical characterization of neat epoxy resin and its failure analysis using FEM

Suhas A. Uthale[1], *Dattaji. K. Shinde*[2]

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[2]*Faculty, Production Engineering Department*

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ABSTRACT

With the advancement and continuing integration of composite materials and technology in today's modern industries, research in this field is becoming more and more significant. Polymeric hybrid nanocomposites, due to improved mechanical and thermal properties, are becoming an essential element in major technologies. Because of their anisotropic nature it is difficult to fully predict their mechanical characteristics and behavior, especially if they are produced with complicated architectures. Development of a realistic theory of describing the structure and behavior of materials is highly dependent on accurate modeling and simulation techniques. Selection of compatible resin for various reinforcing elements to fabricate composite plays significant role in enhancement of mechanical properties of the composites. The present study aims at preparation and testing of neat epoxy resin sample EPOFINE 281 (Diglycidyl ether of bisphenol F) with hardener FINEHARD 5200 by using vacuum assisted resin transfer molding (VARTM) method with proper curing cycles. Neat epoxy resin tensile and flexural test specimens are formed from epoxy resin sheet as per ASTM D638 and ISO 178 standards respectively by using water jet machine. Experimental tests like tensile and flexure (three-point bending) tests have been conducted and results are compared with properties of resin supplied by supplier and results obtained by finite element method. It is recognized that there is a good agreement between the computational and experimental results.

Keywords:(Nanocomposites, FEA, woven fabric, neat epoxy).

1. Introduction

A composite material is a material comprises of at least two physically or chemically different, properly arranged or distributed phases with an interface isolating them. Present day innovations require materials with a weird combination of properties that can't be met by the common materials [1]. In recent years, fiber-reinforced polymers are extensively utilized in varied industries like aerospace, marine, transportation, and defense, attributable to their better mechanical and electrical properties [2]. However, the benefits of those materials are considerably reduced as a result of their possibility to break by low-velocity impacts [3]. Improved properties of composite materials are achieved by a hybridization process. The incorporation of different types of fibers into a single matrix has led to the development of hybrid composites. The most brittle fiber, known as first type fiber, in hybrid composites is almost always carbon fiber, while the second type fiber, known as the hybridization fiber, usually features a higher failure strain [4]. Nanocomposites are a completely unique category of composite materials where one in each of the constituents has dimensions within a range between 1 and 100 nm. Recent and in-progress research on polymer nanocomposites has shown dramatic enhancements in the mechanical properties like stiffness, strength and thermal properties over those of polymers, without compromising on density, toughness or processibility. Major differences in behavior between conventional and nanostructured materials are due to high surface to volume ratio of nanocomposite as compared to conventional materials. Since several necessary chemical and physical interactions are governed by surfaces, a nanostructured material can have totally different properties from a larger-dimension material of an equivalent composition. In the case of fibers or foils, the area per unit volume is inversely proportional to the fiber diameter or the foil thickness. Thus, the smaller these dimensions are, the larger is the surface area per unit volume. Reinforcing efficiency needs high aspect ratios of the particulate constituent that is provided by nanofibers or nanotubes (1-dimensional) and nanofoils (2-dimensional) [5]. Nanoparticles, rod-like nanofillers, and platelet-like nanofillers are three major forms of nanofillers. When all three dimensions of particulates are at nanometeric level, like carbon black, silica, and quantum dots, are referred as equi-axed (isodimensional) nanoparticles or nanogranules or nanocrystals. Nanofillers could belong to organic and inorganic in nature. The particles like silica (SiO_2), Titanium dioxide (TiO_2), Calcium carbonate ($CaCO_3$), etc., are inorganic filler. When two dimensions are at nanometeric level and the third is larger, resulting an elongated structure, are generally referred as 'nanotubes' or nanofibers / whiskers / nanorods. When any one of dimension of particulates is in the nanometer scale are referred as nanolayers / nanoclays / nanosheets / nanoplatelets. This particulate is

Design of battery pack & controller for combined auto driven mini-harvester

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Abstract: The mechanized farming can promisingly increase the profitability and prevent the dependency of farmers on foreign labours. The design and implementation of Battery pack and controller for specially designed combined auto-driven mini harvester is presented in this paper. The mechanical load estimation and its mapping with electrical drives are formulated. The interfacing of electrical drives with remote operation is achieved by Electronic Arduino system. The relay control system is designed with individual drive system. The sketches are mapped with the functionality of drives. The drive selection is a dependant function of mechanical load requirement. The mechanical load estimation is done with actual mechanical failure consideration and design approach. The pin-out connections for all the ports are done on the basis of logical sketch command. The open source Arduino software is used to run the sketches. The sketch written for all the drives is compiled and demo prototype machine is tested for functioning. The run trail is successful and can conclude that the Arduino mega gives the sound interface with 8 channel relay. The computation and measurement results of power requirements for the controller and drive are within the limiting conditions.

Keywords: Arduino Sketch development, Battery-pack design, Electro-mechanical load mapping, Relay interface, Remote operation

1. Introduction

The explosion of population causes upmost requirement of food & agricultural goods all over the world. The shrinking fertile land size is making farmers incapable for adoption of bigger farm machineries. Though the advancement and development in the field of agriculture taking place promisingly still the adoption and implementation for the small countries like India, Indonesia, Brazil is rare or mostly unseen [1]. The combined harvester available is limited for large farm fields and rich farmers. Though attempts have been made to address the issue of small farmers still the problem remain unsolved. [1] The post harvesting operation is most labour intensive work [2]. The post harvesting has to be performed in the hot dry whether to trace the maximum yield. The favourable condition leads to the operating temp about 40 ^{0} C [3]. The manual operation at such an operating temperature leads to severe health issue or may cause death due to heat stroke. The detailed literature review and market survey gives the traces for unavailability of combined mini harvester. The available combined harvester with their capacity and capability & constraints are deeply studied and presented by present

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Evaluation Of Site Core Damage Frequency Of Multi-Unit Nuclear Power Plant Using Probabilistic Safety Assessment

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Abstract*— The nuclear accident that took place at Fukushima (Japan 2011) highlighted the need for development of safety assessment of a multi-unit site. A systematic methodology to perform Level 1 safety assessment of a twin-unit site is presented using Probabilistic Safety Assessment (PSA) approach. The proposed approach quantifies risk from simultaneous failures of one or more systems due to internal initiating events (IE) and from shared system and components (SSC). Site core damage frequency (SCDF) is evaluated by developing an integrated multi-unit modal using fault trees as well as event trees. Major contributors to core damage are identified and analyzed from the minimal cut-sets using Risk-spectrum software.

Keywords*—Probabilistic Safety Assessment; Multi-unit; SCDF; Internal initiating events; Minimal Cut-sets.

I. INTRODUCTION

Today, nuclear power provides 11% of the world's total electricity, and 21% of the electricity in Organization for Economic Co-operation and Development (OECD) countries. Radiation and radioactive substance have many beneficial applications, but there is also very high risk associated with it. The radiation risks to workers, public and environment have to be assessed systematically and controlled. Probabilistic safety assessment approach is preferably used since it provides a systematic framework to assess the risk and insights of potential risk arising from a nuclear power plant over wide range of conditions [1]. The PSA study explicitly accounts for the likelihood of possible accident sequences in an integrated fashion by expressing the likelihood of occurrence of possible accident as frequencies or probabilities. Expected loss is the total risk which is given by sum of products of consequences multiplied by their probabilities.

Systematic methodology is needed to be evolved to assess multi-unit site safety. Hence this paper focuses on risk or hazard from multi-unit site because of occurrence of random internal initiating events and simultaneous failures of one or more systems by considering two typical identical units at a site. This methodology also considers risk from shared systems and components and evaluates their contribution in the total risk. Integrated approach is developed for evaluating SCDF of a twin-unit site. SCDF is the total risk associated with the site and is found out by adding risk of core damage from one or from all the units.

The proposed approach is demonstrated by considering simultaneous failure of systems due to random internal initiating events as well as failure of shared systems and components for a twin-unit by developing fault trees and event trees. Cut-sets obtained from developed model are analyzed to identify important events contributing to core damage. Though all the IE's and SSC's are not demonstrated, the study can be expanded by considering the appropriate IE'S and SSC's using the developed methodology.

A. Objectives

The main objectives of the present work are:

- To evaluate risk at a multi-unit site and assess safety against internal initiating events and failure of shared systems and components.
- To develop a PSA model of twin-unit nuclear plant by constructing fault trees as well as event trees.
- To develop a systematic methodology to quantify risk from multi-unit at a site in terms of SCDF using PSA approach.
- To study influence of critical initiating events and SSC's and measure their involvement in the total risk by analyzing the cut-sets derived from developed model.

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Multi-Body Dynamic Model of a Single-Wheel Robot Stabilized by Reaction Wheel Principle

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[1]*kadamsn5@gmail.com*

[2]*sethbharat@gmail.com*

Abstract

Reactobot is a one-wheel robot developed at IIT Bombay. It is balanced by a reaction wheel actuator suspended from its central axis. The Robot can get accelerated in forward or backward direction by pitching the pendulum mass within the wheel body in the same direction. Turns can be executed by tilting the robot to right or left while in motion. In this paper, we describe a multi-body dynamic model of the Reactobot, which is developed by considering seven generalized variables. The Reactobot is assumed to roll on a flat surface without slipping. The system has two nonholonomic constraints as the direction of the forward velocity of the wheel is constrained to be in the direction of wheel heading. The mathematical model of Reactobot is developed using the Lagrangian constrained generalized formulation. Subsequently, the Lagrangian multipliers are eliminated and the model is converted into 5-DOF normal form. The dynamic model is highly nonlinear. The developed mathematical model is validated by numerical simulation for special cases. The behavior of the system is along expected lines. In every simulation case, the potential energy decreases while the total energy remains constant over time since the dynamic model is conservative.

Keywords: Wheel-robot, Reaction wheel stabilization, Non linear dynamics, Nonholonomic constraints, Lagrange formulation

Nomenclature

γ	Yaw angle
ϕ	Lean angle with horizontal
θ	Spin angle
$\dot{\gamma}$	Angular velocity about yaw axis
$\dot{\phi}$	Angular velocity about roll axis
$\dot{\theta}$	Angular velocity about pitch axis
β	Angle made by L_1 with x_c
ψ	Rotation angle of reaction wheel
$\dot{\psi}$	Angular velocity of reaction wheel
R	Radius of Reactobot
τ_1	Drive torque for Reactobot
τ_2	Reaction wheel torque
r	Radius of reaction wheel

Estimation of Fretting Wear-Limited Life of a Shell and Tube Heat Exchanger Tubes: Analytical Formulation, Computer Implementation and Qualification Against Actual Reported Failure

Gajendra Vasantrao Patil, M. A. Dharap & R. I. K. Moorthy

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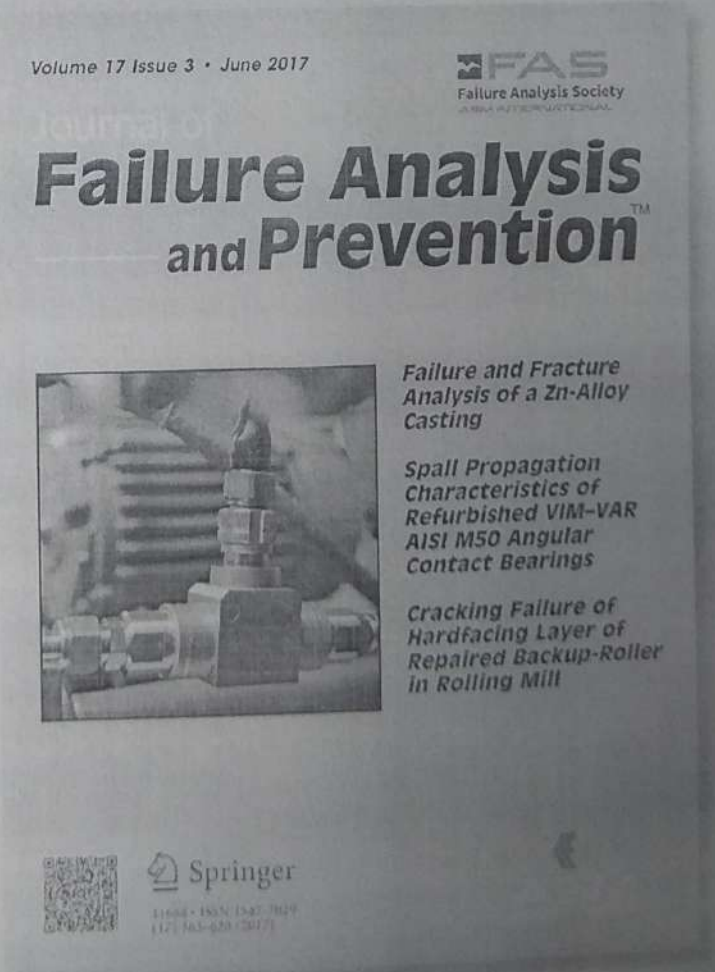

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REVIEW ON DESIGN AND OPTIMIZATION OF THRESHER IN CROP CUTTING MACHINE

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ABSTRACT

In the present paper, an effort has been taken to perform a literature review on the development in the mechanization of thresher in crop cutting machine. The harvesting incurs about 30% cost of total production. In India, considerable R & D work for design and development of agricultural implements and machinery for few operations have been developed. However, the adoption of these implements and machinery has not been up to the desired level. Thus there is a considerable mechanization gap. Research and records have produced data for many individual segments within a total harvesting system. However, to date, very few attempts have been made to numerically optimize the overall system. The different machines and their process parameters are studied and compared through the study.

Keywords: Crop Cutting, Design Optimization, Soya-bean crop, Thresher.

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1. INTRODUCTION

Mechanization in field of agriculture has been carried out promisingly; the due effect of the same can be seen in day to day life. With the explosion of population and limited resources it has become important to develop the system which is most efficient. The review of several countries around the globe has shown that United Nation leads the field of agriculture mechanization than its counterparts. Due to mechanization major impact has been observed in demand and supply for farm labour, profitability of farming. It has also brought considerable amount of changes in the rural landscape including rural communities. As far as foreign countries are concerned the adoption of mechanized farming is quiet easy with view of sustainability and adoption. Whereas in India the adoption of technology is quiet painful for

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Optimization of cutting parameters in Dry Turning of AISI A2 Tool Steel using Carbide Tool by Taguchi Based Fuzzy Logics

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Abstract-

AISI A2 tool steel is generally used for the machine tool parts, blades, punches and forging dies. This paper discusses the applications of Taguchi method with fuzzy logic to optimise the machining parameters for dry turning of AISI A2 tool steel using carbide inserts. Combined effects of the cutting parameters, namely cutting speed, feed rate, depth of cut and nose radius, on the surface roughness and cutting force components, were explored by analysis of variance (ANOVA) and optimization of process parameters were carried out by using fuzzy logic A Multi Response Performance Index (MRPI) was used for optimization. The relationship between the results shows that the overall process is mainly influenced by cutting speed and feed rate.

Selection and/or Peer-review under responsibility of 7th International Conference of Materials Processing and Characterization.

Keywords: AISI A2 tool steel, Taguchi Method, ANOVA, Dry Turning, fuzzy logic optimisation

1. Introduction

In today's competitive environment company can get maximum profit and good quality by selecting optimum parameters and knowledge of recent trends. The optimum performance from the process can be achieved when the all the control parameters which affects the process are selected properly and with prior analysis. This demands the study and analysis of the process parameters and finding out the optimal parameter setting which is used for carrying out the process effectively. The process parameter selection also involves the study of the internal and external elements of the process which may directly or indirectly affect the process. It is needed to make the process more robust and error free. In order to improve the performance of turning process, it is essential to optimize the process parameters, which will help in reducing cost while achieving the required geometrical tolerance.

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ABSTRACT

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Wireless Sensor Networks and the Internet of Things

Future Directions and Applications

Editors

Bhagirathi Nayak | Subhendu Kumar Pani | Tanupriya Choudhury

Suneeta Satpathy | Sachi Nandan Mohanty

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Title	Smart Navigational Shoe for Visually Impaired
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Author keywords	Navigation Android Smart Shoes Visually Impaired sensors
EasyChair keyphrases	smart shoe (80), blind person (70), ultrasonic sensor (70), visually impaired person (47), blind person path (47)
Abstract	Eyes play vital role in our day to day lives and are the most important gift we have. This world is visible to us because we are blessed with eyesight. But there are some people who don't have this ability of visualizing these things. Due to this, Visually impaired people face many challenges when moving in unknown public places. Wearable device should design for such visual impaired people. Smart shoes is wearable system design to provide directional information to visually impaired people. To provide smart and sensible navigation guidance to visually blind people, the system has great potential especially when integrated with visual processing units. During the operation, the user is supposed to wear the shoes. When sensors will detect any obstacle, user will be informed through Android system being used by the user. The Smart Shoes along with the application on the Android system shall help the user in moving around independently.
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Smart Navigational Shoe for Visually Impaired

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Abstract— Eyes play vital role in our day to day lives and are the most important gift we have. This world is visible to us because we are blessed with eyesight. But there are some people who don't have this ability of visualizing these things. Due to this, Visually impaired people face many challenges when moving in unknown public places. Wearable device should design for such visual impaired people. Smart shoes is wearable system design to provide directional information to visually impaired people.To provide smart and sensible navigation guidance to visually blind people, the system has great potential especially when integrated with visual processing units.During the operation,the user is supposed to wear the shoes. When sensors will detect any obstacle, user will be informed through Android system being used by the user. The Smart Shoes along with the application on the Android system shall help the user in moving around independently.

Keywords- Navigation, Android, Smart Shoes, Visually impaired, sensors

I. INTRODUCTION

A blind person basically uses an stick to move around and sense obstacles which are in front. But new smart shoes with android based navigation will help the blind person to manoeuvre easily without the need of stick. We will be using an micro-controller to process the data and the micro-controller needs to be small in size so we will be using the controller used in arduino series which is atmega 328. We will also be using an light & ultrasonic sensor for detection purpose Android is an open source and Linux-based Operating System for mobile devices such as smartphones and tablet computers. Android was developed by the Open Handset Alliance, led by Google, and other companies. Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android. The source code for Android is available under free and open source software licenses. Google publishes most of the code under the Apache License version 2.0 and the rest, Linux kernel changes, under the GNU General Public

https://ieeexplore.ieee.org/document/9457003

Digital Screening Tool to Detect Covid-19 Infected People

Publisher: IEEE Cite This PDF

Jagannath E. Nalavade All Authors

Abstract
Document Sections
I. Introduction
II. Problem Statement
III. Literature Review
IV. Proposed Method
V. Conclusion
Authors
Figures
References
Citations

Abstract:
Covid-19 pandemic is increasing day by day in world. Government agencies informing people to stay safe don't go outside, keep social distancing. Means we want to break chain of corona virus affected people. Till date there is no any automation tool is designed to detect Covid-19 patients. Such type of automation tool is required to detect patient at earlier stage (during first week of infection). If we detect Covid-19 patients in earlier stage and take required actions, we can save all patients. In this proposal we want to design automated digital screening tool to identify the people in the first week of the pandemic. Based on machine learning techniques, system will be trained as per the day to day symptoms. ASHA workers from Rural Health Centre can collect the all the peoples information related to Covid-19. By using Classification algorithm system will classify the people into different categories like healthy people (no any symptoms), first day of Covid-19, second day covid-19, upto fourteenth day of covid-19. Data set required for training the model will be created by studying covid-19 patients per day history. Like first day he had aches and pains, nasal congestion, runny nose, sore throat or diarrhea etc., related any symptoms. Similarly, we will prepare dataset of 5000 patients. Using this dataset model will be trained. After training the model whenever such type of pandemic occurs we will detect the infected people in early stage.We will reach to each of the citizen of India through social workers, ASHA worker, Rural Health care staff. Collect information of each person by using attributes which is decided for dataset. We will provide collected dataset (each citizen information) to our designed system. Designed system will classify according to classes mentioned above. If person don't have any symptoms related to Covid-19 means he is healthy. If he had any symptoms according to day we have classified then such type of people immediately informed and accord...

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Context-Aware Handover Analysis in Heterogenous Wireless Network Using Machine Learning

Divya Parambanchary & V. Malleswara Rao

Conference paper | First Online: 05 March 2021
Part of the Lecture Notes in Electrical Engineering book series (LNEE,volume 700)

Abstract

The speedy development of wireless access mechanisms offers the mobility management and better interoperability methods to accomplish the necessities of users. Nowadays, heterogeneous wireless networks construct a variety of networks of diverse types namely WiFi, WIMAX to offer the users the required signals. These networks are independent, and they differ comprehensively with respect to the service constraints namely, accessing delay, the

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A Whale Optimization Algorithm for Pollution Monitoring in WSN

Harshala Patil & Divya Chirayil

Conference paper | First Online: 05 March 2021

Part of the Lecture Notes in Electrical Engineering book series (LNEE,volume 700)

Abstract

Wireless sensor network's (WSN) primary concern is how to manage their restricted power resources. The efficiency of WSN depends heavily on its life span. As a consequence, several studies have drawn attention to dynamic power management methods to reduce energy use in sensor nodes after creation and network layout. Recently, there has been a powerful interest in using smart instruments, particularly whale optimization algorithm of neural networks in WSN's energy-efficient method. Because of their network lifetime, energy efficiency, throughput and overall stability, he dimensionality and forecasting of sensor data obtained from the outputs of artificial neural network algorithms can lead to reduced energy

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Developing a Sustainable and Economical Infrastructure for the Implementation of IoT in Agriculture

Akshayee Bharat Dhule, Divya Y. Chirayil & Suraj Pandharinath Takekar

Conference paper | First Online: 05 March 2021

Part of the Lecture Notes in Electrical Engineering book series (LNEE,volume 700)

Abstract

This paper acknowledges the importance of measuring the various environmental parameters and discusses the importance of IoT dashboards which will display the data graphically with the help of beautiful widgets. This paper also introduces IoT as an essential part that should be used in farm practices and not as a status symbol which only the rich farmers can afford on their farm. This paper is not restricted to a prototype but focuses on the development of a realistic IoT product which will find its way in every farmland owing to its importance, easy operation, and affordability.

Privacy-Preserving Outsourced Mining of D-Eclat Association Rules on Vertically Partitioned Databases

Publisher: IEEE

Suvarna Kisan Thakur ; Babita Bhagat ; Srijita Bhattacharjee **All Authors**

Abstract

Document Sections

I. Introduction

II. Literature Review

III. System Approach

IV. Results and Discussion

Abstract:

Association rule mining and frequent item set mining are extensively studied information analysis techniques for a number of programs. In this paper, we have highlighted privacy preserving mining on vertically partitioned databases. In such a state of affairs, information owners desire to research the association policies or frequent item sets from a collective dataset, and reveal as meager information concerning their delicate information as conceivable to different statistics owners and outsiders. To ensure information security, we outline an efficient homomorphic encryption scheme and a comfy assessment scheme. We then recommend a cloud-aided frequent item set mining answer which develops an association rule mining solution. Our answers are framed for outsourced databases that

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Publisher: IEEE

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Modified Particle Swarm Optimization with Scout Adaptation and a New Inertia Weight for Workflow Scheduling in Cloud Sector

P. Sanyasi Naidu, Babita Bhagat

Abstract:

One common problems of cloud computing is the job scheduling, where numerous jobs are processed on various machines. Each job comprises of a sequence of tasks that must be carried out in a given order, and each task has to be processed on a particular machine. The main issue is to schedule the tasks on the machines with reduced time consumption. Hence to solve the problems in job shop scheduling, this paper intends to propose a secure job scheduling algorithm for cloud environment by establishing a scout adaptation process in the Particle Swarm Optimization (PSO), represented here as Modified PSO with Scout Adaptation (MPSO-SA) algorithm with a new inertia weight. While assigning tasks to the machines, the

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Challenges and Opportunities in Extending Cloud with Fog Computing

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DOI: https://doi.org/10.14419/ijet.v7i4.39.23827

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Performance Analysis of Misuse Attack Data using Data Mining Classifiers

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Dr. Anitha Patil

M Srikanth Yadav

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PUBLISHED: 2018-12-09

Keywords: Intrusions, KDD Cup, Misuse, Neural Networks, Regression, Support vector Machines

ABSTRACT

A Real Time Healthcare Monitoring System Based on Open Source IoT and ANFIS

Mansi Subhedar ; Vrushali Jadhav ; Shashank Tekade ; Manish Prajapati All Authors

Abstract

Document Sections

I. Introduction

II. Literature Review

III. Design Methodology

IV. Result Analysis

V. Conclusion

Authors

Figures

References

Keywords

Metrics

Abstract:
Integrating the healthcare monitoring devices with various emerging technologies like wireless sensor networks and Internet of Things (IoT), has become a keen area of interest worldwide. The proposed system aims to develop a wearable wireless body sensor device integrating adaptive neural intelligence in the field of healthcare monitoring using IoT. Wireless body sensor units are able to detect behaviour of human body parameters and transmit them using various data analysis and transmission techniques. Adaptive Neural Fuzzy Inference System (ANFIS) would allow the system to prioritize the collected physiological parameters from the sensor nodes by itself, making it a smart healthcare monitoring system. The proposed model has been developed as a prototype of a real-time wearable e-healthcare monitoring system by integrating ANFIS and an open source IoT. The model consists of sensors that collects vital data from patient's body and then transmits using Wi-Fi to the Cloud service which can be accessed by any IoT platform (ThingSpeak) on central HUB. At central HUB, fuzzy logic converts raw data into linguistic variables which is trained in ANFIS to give priority to patients depending on the status of patient. This system results in providing a reliable, accurate and real time data of patients continuously, and transmits the prioritized data during emergency.

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I. Introduction

Healthcare has become one of India's largest sectors. The healthcare sector is growing at a brisk pace due to its strengthening coverage and services. Technological innovations and simplicity in healthcare domain is essential for human life since healthcare is a critical science to deal with. The main objective of patient monitoring system is to diagnose the health conditions of the patient and create an alert for the irregularities in conditions. Healthcare monitoring system always has the scope of development for maintaining the ease in usage. Improvement in such systems is possible by using current advanced technologies in different patient monitoring machines and equipments. Wearable health monitoring is an emerging technology for monitoring of vital body parameters continuously. In this pursuit, there are many e-healthcare devices developed employing various ideas and t

ir ambulance are being launched in India and other N wing demand of healthcare services during emergencies. A very challenging task in this research area, that has attached a lot of interest, is identifying the communication protocol and network architecture [1]. The Internet of Things (IoT) enhances the healthcare industry in many different ways which includes patient care and monitoring, equipment supplies, drug delivery and management, remote surgeries and to connect doctor with patients. A simple and efficient patient monitoring system that can continuously monitor the patient's

Keywords
Metrics

Emerging Technologies in Data Mining and Information Security pp 589-598 | Cite as

Analysing MPLS Performance by SDN

Authors Authors and affiliations

Snehal Patil ✉, Mansi S. Subhedar

Conference paper
First Online: 02 September 2018

Part of the Advances in Intelligent Systems and Computing book series (AISC, volume 814)

Abstract

Nowadays, MPLS has become the first choice for enterprises to connect remote branch offices as it offers several benefits to packet forwarding. MPLS-VPN combines the features of both overlay and peer-to-peer VPNs thus offering the most robust connectivity. However, MPLS-TE faces the problem of creating backup path immediately when the best path goes down or gets congested. At some point of time in near future, all IP networks will be converted into programmable networks. During this transition, there should be some sort of mechanism which will couple the MPLS network to software-defined networking (SDN). This paper analyses the performance of SDN when coupled with MPLS. By using some of the core features of SDN, MPLS performance is enhanced for the tunnel creation. It has been found that coupling SDN with MPLS offers better performance in terms of latency, response time and bandwidth utilization.

Keywords

Software-defined Networking (SDN) Tunnel Creation
Resource Reservation Protocol (RSVP) OpenFlow Label Edge Router (LERs)

These keywords were added by machine and not by the authors. This process is experimental and the keywords may be updated as the learning algorithm improves.

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Optimizing MPLS Tunnel Creation Performance by Using SDN

Authors Authors and affiliations

Snehal Patil, Mansi S. Subhedar

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Abstract

In today's world, many high-speed enterprise links are running on MPLS. For enterprises, it is not possible to migrate to SDN technology directly and smooth transition of MPLS networks onto SDN needs to be ensured. This paper aims at optimizing the MPLS performance by coupling it with SDN. SDN controller uses some features of MPLS-TE to read network statistics. Based on the input of OSPF extension headers, SDN will reroute the traffic whenever there is congestion. The controller is preprogrammed with flows written from OpenFlow Manager. Whenever there is some change in topology or network statistics, packet header will be modified as per the flows and it will be rerouted.

Keywords

MPLS VPN Traffic engineering Software-defined networking OpenFlow controller

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Pathological Brain Tumour Detection Using Ridgelet Transform and SVM

Authors Authors and affiliations

Patil Ankita ✉, Mansi Subhedar

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Abstract

The identification, detection and classification of brain MRI images into abnormal and healthful is a main pre-clinical step for patients. Standard classification is tedious, valuable, inimitable, and time consuming. Using simple imaging techniques, it is very difficult to have vision about the normal and tumour cell due to the similarities between them. The proposed brain tumour detection method employs ridgelet transform and SVM to identify malignant and benign tumour. In this work, gray level co-occurrence matrix (GLCM) based texture analysis of discrete ridgelet transform coefficients is carried out. SVM classifier is trained using textural features and intensity based features. Principal component analysis (PCA) method is used to lessen the number of features used. SVM outputs the classified image and helps for automated detection. Experimental results demonstrated the efficacy with respect to precision, sensitivity, specificity and accuracy for tumour detection.

Keywords

MRI Ridgelet transform GLCM SVM

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Chapter

Performance Analysis of Computer Aided Brain Tumour Detection using Framelet Transform and KNN

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Smart Apron Using Embroidered Textile Fractal Antenna for E-Health Monitoring System

Authors Authors and affiliations

Shruti Gite, Mansi Subhedar

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Abstract

The rapid advances in the wireless communication field have given a new dimension to antenna design. This paper is envisioned to design a wearable textile antenna for healthcare and medical applications. The proposed antenna is being embroidered on a polyester substrate using conductive stainless steel thread. The antenna is designed at operating frequency of 2.4 GHz (ISM band) used for industrial and medical field. The proposed antenna is embroidered using minkowski fractal design on the pocket of apron. It can be used by doctors and assists in hospitals for data exchange between hospitals, pharmacies, labs, clinicians and even patients. The apron can ensure doctors and healthcare authorities a continuous health monitoring and hence can be rightly termed as "Smart apron." The feasibility of the proposed wearable antenna in our venture has to be tempered with pragmatism. The proposed antenna is being designed using a full-wave electromagnetic simulation tool. Results are obtained in terms of VSWR, bandwidth, current distribution and radiation pattern. The work presented here has profound implications for integrating antennas into smart wearable clothing.

Keywords

Fractal geometry Minkowski fractal Smart apron Embroidered antenna ISM band

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Three Phase Fault Analysis and Tripping using Timer

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ABSTRACT*:* The project is designed to develop an automatic tripping mechanism for the three-phase supply system. The project output resets automatically after a brief interruption in the event temporary fault while it remains in tripped condition in case of permanent fault.The faults might be LG (Line to Ground), LL (Line to Line), 3L (Three lines) in the supply systems and these faults in three phase supply system can affect the power system. To overcome this problem a system is built, which can sense these faults and automatically disconnects the supply to avoid large scale damage to the control gears in the grid sub-stations.555 timers are used for handling short duration and long duration fault conditions.A set of switches are used to create the LL, LG and 3L fault in low voltage side, for activating the tripping mechanism. Short duration fault returns the supply to the load immediately called as temporary trip while long duration shall result in permanent trip.

KEYWORDS: Temporary fault; permanent fault; 555 timer

I. INTRODUCTION

In India it is common to observe the failures in supply system due to the faults that occur during the transmission or distribution. The faults might be LG (Line to Ground), LL (Line to Line), 3L (Three lines) in the supply systems and these faults in three phase supply system can affect the power system. To overcome this problem a system is built, which can sense these faults and automatically disconnects the supply to avoid large scale damage to the control gears in the grid sub-stations.

This system is built using three single phase transformers which are wired in star input and star output, and 3 transformers are connected in delta connections, having input 220 volt and output at 12 volt. C.Nagarajan et al [2,4,6] have developed the concept low voltage testing of fault conditions is followed as it is not advisable to create on mains line. 555 timers are used for handling short duration and long duration fault conditions.

A set of switches are used to create the LL, LG and 3L fault in low voltage side, for activating the tripping mechanism. Short duration fault returns the supply to the load immediately called as temporary trip while long duration shall result in permanent trip. The concept in the future can be extended to developing a mechanism to send message to the authorities via SMS by interfacing a GSM modem.

Auto reset means the systems get restart after fault clearing automatically itself it does not require to start it manually. Auto reset is happened when fault is of temporary fault i.e. the system detect fault is of for lower time i.e. temporary fault means loads get automatically off when fault occurs and automatically after fault clearing process is called as Auto Reset.

Permanent trip means, we have to start the system after fault clearing process manually. In this prototype model this permanent trip is happened when fault is of permanent fault i.e system detect fault is of for higher time .Here loads get

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automatically off when fault occurs and after fault clearing process load will not get automatically thus we have to restart the system manually is called as Permanent trip.

Temporary fault is nothing but the fault which occurs for the small duration, which causes disturbance in the power system for small duration, and clear after some time and resets the system automatically .

II. DESIGN METHODOLOGY

The modern power system is very big and there many chances of fault occurrence on the power system. In order to protect the power system we have to take precaution means by using protecting devices such as fuses, circuit breaker, relays and other fault detector. Because of use of this type of devices we can protect power system from fault and avoid damage to it. For such protection there are various types of devices available in the market, we have to choose the correct equipment and apply it as per rating required.

Functional Block Diagram

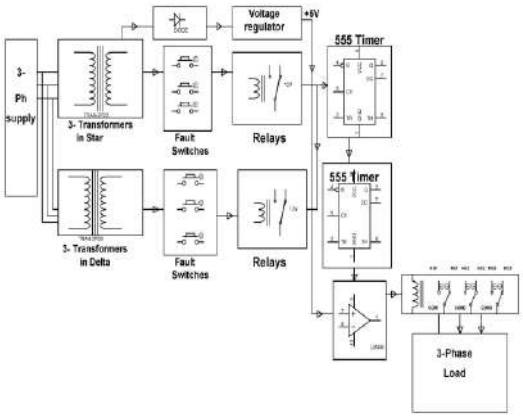

Fig 1: Functional block diagram

The above shown diagram shows the functional block diagram of prototype model which is used for the fault clearing process. The model uses 6numbers step-down transformers for handling the entire circuit under low voltage conditions of 12v only to test the 3 phase fault analysis. The primaries of 3 transformers are connected to a 3 phase supply in star configuration, while the secondary of the same is also connected in star configuration. The other set of 3 transformers with its primary connected in star to 3 phases have their secondaries connected in delta configuration. The outputs of all the 6 transformers are rectified and filtered individually and are given to 6 relay coils. 6 push buttons, one each connected across the relay coil is meant to create a fault condition either at star i.e. LL Fault or 3L Fault. The NC contacts of all the relays are made parallel while all the common points are grounded. The parallel connected point of NC are given to pin2 through a resistor R5 to a 555 timer i.e. wired in monostable mode. The output of the same timer is connected to the reset pin 4 of another 555 timer wired in astable mode. LED'S are connected at their output to indicate their status. The output of the U2 555 timer from pin3 is given to an Op-amp LM358 through wire 11 and d12 to the non-inverting input pin3, while the inverting input is kept at a fixed voltage by a potential divider RV2. The voltage at pin2 coming from the potential divider is so held that it is higher than the pin3 of the Op-amp used as a comparator so that pin1 develops zero logic that fails to operate the relay through thedriver transistor Q1. This relay Q1 is '3CO' relay i.e. is meant for disconnecting the load to indicate fault conditions.

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Operating Procedure

Turn the preset fully anticlockwise and connect the 6 transformers to the board, all the 6 relay LED, power supply LED, 3 phase relay LED shall be glowing. After that observe that the LED of both 555 timer shall be in off position. Turn the preset slowly clockwise notice that 3 c/o relay LED goes off that completes the setting procedure and the model is ready for use. While the board is powered from a 3phase supply all the 6 relay coils get DC voltage and their common point disconnects from the NC and moves on to the NO points there by providing logic high at pin2 of 555 timer U1 i.e. that is kept on monostable mode. While any push button across the relay is pressed it disconnects that relay and in the process in common contacts moves to the NC position to provide a logic low at trigger pin of 555 timer to develop an output that brings the U2 555 timer which is used in astable mode for its reset pin to high such that the astable operation takes place at its output which is also indicated by flashing D11 LED. If the fault is off temporary in nature i.e. if the push button pressed is released immediately the U1 monostable disables U2 the output of which goes to zero in the event of any push button kept pressed for a longer duration the monostable output provides a longer duration active situation for U2 the astable timer the output of which charges capacitor C13 through R11 such that the output of the comparator goes high that drives the relay to switch off three phase load. The output of Op-amp remains high indefinitely through a positive feedback provided for its pin1 to pin3 through a forward biased diode and a resistor in series. This results in the relay permanently switched on to disconnect the load connected at its NC contacts permanently off. In order to maintain the flow of DC supply the star connected secondary set DC'S are paralleled through D8, D9 & D10 for uninterrupted supply to the circuit voltage of 12V DC and 5V DC derived out of voltage regulator IC 7805.

Temporary Fault Clearing Process

Turn the preset fully anticlockwise and connect the 6 transformers to the board, all the 6 relay LED, power supply LED, 3 c/o relay LED shall be glowing. After that observe that the LED of both 555 timer shall be in off position. Turn the preset slowly clockwise notice that 3 c/o relay LED goes off that completes the setting procedure and the model is ready for use. While the board is powered from a 3phase supply all the 6 relay coils get DC voltage and their common point disconnects from the NC and moves on to the NO points there by providing logic high at pin2 of 555 timer U1 i.e. that is kept on monostable mode. While any push button across the relay is pressed it disconnects that relay and in the process in common contacts moves to the NC position to provide a logic low at trigger pin of 555 timer to develop an output that brings the U2 555 timer which is used in astable mode for its reset pin to high such that the astable operation takes place at its output which is also indicated by flashing D11 LED. If the fault is off temporary in nature i.e. if the push button pressed is released immediately the U1 monostable disables U2 the output of which goes to zero. In this condition the output of U1 monostable 555 timer is directly applied across the 3 c/o relay coil which switches off the load and when the switch is released the load gets on automatically means "Auto Reset" on temporary fault.

Permanent Fault Clearing Process

Turn the preset fully anticlockwise and connect the 6 transformers to the board, all the 6 relay LED, power supply LED, 3 c/o relay LED shall be glowing. After that observe that the LED of both 555 timer shall be in off position. Turn the preset slowly clockwise notice that 3 c/o relay LED goes off that completes the setting procedure and the model is ready for use. While the board is powered from a 3phase supply all the 6 relay coils get DC voltage and their common point disconnects from the NC and moves on to the NO points there by providing logic high at pin2 of 555 timer U1 i.e. that is kept on monostable mode. While any push button across the relay is pressed it disconnects that relay and in the process in common contacts moves to the NC position to provide a logic low at trigger pin of 555 timer to develop an output that brings the U2 555 timer which is used in astable mode for its reset pin to high such that the astable operation takes place at its output which is also indicated by flashing D11 LED. If the fault is off temporary in nature i.e. if the push button pressed is released immediately the U1 monostable disables U2 the output of which goes to zero in the event of any push button kept pressed for a longer duration the monostable output provides a longer duration active situation for U2 the astable timer the output of which charges capacitor C13 through R11 such that the output of the comparator goes high that drives the relay to switch off three phase load. The output of Op-amp remains high indefinitely through a positive feedback provided for its pin1 to pin3 through a forward biased diode and a resistor in

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series. These results in the relay permanently switched on to disconnect the load connected at its NC contacts permanently off, this are called as permanent trip. After this permanent trip we have to shut down the whole system and restart the system.

Power Circuit diagram

In power circuit diagram of fault clearing prototype. uses 6 numbers step-down transformers for handling the entire circuit under low voltage conditions of 12V only to test the 3 phase fault analysis. The primary of 3 transformers is connected to a 3-phase supply in star configuration, while the secondary of the same is also connected in star configuration. The other set of 3 transformers with its primary connected in star to 3 phases have their secondary connected in delta configuration. The output of all the 6 transformers is rectified and filtered individually and is given to 6 relay coils. 6 push buttons, one each connected across the relay coil is meant to create a fault condition either at star i.e. LL Fault or 3L Fault. The NC contacts of all the relays are made parallel while all the common points are grounded. The parallel connected point of NC is given to pin2 through a resistor R5 to a 555 timer i.e. wired in monostable mode. In the control circuit diagram of fault clearing prototype which uses two 555 IC, one in monostable mode and second in astable mode. The output of the same timer is connected to the reset pin 4 of another 555 timer wired in astable mode. LED'S are connected at their output to indicate their status. The output of the U2 555 timer from pin3 is given to an Op-amp LM358 through wire 11 and d12 to the non-inverting input pin3, while the inverting input is kept at a fixed voltage by a potential divider RV2. The voltage at pin2 coming from the potential divider is so held that it is higher than the pin3 of the Op-amp used as a comparator so that pin1 develops zero logic that fails to operate the relay through the driver transistor Q1. This relay Q1 is '3 contacts (3CO) relay i.e. is meant for disconnecting the load to indicate fault conditions. Result

Continuity test: In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open". Devices that can be used to perform continuity tests include mustimeters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows. An important application is the continuity test of a bundle of wires so as to find the two ends belonging to a particular one of these wires; there will be a negligible resistance between the "right" ends, and only between the "right" ends. The test is performed just after hardware soldering and configuration has been completed. This test aims at finding any electrical opening paths in the circuit after the soldering. Many time's the electrical continuity in the circuit is lost due to improper soldering wrong and rough handling of PCB improper usage of soldering component failures and presence of bugs in the circuit diagrams. we connect both the terminals across path that needs to be checked. If there is continuation then it will appear beep sound.

Power on Test:

This test is performed to check whether the voltage at different terminals is according to requirement or not. We take a multimeter and put it in voltage mode. Remember that this test is performed without microcontroller. Firstly, we check the output of the transformer whether we get the required 12v AC voltage Then we apply this voltage to the power supply circuit. Note that we do this test without microcontroller because if there is any excessive voltage, this may lead to damping the controller. We check for the input to voltage regulator. In this way we can ensure that voltage al all terminals is as per the requirement.

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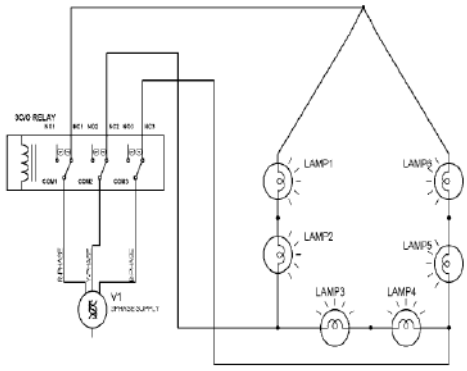

Fig:2. Load connections

Load Connection:

The above diagram shows the connection of 3 co relay connected to load i.e. 6 lamps which were connected in series with each other. Each lamp has rating of 250V,15W and the relay i.e. 3co relay used which is having 11 terminals which consists of 3 NC contacts, 3 NO contacts, 3 common points and 2 & 10 terminals are used as coil for the operation of relay. In this chapter we have seen that the information regarding to the prototype and its power circuit diagram, control circuit diagram and load connected to 3 co relay diagram explanation and its working and basic information, functions and characteristics about the components used in this prototype.

III. CONCLUSION

This project is designed in the form of Hardware for three single phase transformers 230v to 12V of output for to develop an automatic tripping mechanism for the three phase supply system while temporary fault and permanent fault occurs. Here we used 555 timer with relay for the fault is temporary or permanent. Short duration fault returns the supply to the load immediately called as temporary trip while long duration shall result in permanent trip.

IV. FUTURE SCOPE

The model output resets automatically after a brief interruption in the event of temporary fault while it remains in tripped condition in case of permanent fault. By incorporating sensors and microcontrollers we can make this system more advances. Because of this addition of microcontrollers and sensors the system will analyse fault very early and clear early. In future the prototype model can be develop with a mechanism when fault occur it will send a message to the authorities via SMS by interfacing a GSM modem and it will play important role in power system as reliable protection system. In future there can be more advancement in three phase fault analysis system like [1] GPRS based network used for tracking transformers [2] A mechanism to send message to authorities via SMS by interfacing GSM modem [3] Improvement to human machine interface [4] Long distance Data transmission.

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DESIGN AND IMPLEMENTATION OF MOBENSIC TOOL TO AID MOBILE FORENSICS

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Abstract
Mobile phones have become an integral part of our daily lives. Today it is difficult to think of a life without a mobile phone because it is not only a phone but also a calculator, camera, computer, email, a storehouse of information, PlayStation and a music system too. But the advancement of mobile has led to a subsequent increase in the rate of cyber crimes through mobiles. Mobile forensics is used to detect and analyze any malicious activity that might have been performed using the device. Our objective is to help reduce the criminal activities by creating a toolkit to aid mobile forensics for android devices. Currently, there is no single compiled tool available to perform mobile forensics, hence we propose to design a toolkit for the same. The process of mobile forensics includes three major steps, image acquisition, data extraction and data analysis. The toolkit will help to create an image of the entire device, extract deleted and hidden files and perform analysis of video, audio and multimedia files.
Keywords: Android Live Imaging, Android Debug Bridge, Kali Linux, Mobile Forensics, Rooting, Forensic Toolkit Imager, Autopsy.

I. INTRODUCTION

Digital Forensics is the process of uncovering and interpreting electronic data. The goal of the process is to preserve any evidence in its most original form while performing a structured investigation by collecting, identifying and validating the digital information for the purpose of reconstructing past events.
The context is most often for usage of data in a court of law, though digital forensics can be used in other instances.
The term "forensics" implies that digital forensics is used to recover evidence to be used in the court of law against some offender. This is very useful to detect corporate frauds, perhaps an employee stole a valuable data or even for the analysis of mobiles recovered at a crime site. The contents of the device, like chats, images etc. can be used to provide evidence against such crimes.

Mobile forensics is a branch of digital forensics which deals with the recovery of digital evidence or data from a mobile device under forensically sound conditions. The use of mobile phones/devices in crime has widely increased for few years, but the forensic study of mobile devices is a new field, from the early 2000s. There are various challenges that are faced while recovering data from mobile due to many reasons. To remain competitive the manufacturers change the original equipment file structures, data storage etc. and hence forensics examiner has to find out alternative ways than used in computer forensics. The storage capacity of devices grows continuously. These are some of the challenges faced in mobile forensics.

Kali Linux is a Debian-derived Open Source L inux distribution designed for digital forensics and p enetration testing. It is maintained and funded by O ffensive Security Ltd. Kali has more than 600 penetration testing tools along with multi-language support. The Kali Linux operating system is completely customizable all the way down to the kernel and is developed in a secure environment. It is specifically tailored to the needs of penetration testing professionals, thus providing a secure environment to carry out various forensic activities.

Android is a mobile-based operating system developed and maintained by Google. It is based on modified version of the Linux operating system and other open source software. Android is available for devices such as smartphones and tablets. Google has also developed Android TV for television and Android Wear for wrist watches. There are various versions of Android available ranging from earliest Gingerbread (2.3) to the latest Oreo (8.0).

II. LITERATURE SURVEY

In paper[1] The Author gives us a tool to extract data from memory card and analysis of WhatsApp application installed on the memory card from different models of mobile phone. There are many mobile forensics tools that can retrieve information from both internal and external memory. Because of the complexity of using different forensics tools and processing time, there is a requirement of one tool that automates the process. The methods followed are File Extraction, File Recovering, File Converting and Decrypting and Reporting and GUI.

In File Extraction, the input to the tool is disk image file and OS relevant file categories will be extracted like pictures, video, audio, and documents.

In File Recovering process the deleted files are extracted and recovered files are sorted in various categories.

In File Converting and Decrypting the audio, video, thumb files containing pictures and additional information and WhatsApp databases are decrypted into a readable format. The last method which is Reporting and GUI offer UI and final report to the investigator.

In paper[2] the author proposes a solution to the anti-forensic technique of steganography by designing and developing an application that will detect the presence of stegno data within the Android device and then perform logical data acquisition of images, audio, and videos. The application proposed by the author that is Mobile forensic Analyser is developed with the hash function and buttons like extract and report. The analysis of stegno data will be in png, mp3, mp4. The tool is also used for detecting hidden data on an image, audio, video. It maintains the integrity of data by using strong tools like hash.

The authors of the paper[3] have proposed file signature analysis which is used to detect if the file extension has tampered or not. The two methods used by them are multimedia file signature acquisition in which they have extracted and compared multimedia file signature of different mobile phones using hex editor, whereas in second method that contents inspection there are two steps the first step is similar to the above and the second step is to compare content and metadata of original and amended multimedia files in order to detect changes. The results obtained by the authors after smartphone multimedia file signature analysis on camera images examined has a file extension .jpg. The camera videos file extension observed are .mp4 (Samsung, Blackberry, Lenovo, Nokia) and .mov. The audio file extensions examined are .wav(Samsung, Nokia), m4a(iPhone) and .amr(Blackberry and Lenovo). The results obtained after content examination for camera images/videos/audio contains metadata which has information such as a timestamp(creation time and date) and company name (manufacturer name, device name, OS).

The content examination of application video obtained multimedia files extracted from WhatsApp have different file extension such as .jpg, .mp4, .mov etc.

III. EXISTING SYSTEM

Mobile forensic is a vast field with a lot of exploration that needs to be performed. The number of mobile phones keeps on increasing day by day with newer versions of a certain phone being released biannually. This has led to an increase of data being produced in a day, this has, in turn, led to increasing of cybercrime at an alarming rate ultimately resulting in a high demand for a complete mobile forensic tool. Currently, there are some tools available for performing image creation process like FTK Imager and for analysis of the created image like Autopsy.

FTK Imager is a Forensic Toolkit Imager w hich is distributed by AccessData used for forensic imaging. It is a commercial software package. FTK Imager is often used for creating images of disks and portable devices**.** T his image is stored as a single file or as segments that may later be reconstructed to obtain the full disk image. It offers MD5 hash calculation and hence confirms the integrity of the data. The resulting image file can be saved in several formats including the DD raw format.

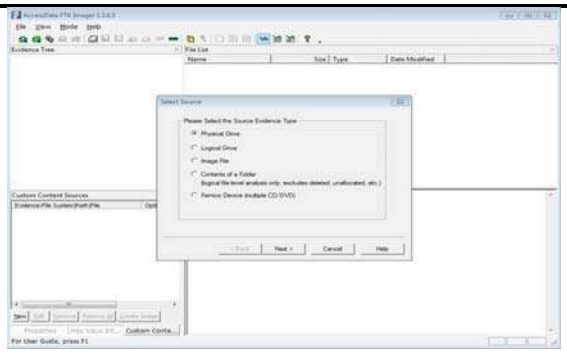

Fig. 1. Forensic toolkit Imager.

An autopsy is a computer software that is used for the forensic analysis process, making it easier for the investigators to carry out their analysis in a secure and efficient manner. This tool is designed with three principles in mind: extensible, framework and ease of use. Extensibility states that the user should be able to add new functionality that can analyze the underlying data source. Frameworks offer standard approaches for investigation, analysis, and reporting. Ease of use makes it easier for users to repeat their steps without reconfiguration.

To initiate the process of analysis we provide the image of the concerned device to the tool in formats such as dd, raw etc. The autopsy software then begins the analysis process, segregating the files on the image into various suitable formats such as documents, multimedia, deleted as well as emails etc. The autopsy GUI provides a simple way to access, analyze and extract the files that are required by the forensic expert.

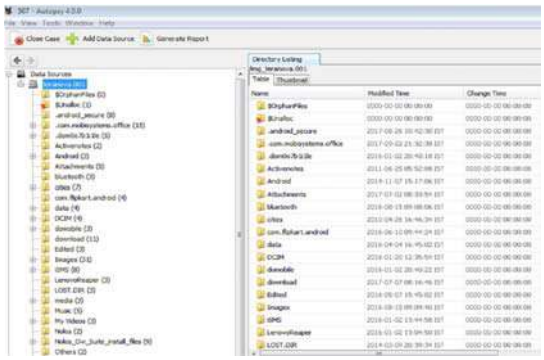

Fig. 2. Autopsy.

Thus we observe that even when we have such tools available for forensic analysis in the market, these do not provide a complete tool to carry out the process of forensic analysis. Each tool provides the functionality to perform one part of the complete task. Hence we propose a complete mobile forensic analysis toolkit called as **Mobensic**. This will help us in performing the various tasks of image creation and data analysis in one platform itself.

IV. PROPOSED SYSTEM

As we have observed that from the existing tools available for mobile forensics the procedure to get all the usable information from the internal memory of the mobile phone is a time-consuming process. There is a need for developing a single tool that simplifies the forensic process. So we propose to design a single toolkit to aid mobile forensics and simplify the investigation of internal memory of the mobile phone. The important thing is that with the help of new toolkit digital investigators can start with the investigation without searching all kinds of tools. Proposed tool will be user-friendly, simple and time-saving. The Mobensic tool works in the Kali Linux environment. The entire process from image creation to the analysis and report generation will be provided by a single tool which will make the process of collecting evidence from the mobile phone much easier.

Figure (a), gives the architecture of our proposed **Mobensic Tool.** It includes the process of creating an image of the mobile device, extracting the required data from the created image and finally performing analysis on the data extracted. Once the data analysis is completed, a detailed report of the entire forensic process is generated for the expert to view.

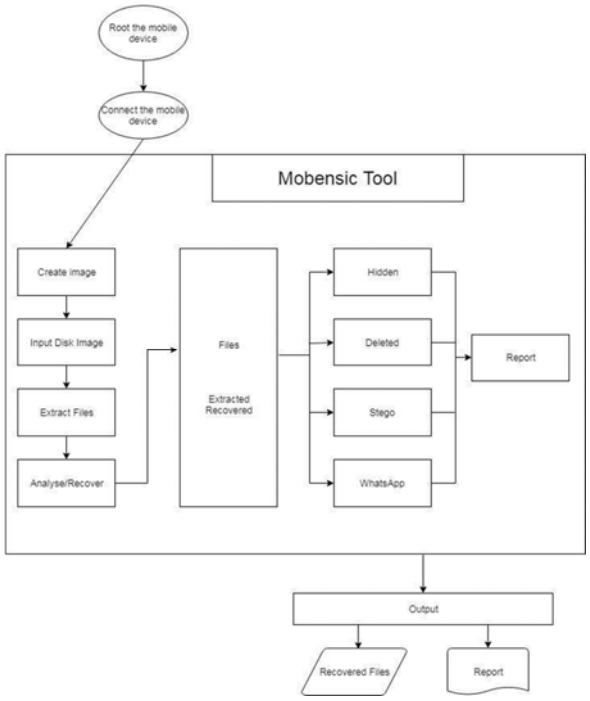

Fig. 1. The architecture of Proposed System.

1. Rooting the device:

The process of rooting allows the user of smartphones, tablets and other devices running on the Android operating system to gain root access to the android subsystems. The Android operating system uses the Linux kernel and hence rooting gives similar administrative permissions as on Linux or any other Unix like operating system.

For the designing of Mobensic toolkit, a Moto G 3rd Generation device running on Android OS version 6.0.1 was used. For the Moto G 3rd generation device, first, unlock the bootloader on the device(if locked) and install the necessary device drivers. Next, install ADB and Fastboot tools along with the latest version of SuperuserSu and TWRP manager.Now make use of the necessary drivers and tools to root the device and attain administrative(Superuser) access.

However, the rooting process may not be the same for each and every device. It may vary depending on the device in consideration as well as the Android OS running on the device.

2. Image creation

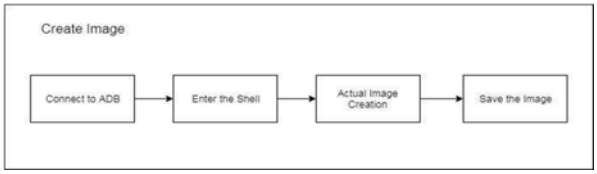

Fig. 2. Internal working of Image creation.

Figure 2, further elaborates the image creation module from the proposed architecture. To create an image of the mobile device, very first step is to activate the write blocker function. Write blocker is a function that will disable all the write access rights on the device, making sure that the device and its contents have not been tampered with. A write blocker will help the forensic expert to prove that the device and its contents have not been manipulated, which is a very important aspect in the court of law to use a mobile device as a proof. After write blocker has been activated, the forensic expert now connects the device to the toolkit using Android Debug Bridge (ADB). The user now enters the ADB Shell. In the shell, perform the actual function of creating the image using Android live Imaging process. This process creates a complete image of the internal memory of the device. The image is then saved for further analysis.

3. Data extraction

Once the image of the entire device has been created, move towards extraction of data from the image. The data extracted is stored in a folder format for easy retrieval and analysis. Mobensic tool will be able to extract the hidden files from, stegno data files, deleted files and also the WhatsApp conversation details from the device.

4. *D ata analysis and Reporting*

After performing the action of data extraction, the expert will need to analyze the data extracted. This will be done in the data analysis and the reporting module of the tool. The forensic expert will be able to classify and analyze the data into different formats like Whats App data, stegno data, multimedia files, and Documents.
The toolkit will further also generate a report on the data that is extracted and classified.

V. RESULTS ACHIEVED

In this section, we deploy our Mobensic tool for analysis and testing. It is difficult to build one tool that can perform all Forensic process as mentioned in section III. This Mobensic tool can simplify the process by integrating all Forensic steps in one single tool.In this section, we test Mobensic tool by analyzing internal memory of mobile devices.

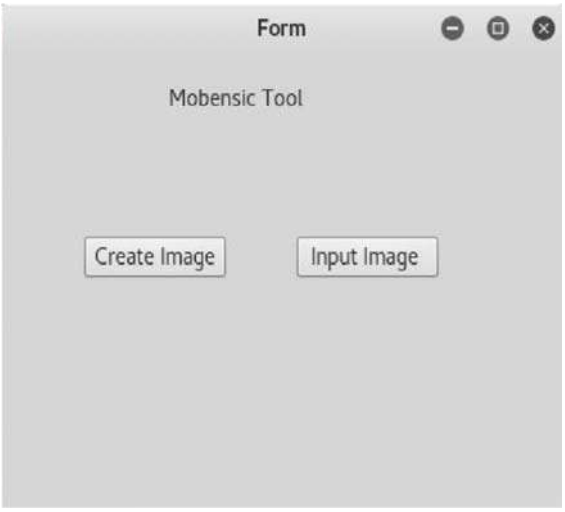

Fig. 1. GUI for Mobensic Tool.

The toolkit provides two options one is to create an image of the internal memory of the mobile device or to directly input the image of the mobile device. In creating image option the image of the mobile device connected is created and stored on your machine whereas in input image option the image of the device is loaded for further analysis.

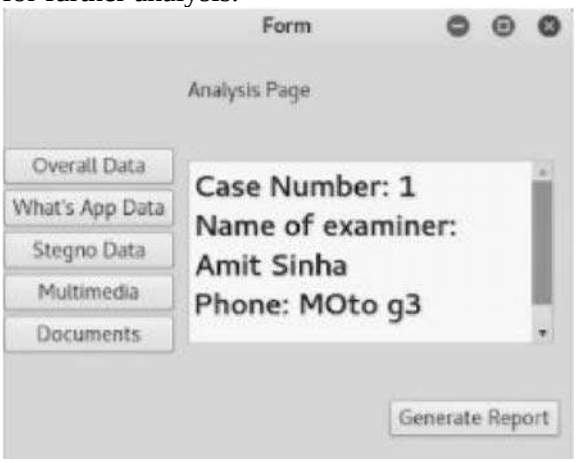

Fig. 2. Analysis screen for Mobensic Tool.

The figure 2 above shows the analysis screen where the input image is analyzed and the data which is recorded is classified as Whatsapp data, Stegno data, Multimedia, Documents. The toolkit also provides a report generation option for a summary of all the extracted data. Now from this, the user can click on any of the options to view and analyze the various data extracted.

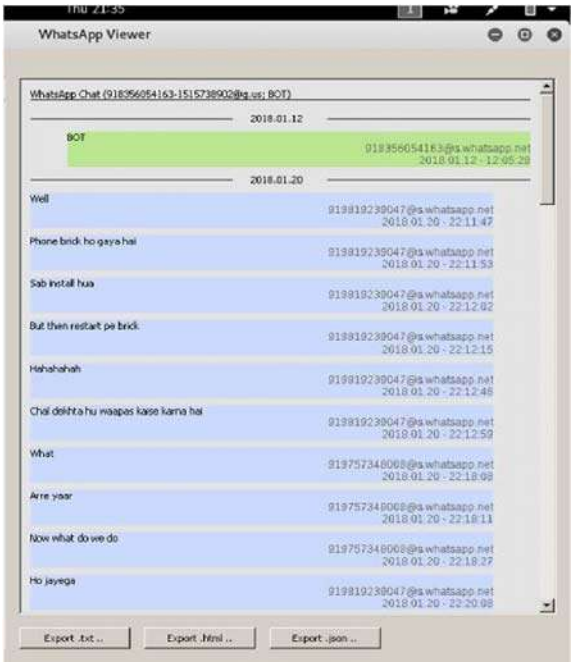

Fig. 3.Whatsapp Viewer.

The above figure 3 shows Whatsapp Viewer which display the Whatsapp chats which were recovered during the analysis phase. When the user clicks on "WhatsApp data" option the conversations stored in the mobile device are displayed to the user.

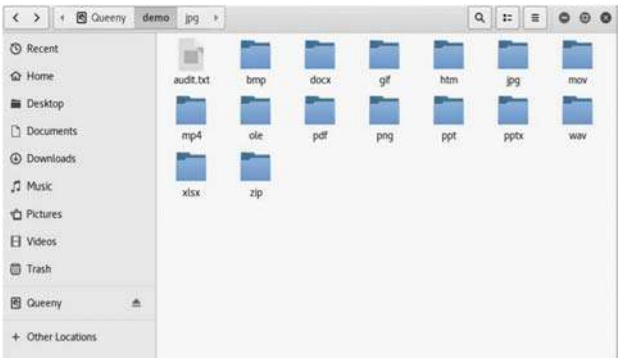

Fig. 4.Data Recovered

Figure 4 above shows the classification output in the extraction of the data from the image of the device. Once the user clicks on the "Overall data" option, the tool gives a complete view of the various sub-folders containing data like jpg files, png files, pdf files, text files etc. which have been recovered in the extraction module.

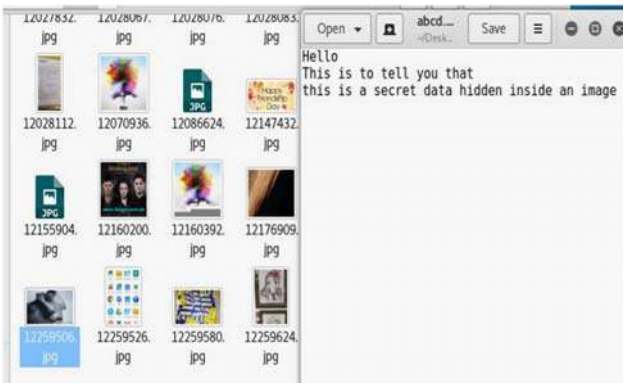

Fig. 5.Stegno Image.

The figure 5 above depicts an example of the stegno image that has been extracted using the Mobensic tool. When the user clicks on “Stegno data” option, the stegno image stored in the mobile device along with its hidden text is recovered by the tool and displayed to the expert.

VI. CONCLUSION

In the past decade, advancement in technology has made us more and more dependent on our mobile devices for day to day activities. This in turn has led to an increase in the number of frauds and malicious activities being performed with the help of the mobile phones. A tool like ours

can help in analyzing the matter and further reach conclusions. Mobensic tool can be used in a vast frame of applications like,

- Military intelligence
- Corporate investigations
- Private investigations
- Criminal and civil defense
- Electronic discovery

In future, the Mobensic tool can be further be enhanced to extract and analyze Call Logs, Contact Information, text messages, and Email. Further, the toolkit can also be available for other operating systems like iOS. The rooting process can also be incorporated into the toolkit, making the process even easier for the forensic expert.

VII. ACKNOWLEDGMENT

We would like to take this opportunity to express our profound gratitude and deep regard to Prof. Dr. Madhumita Chatterjee for her guidance and constant encouragement throughout the course of this project. We are immensely obliged for her cordial support, supervision and providing necessary information.

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WOA-NN: a decision algorithm for vertical handover in heterogeneous networks

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Abstract
The heterogeneous network of a 4th generation not always support better communication and mobility between the Wireless Access Networks. Hence, the vertical handoff is highly necessitated. This paper establishes vertical handover, which is context-aware in a heterogeneous environment with WiMax and WiFi. Successful handover results with the better determination of handover points. So, an Artificial Neural Network-based network model to understand the network characteristics is firstly developed. Under simulated environment, the Received Signal Strength (RSS) of the heterogeneous network is observed to construct the training library. The trained network predicts RSS for resolving the handover points in the heterogeneous network. To ensure precise learning of the neural network about the RSS network characteristics, a renowned Whale Optimization Algorithm (WOA) is developed. The performance of WOA-NN model is compared with the conventional Levenberg–Marquardt-Neural Network, Fire Fly-Neural Network, Particle Swarm Optimization-Neural Network and Grey Wolf Optimization-Neural Network through throughput, handover, predicted RSS and Mean Absolute Error analyses. The predicted RSS of the proposed WOA-NN-based network model seems nearly closer to the actual model, attaining effective handoff.

Keywords Heterogeneous network · WiFi · WiMax · Vertical handover · RSS

1 Introduction

The prompt and extensive development of broadband Wireless Networks (WNs) has ultimately evaluated the expectation of countless multimedia services, especially in the mobile environments. While supporting the multimedia applications, the major requirement is the effective managing of network resources. The resources fall gradually, if many users request the same multimedia applications or data such as, movies, sports, news, etc., necessitating point-to-point channel for each and every user [1]. This need for cost-effective resources for multimedia data delivery has focused the standardization group towards providing care on widespread broadcast and multicast services [2, 3].

Worldwide Interoperability for Microwave Access (WiMAX) is a communication network, which is based on the IEEE 802.16 standard. It promises outstanding wireless access for the mobile handlers with high Quality of Service (QoS). In fact, the WiMAX Forum promotes WiMAX by certifying interoperability and conformity [4]. Further, some other communication networks such as, the Third Generation Partnership Project (3GPP), 3GPP2 and IEEE 802.11 Wireless Local Area Network (WLAN) have also been developed to support the inefficient wide broadcast and multicast services. While implementing any mobile network, a Handover (HO) scheme [5–8] is quite important, as it imparts uninterrupted communication session during the user's movement from one place to another.

HO handles [9–11] the user's switch from one Base Station (BS) [12] to another, on the basis of the cost of service, speed, quality and availability provided by the

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network. In addition, the HO process [13–18] is not only dedicated to a single network. It has wide usage in heterogeneous networks as well. For example, interworking among 3GPP as well as WiMAX/WLAN networks [19, 20] is more attractive, since the 3GPP network has its own complementary nature. This kind of integrated heterogeneous wireless network architecture is remarked as beyond 3G (B3G) or Fourth-Generation (4G) network [21]. If the user prefers switching from one wireless network to the other, then it is referred to as heterogeneous HO. In a sense, a fast moving person launches an online video chatting application over a WiMAX network and performs HO to 3GPP wireless network [22]. This handover must be on the basis of certain qualities like, speed, cost, etc. to guarantee less access cost and QoS. However, user switching from one network to the other network is not so simple because certain criteria like, good service coverage, consolidated billing and lower cost must be satisfied. Along with this, the network must resist many renowned attacks that threaten the network. One of the important aspects to be mainly considered is the authentication of participated users. Numerous handover authentication schemes have been evaluated and are still being introduced to meet the security requirements of the communication networks. Yet, many obstacles (such as, the handover delay, latency and computational overhead) remain, while HO is carried out. Hence, it is crucial to develop an efficient handover authentication scheme.

Contribution:

- The paper develops vertical handover in a heterogeneous network with WiMax and WiFi, using the WOA-NN method.
- The paper validates the effectiveness of the handoff by measuring the RSS.
- The paper compares the performance of the WOA-NN model with the conventional LM-NN, FF-NN, PSO-NN and GWO-NN models.

The rest of the paper is organized as follows: Sect. 2 portrays the literature review and problem definition. Section 3 illustrates the modeling of a heterogeneous network. Section 4 depicts the proposed handover decision algorithm. Section 5 describes the simulation results and Sect. 6 concludes the paper.

2 Literature review

2.1 Handover basis

In 2016, Abhijit et al. [23] have proposed a handover decision methodology for the Heterogeneous Network (HetNet), which was integrated using Wifi and Wimax. It highly maintained both the user requirements of Quality of experience as well as Quality of service. The HetNet was a major concept of the next-generation wireless architecture, in which several technologies could coexist. Here, the user must have the possibility to select the desired connectivity, as per the current situation. The IEEE 802.11 and IEEE 802.16 were the initial building schemes for the HetNet. The authors have reviewed the conventional literature and understood the interoperability among the technologies. They found the defects in the effective utilization of the techniques. The proposed mechanism solved the problem and that was proved by analyzing the results of the simulation.

In 2012, Fu et al. [24] have proposed a handover authentication scheme for the WiMax network, which was a group-based scheme. The processes involved the understanding of the time of movement of the initial Mobile Station (MS) of the group to the target Base Station (BS) from the service BS and the time of transfer of all people's security context from the service BS to the target BS. Hence, the remaining MS in the group bypassed a protocol, named Extensible Authentication Protocol (EAP), and allowed the security context transmit phase to perform the authentication immediately. Therefore, the scheme ultimately minimized the latency of handover. Further, the proposed method achieved better privacy preservation.

In 2013, Ben-Mubarak et al. [25] have proposed a self-adaptive handover, which was based on fuzzy logic (Fuz-SAHO). The proposed protocol overcame issues like, handover delay and handover ping-pong. The proposed algorithm initially self-adapted the parameters of handover, which were on the basis of multiple criteria such as, Mobile Station (MS) and Received Signal Strength Indicator (RSSI) velocity. Using the values of handover parameter, the handover decision was executed. The results showed that the proposed algorithm could reduce the handover ping-pong as well as the handover delay.

2.2 Authentication basis

In 2012, Nguyen and Ma [26] proposed an enhanced EAP-based pre-authentication scheme (EEP), which resisted all vulnerabilities like, the long delay in consuming time, which was considered as the renowned pitfall of the IEEE 802.16 handover method. The pitfall might disrupt, if the mobile user moved among the base stations. Moreover, other barriers that were mentioned are the Denial of Service (DoS) and the replay attacks. The proposed methodology solved all the mentioned problems, even with minimum requirements of communication as well as computational resources.

In 2011, Al Shidhani and Leung [27] presented and analyzed five protocols, which were the reauthentication

protocols among WLAN and WiMAX, using the 3G Partnership Project (3GPP) standards. The developed protocol showed its outstanding performance using reauthentiaction delay and reauthentication signaling traffic. Meanwhile, the authors have also fulfilled the seamless handover (HO) security requirements (which included the frontward and backward secrecy and the mutual authentication provision).

In 2011, Lee et al. [1] have presented an architecture, named Multimedia Multicast/Broadcast Service (MBS), which was based on Location Management Areas (LMAs). Their architecture increased the zone size of the MBS and reduced the average handover delay, without any loss of bandwidth. Moreover, they have developed an analytical model for quantifying the server-disruption time, the probability of blocking and the usage of bandwidth for various MBS zone sizes and LMA sizes. Meanwhile, the distribution of the users, the mobility of the user and the session popularity of MBS were also considered. Using the proposed model, the MBS zones and LMAs finest sizes were also determined. The simulation and the analytical results demonstrated that the proposed LMA-based MBS scheme achieved better efficiency in multicast delivery and at the same time, the service disruption time was also retained.

In 2013, Huang et al. [28] have presented a faster authentication scheme, which was exclusively utilizable for the mobile stations that were roaming within the WiMAX-WLAN connected scenario. Moreover, they incorporated the key reuse design, which prevented repeated transactions. In that way, the security was ensured, while maintaining numerous sites. Additionally, a handover optimization design was specified for WiMAX, so as to support the WiFi-to-WiMAX handovers. The proposed methodology was compared to the conventional schemes. The analytical and the simulation results showed that the proposed mechanism was superior in handling the handover packet loss and delay, meeting the requirements of the delay-sensitive applications.

3 Modeling of heterogeneous network

3.1 Network model

The distribution of continuous services to the user is the main reason to operate handoff between two cellular networks. Initializing the handoff between two networks mainly depends on two fundamental rules, called the horizontal handoff and the vertical handoff. This paper intends to implement a handoff between two networks, namely, the Wifi network and the WiMAX network. Figure 1 shows the architecture for forming the horizontal and the vertical handoffs between the WiFi and the WiMax networks. In fact, the horizontal handoff indicates a connection between homogeneous networks, whereas the vertical handoff indicates a connection between heterogeneous networks. In the vertical handoff process, the handoff takes place between two cells that have two different technologies. It can also be stated as the transmission of the node between diverse wireless access networks. Since the node travels from one network to another network, the IP address and the technology may change. Thus, this process mostly focuses on the alteration of IP address and the network interface.

3.2 WiFi model

One of the hidden technologies of WLAN is the WiFi network. It has provided services to a limited number of users in the beginning. But now, the services have increased, as the performance of the network has also increased to the maximum level. Basically, the WiFi network involves clients and Access Points (AP) and the speed of this network is 108 Mbps. However, there is a situation of collision formation, as the communication of WiFi is through the air. Therefore, data transmission is highly affected by several radio packets.

The reduction of the power density of a wave, while traveling through space is termed as the path loss. Path loss is the difference between the transmitted and the received powers. The path loss of the WiFi network for the distance partitioned model is shown in Eq. (1), where, P_{L_1} specifies the path loss over distance d_{TR}, P_{L_0} specifies the path loss over an initial meter, d_{TR} indicates the distance between the transmitter and the receiver, d_{BP} is the distance of the static breakpoint and β_1 and β_2 indicate the distance power gradients that arise before and after the breakpoints. The unit of P_{L_1} and P_{L_0} are dB, d_{TR} and d_{BP} are meters and β_1 and β_2 are dB/meter.

$$P_{L_1} = P_{L_0} + \begin{cases} 10\beta_1 \log(d_{TR}), & d_{TR} < d_{BP} \\ 10\beta_1 \log(d_{BP}) + 10\beta_2 \log\left(d_{TR}/d_{BP}\right), & d_{TR} > d_{BP} \end{cases} \quad (1)$$

3.3 WiMAX model

WiMAX is the advanced network, which offers higher speed (70mbps) and coverage area than WiFi. Apart from the speed and the coverage area, the benefit of WiMax relies on providing proficient bandwidth and reduced interference. WiMAX technology is considered as more secure, where the data transmission is through two channels, called the uplink and the downlink. The transmission of data from the base station to the user is through the uplink and the data transfer from user to base station is through the downlink. The path loss model of the WiMax network is based on Eq. (2), where F indicates the frequency in MHz.

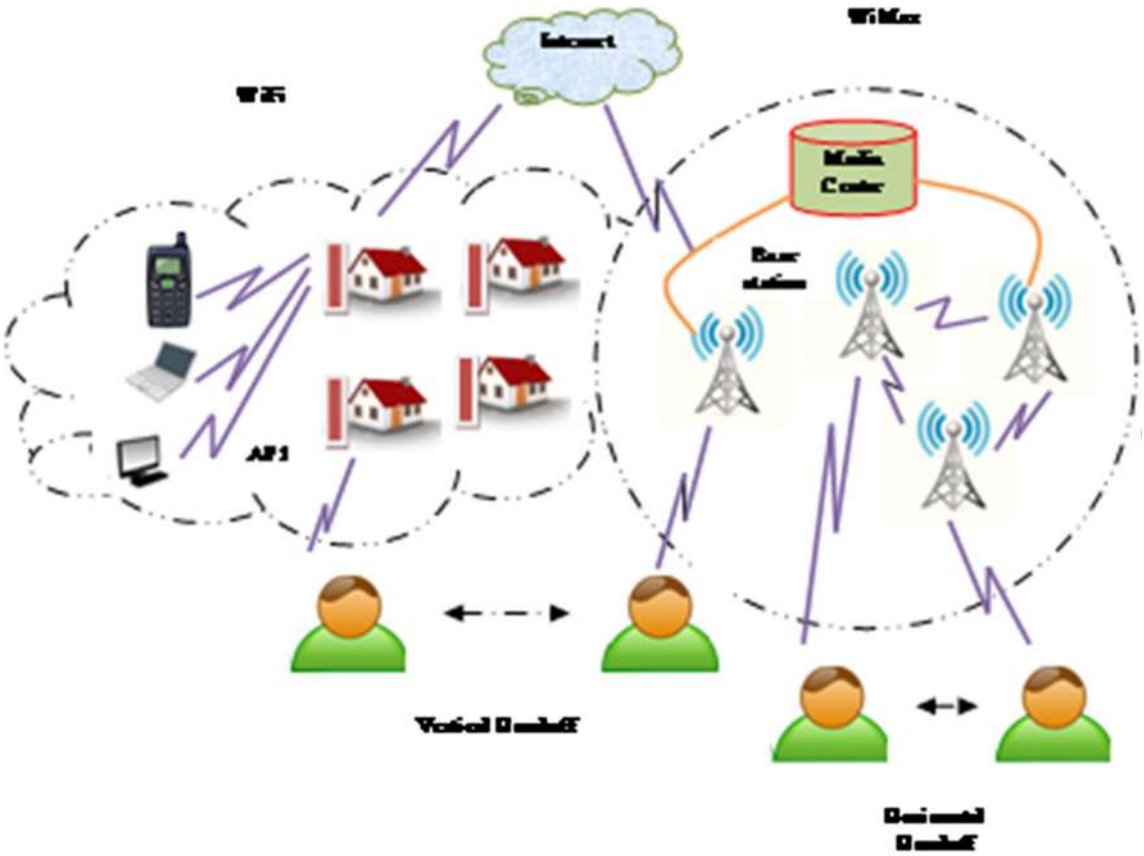

Fig. 1 Architecture of vertical and horizontal handoff between Wifi and WiMax

$$P_L = 20\log_{10}(F) + 20\log_{10} d_{TR} + 32.45 \quad (2)$$

The total strength of the received signal is termed as RSS. The overall RSS of the WiFi and WiMax network can be formulated as the inverse of path loss, which shown in Eq. (3).

$$R = \frac{1}{P_L} \quad (3)$$

4 Proposed handover decision algorithm

4.1 Proposed RSS prediction

In this experiment, RSS is predicted using NN. Since the user is moving to access the network with several access points, it is difficult to predict the appropriate RSS. Here, the RSS prediction is possible through the NN algorithm.

In fact, NN is a machine learning algorithm that is inspired by the biological nervous system. To predict RSS, it is needed to know the current location of the user and the distance between the user location and the access points. Consider a user accessing the WiFi and WiMAX network, who has a location with two coordinates x_i^{loc} and y_i^{loc}. The distance between the

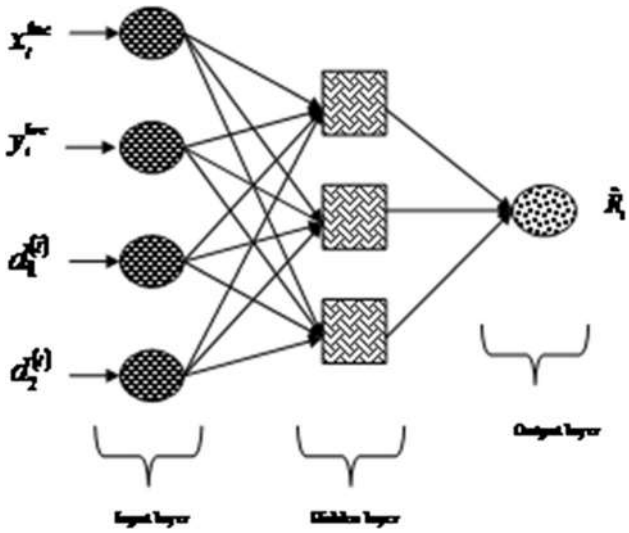

Fig. 2 Architecture of the NN model

current location of the user and the access point of WiFi is set as $d_1^{(i)}$, whereas the distance between the current location of the user and the access point of WiMax is set as $d_2^{(i)}$. The optimal weights for the learning algorithm are assigned as $W_1, W_2, \ldots W_n$. The ANN is trained on the basis of historical

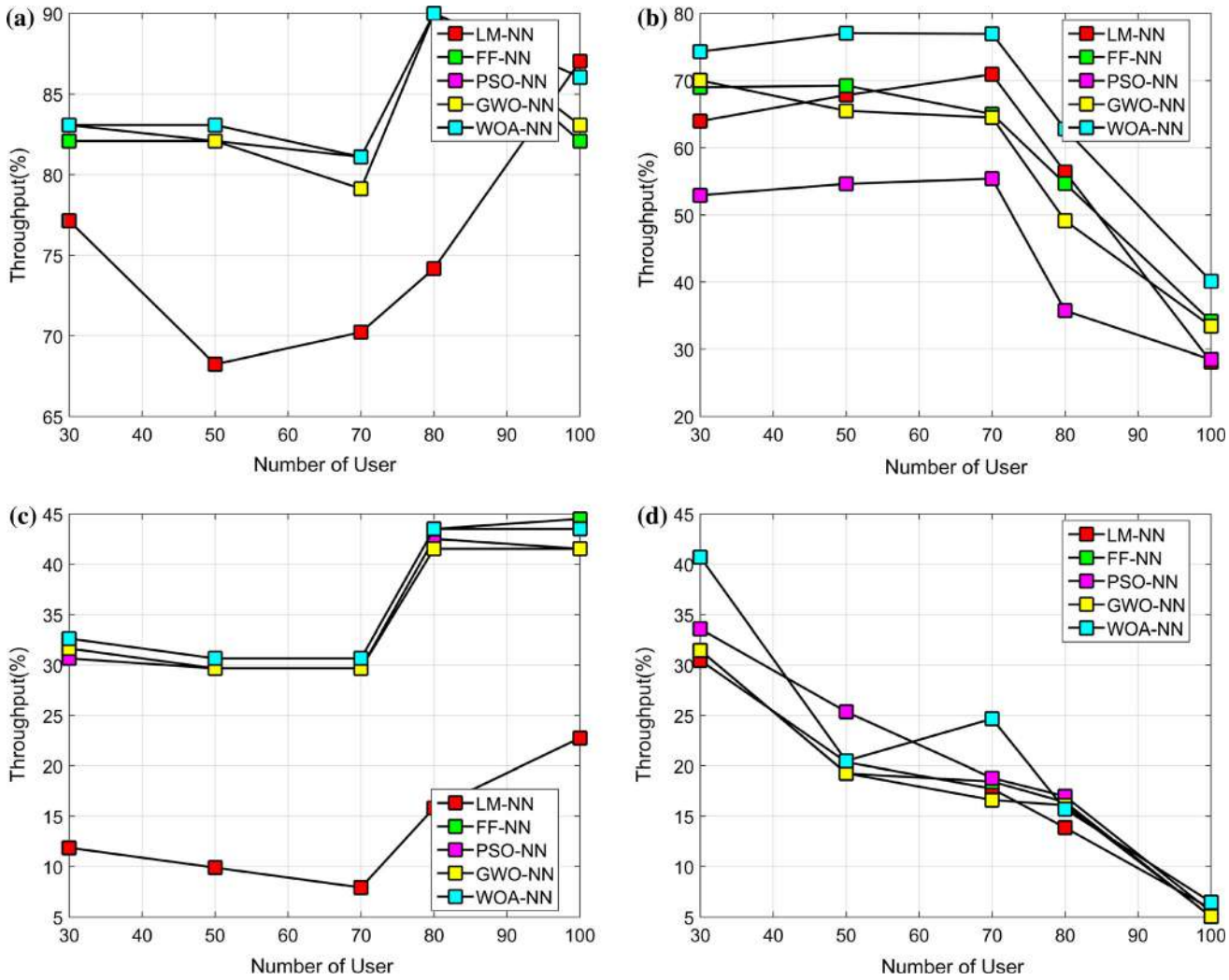

Fig. 3 Throughput analysis of the proposed and the conventional vertical handover models for obtaining **a** voice signals without load balancing conditions, **b** voice signals with load balancing conditions, **c** video signals without load balancing conditions, **d** video signals with load balancing conditions

data. Accordingly, the architecture of the NN model is shown in Fig. 2. The inputs such as, x_i^{loc}, y_i^{loc}, $d_1^{(i)}$ and $d_2^{(i)}$ are collectively denoted as U_i and it is given to the network for classification. The number of hidden layers is one and the output of the hidden layer is given in Eq. (4), where, N_I refers to the number of input neurons, F_1 indicates the activation function, w_{bj}^H indicates the bias weight to the j^{th} hidden layer and w_{ij}^H indicates the weight from the i^{th} input neuron to the j^{th} hidden neuron.

$$H_j = F_1\left(w_{bj}^H + \sum_{i=1}^{N_I} w_{ij}^H U_i\right) \tag{4}$$

Accordingly, the output of the NN model is expressed in Eq. (5), where N^H specifies the number of hidden neurons, F_2 indicates the activation function, w_{bi}^O indicates the bias weight to the i^{th} output neuron, w_{ij}^H indicates the weight from the j^{th} hidden neuron to the i^{th} output neuron. Moreover, the optimal selection of weight is achieved through the minimization of the objective function, as shown in Eq. (6) ($\hat{R}_i$ refers to the predicted RSS output and $\hat{R}_i^*$ refers to the actual RSS output). The minimization of the objective function is possible by the adoption of a recent meta-heuristic algorithm, called WAO.

$$\hat{R}_i = F_2\left(w_{bi}^O + \sum_{j=1}^{N_H} w_{ji}^O H_j\right) \tag{5}$$

$$E^R = \underset{\left\{w_{bj}^H, w_{ij}^H, w_{bi}^O, w_{ji}^O\right\}}{\arg\min} \left\|\hat{R}_i - \hat{R}_i^*\right\| \tag{6}$$

Initially, the weight is updated by the standard WOA-based learning algorithm [29]. The WOA is a novel meta-heuristic algorithm and it is a population-based method. WOA simulate the bubble-net attacking approach of the humpback whales, while they are hunting their preys. In

Table 1 Features and challenges of various handover schemes for the WiFi-WiMAX network

References	Method	Features	Challenges
Abhijit et al. [23]	Load balancing and handover policy	Reduced communication cost Highly improved Quality of Service (QoS) as well as Quality of Experience (QoE) of the user	Failed to control the handovers Exact decision making was a tedious task
Fu et al. [24]	Group-based handover authentication scheme	Reduced handover latency Offered privacy preservation	Increased computational overhead Computational complexity was high in the initial phase
Nguyen and Ma [26]	Enhanced EAP-based pre-authentication (EEP) model	More efficient and secure Reduced delay of handover	Had more handover latency Increased the signaling cost
Al Shidhani and Leung [27]	HO reauthentication protocol	Reduced reauthentication delay and signaling traffic More secure	Unable to support multihop wireless communication Required additional mechanisms to encounter the errors that occurred in the protocol
Lee et al. [1]	Location Management Area (LMA)-based multicast-broadcast service	Reduced handover delay Granted efficient multicast services	Additional storing and modeling schemes were required to achieve the efficiency Since the population increased dramatically, it required a location update triggering
Ben-Mubarak et al. [25]	Fuzzy logic-based self-adaptive handover (FuzSAHO)	Reduced number of handovers and delay Increased performance rate	Failed to consider the interference parameter and hence, there was a possibility of inaccurate decision making The real-time application was difficult
Huang et al. [28]	Fast authentication mechanism (FAME)	Reduced handover delay Improved security level	Needed more enhancements for better performance More investigation was needed for yielding effective outputs

addition, it has a special hunting mechanism that is known as the bubble-net feeding approach. This foraging behaviour is performed by crating special bubbles in spiral shape. By exploiting WOA, the error performance of learning algorithm is measured, and the updated weight may have minimized error, which is given for training. In the WOA algorithm, the position vector of the whales is W and the position vector of the prey is W'. The updated position of the whales for iteration t is expressed in Eq. (7).

$$W^*(t+1) = \begin{cases} W'(t) - G.H & if \quad q < 0.5 \\ D' \cdot e^{bl} \cdot \cos(2\pi l) + W'(t) & f \quad q > 0.5 \end{cases} \tag{7}$$

$$H = |Q \cdot W'(t) - W(t)| \tag{8}$$

$$G = 2a.r - a \tag{9}$$

$$Q = 2r \tag{10}$$

In Eq. (7), D' represents the distance as $D' = W'(t) - W(t)$. Additionally, G and Q indicate the coefficient vectors, '.' indicates the elemental-wise multiplication, b represents the constant and l and q indicate a random number between 0 and 1, respectively. In Eqs. (9) and (10), r represents a random number that is distributed among [0, 1] and a is linearly reduced from 2 to 0. The learning algorithm for weight updating is shown in Algorithm 1.

ALGORITHM 1: Pseudo code for Weight updating	
Input: x_i^{loc}, y_i^{loc}, $d_1^{(i)}$ and $d_2^{(i)}$	
Output: W^*	
//Learning phase	
1	Set $t = 1$
2	Initialize the population $W_i = 1,2.....n$
3	Initialize a, G, Q, l and q
4	For every search agent
5	Determine the basis function
6	Determine the activation function
7	Calculate RSS using eq. (3)
8	Calculate E^R using eq. (6)
9	End for
10	Find the best search agent
11	Update the weights using eq. (7)
12	$t+1$
13	If $< t^{max}$
14	Go to step 4
15	else
16	Go to testing phase
17	End if

Table 2 Handover analysis (number of handover to wifi and wimax) of proposed and conventional vertical handover models for obtaining voice signals without load balancing condition

Network configuration			Methods									
Wimax	WiFi	User	LM-NN		FF-NN		PSO-NN		GWO-NN		WOA-NN	
			WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax
5	15	30	87	3	89	1	89	1	89	1	89	1
5	15	50	85	5	88	2	90	0	86	4	89	1
5	15	70	63	27	90	0	90	0	90	0	90	0
5	15	80	90	0	89	1	89	1	89	1	89	1
5	15	100	79	11	89	1	90	0	89	1	90	0
7	25	30	85	5	88	2	90	0	88	2	90	0
7	25	50	80	10	88	2	89	1	88	2	88	2
7	25	70	78	12	85	5	89	1	84	6	88	2
7	25	80	83	7	90	0	90	0	90	0	90	0
7	25	100	89	1	90	0	90	0	90	0	90	0
10	30	30	90	0	90	0	90	0	90	0	90	0
10	30	50	71	19	90	0	90	0	90	0	90	0
10	30	70	85	5	85	5	87	3	85	5	87	3
10	30	80	77	13	86	4	90	0	88	2	89	1
10	30	100	76	14	87	3	87	3	87	3	89	1
12	35	30	86	4	89	1	90	0	90	0	90	0
12	35	50	71	19	88	2	90	0	87	3	90	0
12	35	70	82	8	86	4	88	2	84	6	86	4
12	35	80	84	6	90	0	90	0	90	0	89	1
12	35	100	86	4	88	2	89	1	88	2	89	1
15	40	30	78	12	90	0	90	0	90	0	89	1
15	40	50	79	11	89	1	90	0	89	1	90	0
15	40	70	90	0	88	2	90	0	87	3	88	2
15	40	80	71	19	87	3	88	2	85	5	88	2
15	40	100	82	8	88	2	90	0	88	2	89	1

Algorithm 2: Pseudo code of proposed scheme

Step 1:	Set the input, hidden and output layer of the Neural Network
Step 2:	Give the input x_i^{loc}, y_i^{loc}, $d_1^{(i)}$ and $d_2^{(i)}$ to the input layer
Step 3:	Optimize the weights $w_{bj}^H, w_{ij}^H, w_{bi}^O, w_{ji}^O$ using Algorithm 1 (WOA) that gives W^*
Step 4:	Allot bias weight w_{bj}^H, weight from the input layer w_{ij}^H, along with the input to hidden layer
Step 5:	Determine the output of the hidden layer using Eq. (4)
Step 6:	Allot the bias weight w_{bi}^O, weight from the hidden layer w_{ij}^H, along with the hidden output to output layer
Step 7:	Determine the output of the network (RSS) using Eq. (5)

4.2 Deciding vertical handover

In general, several users are available to access the network. In focussing on a particular mobile user, RSS can be predicted with both the no-load and the load balancing conditions. In the load balancing condition, RSS of a mobile user is determined by dividing it by the total number of users in the network. Conversely, the no-load condition may not consider the other users. Thus, to determine the generalized RSS, the output from the NN model is evaluated, if there is a need to enable or disable the load. Equation (11) expresses the mathematical model of the generalized RSS, where N_u represents the number of users.

$$\hat{R}_G = \frac{\hat{R}}{N_u}(w(1 - N_u) + N_u) \tag{11}$$

Table 3 Handover analysis (number of handover to wifi and wimax) of proposed and conventional vertical handover models for obtaining voice signals with load balancing condition

Network configuration			Methods									
Wimax	WiFi	User	LM-NN		FF-NN		PSO-NN		GWO-NN		WOA-NN	
			WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax
5	15	30	87	3	89	1	89	1	89	1	89	1
5	15	50	85	5	88	2	90	0	86	4	89	1
5	15	70	63	27	90	0	90	0	90	0	90	0
5	15	80	90	0	89	1	89	1	89	1	89	1
5	15	100	79	11	89	1	90	0	89	1	90	0
7	25	30	85	5	88	2	90	0	88	2	90	0
7	25	50	80	10	88	2	89	1	88	2	88	2
7	25	70	78	12	85	5	89	1	84	6	88	2
7	25	80	83	7	90	0	90	0	90	0	90	0
7	25	100	89	1	90	0	90	0	90	0	90	0
10	30	30	90	0	90	0	90	0	90	0	90	0
10	30	50	71	19	90	0	90	0	90	0	90	0
10	30	70	85	5	85	5	87	3	85	5	87	3
10	30	80	77	13	86	4	90	0	88	2	89	1
10	30	100	76	14	87	3	87	3	87	3	89	1
12	35	30	86	4	89	1	90	0	90	0	90	0
12	35	50	71	19	88	2	90	0	87	3	90	0
12	35	70	82	8	86	4	88	2	84	6	86	4
12	35	80	84	6	90	0	90	0	90	0	89	1
12	35	100	86	4	88	2	89	1	88	2	89	1
15	40	30	78	12	90	0	90	0	90	0	89	1
15	40	50	79	11	89	1	90	0	89	1	90	0

The two conditions for determining $\bar{R}_G$ are given as follows:

- $w = 1$, if load balancing is enable
- $w = 0$, if no load balancing

Theorem *The predicted RSS using the proposed scheme considers balancing load conditions at* $w = 1$ *and* vice versa.

Proof Let us assume that the balanced load conditions distribute the RSS of AP to all the available users. Hence,

$$R^{load} = \frac{\hat{R}}{N_u} \tag{12}$$

According to the theorem, the generalized version of the predicted RSS can be given first, as shown in Eq. (13), where, $w = 1$ considers the balanced RSS and $w = 0$ considers no RSS.

$$\hat{R}_G = w\frac{\hat{R}}{N_u} \tag{13}$$

By including the predicted RSS under no load conditions,

$$\hat{R}_G = w\frac{\hat{R}}{N_u} + (1-w)\hat{R} \tag{14}$$

$$= \hat{R}\left({}^{w}/_{N_u} + (1-w)\right) \tag{15}$$

$$= \frac{\hat{R}}{N_u}(w + (1-w)N_u) \tag{16}$$

$$\hat{R}_G = \frac{\hat{R}}{N_u}(w(1-N_u) + N_u) \tag{17}$$

□

5 Simulation results

5.1 Simulation setup

The proposed WOA-NN-based RSS prediction of the heterogeneous WiFi and WiMax network is simulated in MATLAB and the simulation results are observed. In the network configuration, (WiMax, WiFi) is set as (5, 15), (7, 25), (10, 30), (12, 35) and (15, 40), where the number of

Table 4 Handover analysis (number of handover to wifi and wimax) of proposed and conventional vertical handover models for obtaining video signals without load balancing condition

Network configuration			Methods									
Wimax	WiFi	User	LM-NN		FF-NN		PSO-NN		GWO-NN		WOA-NN	
			WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax
5	15	30	87	3	89	1	89	1	89	1	89	1
5	15	50	85	5	88	2	90	0	86	4	89	1
5	15	70	63	27	90	0	90	0	90	0	90	0
5	15	80	90	0	89	1	89	1	89	1	89	1
5	15	100	79	11	89	1	90	0	89	1	90	0
7	25	30	85	5	88	2	90	0	88	2	90	0
7	25	50	80	10	88	2	89	1	88	2	88	2
7	25	70	78	12	85	5	89	1	84	6	88	2
7	25	80	83	7	90	0	90	0	90	0	90	0
7	25	100	89	1	90	0	90	0	90	0	90	0
10	30	30	90	0	90	0	90	0	90	0	90	0
10	30	50	71	19	90	0	90	0	90	0	90	0
10	30	70	85	5	85	5	87	3	85	5	87	3
10	30	80	77	13	86	4	90	0	88	2	89	1
10	30	100	76	14	87	3	87	3	87	3	89	1
12	35	30	86	4	89	1	90	0	90	0	90	0
12	35	50	71	19	88	2	90	0	87	3	90	0
12	35	70	82	8	86	4	88	2	84	6	86	4
12	35	80	84	6	90	0	90	0	90	0	89	1
12	35	100	86	4	88	2	89	1	88	2	89	1
15	40	30	78	12	90	0	90	0	90	0	89	1
15	40	50	79	11	89	1	90	0	89	1	90	0

users is varied from 30 to 100. Here, one mobile user is moved over the network for whom the generalized RSS has to be determined and the remaining users are kept static. The analysis based on throughput, handover and RSS is carried out and evaluated. In the analysis, the performance of the WOA-NN-based model is compared with the performance of the conventional models like, NN-LM [30, 31], FF-NN [32], PSO-NN [33] and GWO-NN [34] - based handover models to validate its performance.

5.2 Throughput analysis

The throughput analysis of the simulated vertical handover model is carried out by focussing on a particular mobile user, who is moving from one place to another. Since the handover network contains both WiFi and WiMax, the mobile user gets a signal from both the networks. Thus, it is needed to estimate the generalized RSS of the mobile user that is obtained from either WiFi or WiMAX. The mobile user selects a signal, which is at less distance from the network, and the RSS of the mobile user should be higher than the threshold RSS. The predicted RSS that is higher than the threshold RSS is assigned as the better handover. Accordingly, the throughput analysis of a vertical handover model with different network configurations, without and with load balancing conditions, concerning both voice and video signals is shown in Fig. 3. The required signal should be high for functioning with video and less for voice. On considering the voice signals, the throughput of vertical handover model using the proposed and the conventional algorithms, without and with load balancing conditions for varied users, are shown in Fig. 3(a), (b), respectively.

Figure 3(a) shows the throughput of the proposed WOA-NN-based vertical handover model for obtaining the voice signal, without load balancing condition. In this case, the users are not considered and this results in increased throughput over the other conventional methods. Moreover, the throughput of the WOA-NN vertical handover model for 100 users is orderly 12.70, 34.34, and 9.85% better than the throughputs of GWO-NN, PSO-NN, and FF-NN-based models for obtaining the voice signal, with load balancing conditions, as shown in Fig. 3(b). The users

Table 5 Handover analysis (number of handover to wifi and wimax) of proposed and conventional vertical handover models for obtaining video signals with load balancing condition

Network configuration			Methods									
Wimax	WiFi	User	LM-NN		FF-NN		PSO-NN		GWO-NN		WOA-NN	
			WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax	WiFi	Wimax
5	15	30	87	3	89	1	89	1	89	1	89	1
5	15	50	85	5	88	2	90	0	86	4	89	1
5	15	70	63	27	90	0	90	0	90	0	90	0
5	15	80	90	0	89	1	89	1	89	1	89	1
5	15	100	79	11	89	1	90	0	89	1	90	0
7	25	30	85	5	88	2	90	0	88	2	90	0
7	25	50	80	10	88	2	89	1	88	2	88	2
7	25	70	78	12	85	5	89	1	84	6	88	2
7	25	80	83	7	90	0	90	0	90	0	90	0
7	25	100	89	1	90	0	90	0	90	0	90	0
10	30	30	90	0	90	0	90	0	90	0	90	0
10	30	50	71	19	90	0	90	0	90	0	90	0
10	30	70	85	5	85	5	87	3	85	5	87	3
10	30	80	77	13	86	4	90	0	88	2	89	1
10	30	100	76	14	87	3	87	3	87	3	89	1
12	35	30	86	4	89	1	90	0	90	0	90	0
12	35	50	71	19	88	2	90	0	87	3	90	0
12	35	70	82	8	86	4	88	2	84	6	86	4
12	35	80	84	6	90	0	90	0	90	0	89	1
12	35	100	86	4	88	2	89	1	88	2	89	1
15	40	30	78	12	90	0	90	0	90	0	89	1
15	40	50	79	11	89	1	90	0	89	1	90	0

are considered in the load balancing condition. Further, in Fig. 3(d), the throughput of the proposed WOA-NN-based handover network for 70 users is orderly 47.72, 25.17%, better than the throughputs of GWO-NN and PSO-NN-based models.

5.3 Handover analysis

Tables 1 and 3 depict the handover analysis of the proposed and the conventional vertical handover models for obtaining the voice signal without and with load balancing conditions. One can observe the total number of handoffs of the mobile connected with WiFi and WiMax through this analysis. In fact, the number of handoffs in the current simulation is set as 90, i.e., one handoff for one instant and the simulation contains a total of 90 instants. In fact, the mobile user may achieve the handover to the nearly existed network. As the number of signals in the WiFi network is higher than in the WiMax network, mostly there is a possibility of achieving higher handover counts to the WiFi network than in the WiMax network, as shown in Tables 2 and 3. Similarly, the number of handovers of the proposed vertical handover for obtaining video signals without and with load balancing conditions is shown in Tables 4 and 5.

5.4 RSS prediction

The predicted RSS of the proposed and the conventional vertical handover models is shown in Fig. 4. The analysis is carried out for various network configurations of (WiMax, WiFi) as (5, 15), (7, 25), (10, 30), (12, 35) and (15, 40). The predicted RSS should be very close to the target or the actual RSS to attain the best performance. As in Fig. 4(a), the percentage deviation of RSS from the actual RSS for network configuration with WiMax 5 and WiFi 15, in case of WOA-NN model is 69.69%, LM-NN is 93.93%, FF-NN is 76.76%, PSO-NN is 75.75%, and GWO-NN is 74.74%. Moreover, the percentage deviation of RSS from the actual RSS for network configuration with WiMax 7 and WiFi 25, in case of WOA-NN, LM-NN, FF-NN, PSO-NN, and GWO-NN is 5.88, 12.5, 20, 9.90 and 9.90%, respectively. A similar performance is observed for the

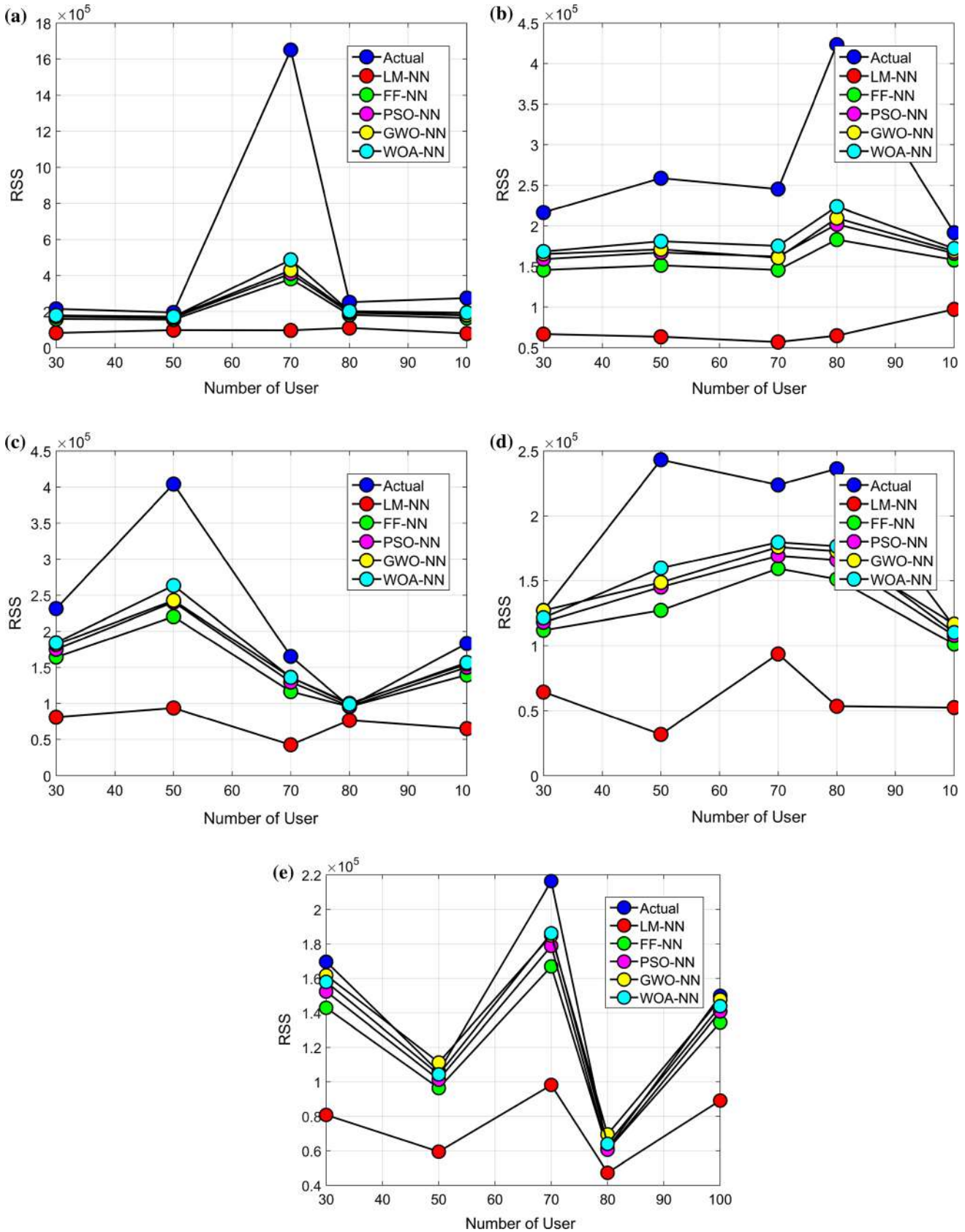

Fig. 4 RSS prediction of the proposed and the conventional vertical handover models of different network configurations with (Wimax, WiFi) as **a** (5, 15), **b** (7, 25), **c** (10, 30), **d** (12, 35) and **e** (15, 40)

Table 6 MAE of RSS predicted by the proposed and the conventional models with actual RSS

Network configuration			Methods				
Wimax	WiFi	User	LM-NN	FF-NN	PSO-NN	GWO-NN	WOA-NN
5	15	30	76461.93	31653.49	22568.48	24916.84	19968.09
5	15	50	64188.29	23800.62	15688.47	16231.27	14569.38
5	15	70	790950.9	637339.4	620993.3	614450.7	581871.7
5	15	80	85235.09	40967.7	30360.84	29568.56	28185.39
5	15	100	118089.4	60396.54	48557.09	51509.53	43433.44
7	25	30	85676.48	39524.11	29842.9	32180.08	26752.82
7	25	50	113159.5	57807.08	46992.64	49624.38	42071.9
7	25	70	110596.3	53365.97	42328.96	45723.17	37115.56
7	25	80	187047.2	124265.2	111236.1	113924.5	101933
7	25	100	63324.85	22435.87	13509.16	15367.66	12951.14
10	30	30	82841.61	39318.42	28746.32	31420.28	25866.47
10	30	50	172102	95922.74	83343.11	88508.76	72456.93
10	30	70	67542.22	26837.68	18668.23	21837.29	16918.29
10	30	80	26812.01	4473.369	1105.993	3462.165	1995.985
10	30	100	67724.63	26445.62	17216.94	21724.67	15424.32
12	35	30	42785.94	11706.64	5065.403	8930.013	6229.084
12	35	50	114193	60756.02	50265.12	55838.41	43986.08
12	35	70	90666.9	39543.6	28142.85	30781.56	26026.31
12	35	80	96495.7	46891.42	35998.66	40969.07	31640.8
12	35	100	37594.71	10037.76	4150.895	8123.325	5003.85
15	40	30	61568.7	17399.28	10068.07	13581.11	8656.514
15	40	50	41039.57	9578.594	3144.942	8239.782	4523.017
15	40	70	74142.94	29162.98	20325.81	21396.34	18487.95
15	40	80	24255.08	3950.436	1036.897	4900.776	1854.327
15	40	100	48019.41	13257.33	5840.637	9292.835	6688.039

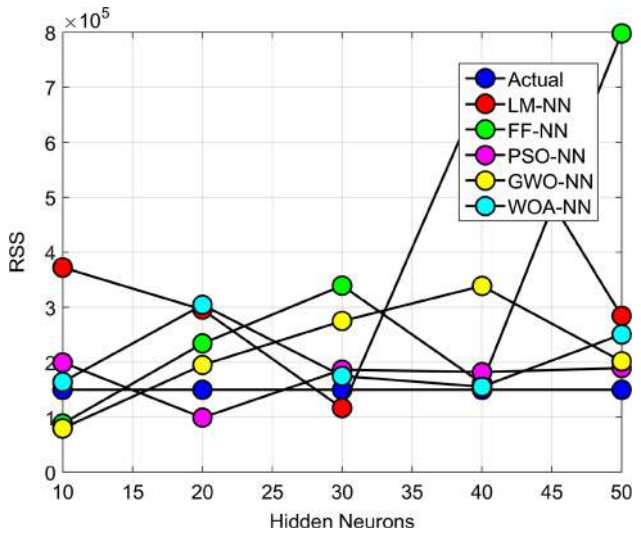

Fig. 5 RSS prediction of the proposed and the conventional vertical handover models of hidden neurons

network configuration with (WiMax, WiFi) as (10, 30) and (12, 35), which is shown in Fig. 4(c), (d). As per Fig. 4(e), the percentage deviation of RSS from the actual RSS for network configuration with WiMax 15 and WiFi 40, in case of WOA-NN model is 2.19%, LM-NN is 54.33%, FF-NN is 29.58%, and PSO-NN is 21.66%. Thus, the performance of the proposed vertical handover network is superior to the conventional models, yielding higher RSS predictions.

Further, MAE is measured to validate how close the predicted RSS is to the actual RSS. Here, MAE is determined by measuring the difference between the actual and the predicted RSS. Accordingly, MAE of RSS, which are predicted by the proposed and the conventional models with actual models, is shown in Table 6. For the network configuration with WiMax 5, WiFi 15 and users 30, MAE of the proposed WOA-NN model is 73.88% lesser than LM-NN, 36.91% lesser than FF-NN, 11.52% lesser than PSO-NN and 19.86% lesser than the GWO-NN models. Moreover, MAE of WOA-NN is 57.89, 24.46, 13.06 and 18.13% lesser than LM-NN, FF-NN, PSO-NN and GWO-NN models for the network configuration with WiMax 10, WiFi 30 and users 50. Thus, it is clear that the MAE of the proposed method is less, when compared to the other conventional network models, leading to provide an effective vertical handover model. Figure 5 demonstrates

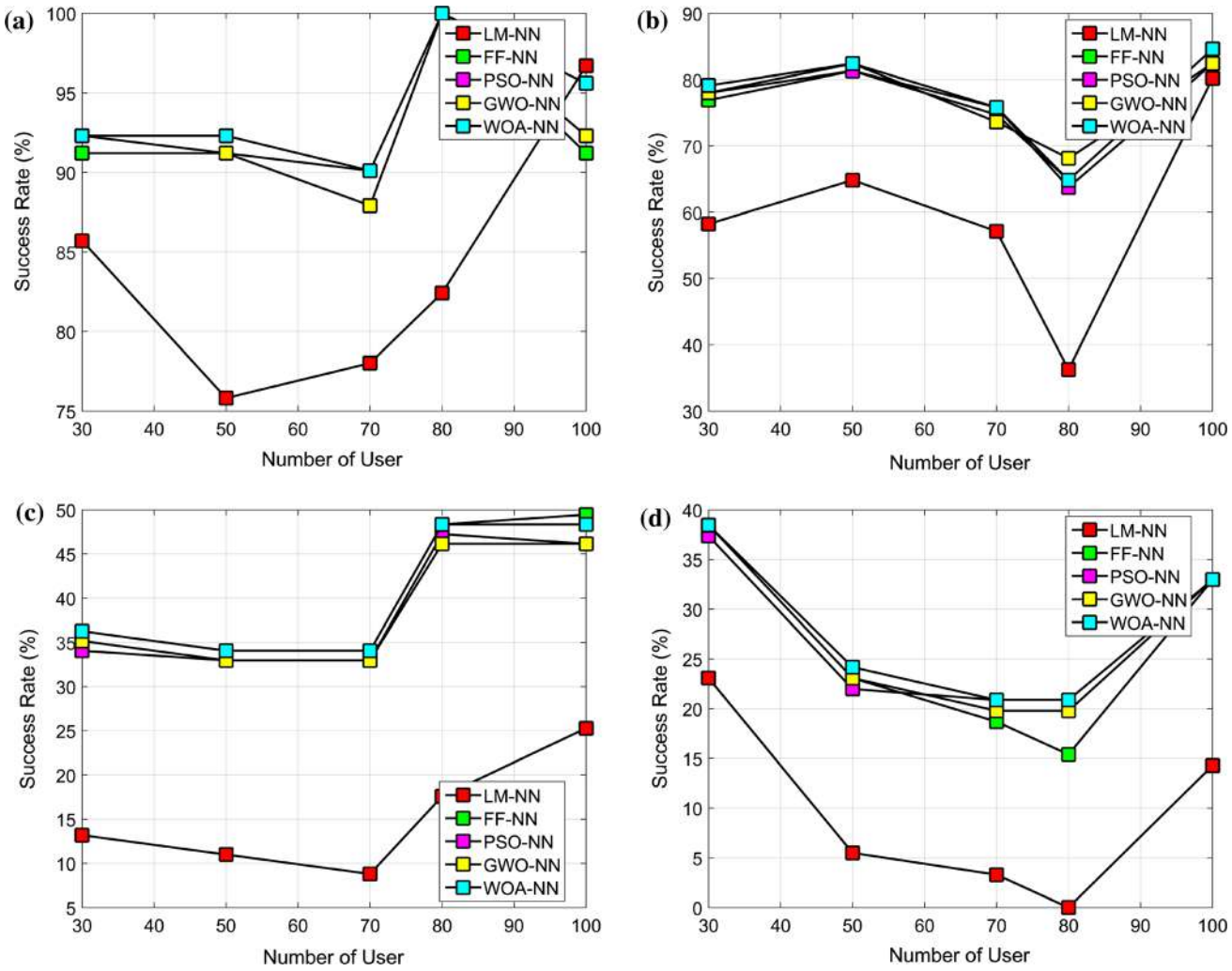

Fig. 6 Success rate analysis of the proposed and the conventional vertical handover models for obtaining **a** voice signals without load balancing conditions, **b** voice signals with load balancing conditions, **c** video signals without load balancing conditions, **d** video signals with load balancing conditions

the RSS prediction of the proposed and the conventional vertical handover models of hidden neurons. As shown in Fig. 5, the proposed model highly correlates with the actual value, in most of the cases.

5.5 Success rate analysis

This section explains the success rate analysis of the vertical handover model, with different network configurations, under no load and load balancing conditions, concerning both voice and video signals. The success rate is calculated using Eq. (18)

$$Sucess\ rate = \frac{Number\ of\ Sucessed\ Handoff}{Total\ number\ of\ Handoff} \tag{18}$$

The success rate of the proposed model for the voice signal, without load balancing, is 1.54 and 21.65% better than GWO-NN and LM-NN, respectively and this is proven by Fig. 6(a). Figure 6(b) gives the success rate of the proposed model over the other models for voice signal handoff with load balancing and the proposed method is 1.07, 1.82 and 34.03% better than GWO-NN, FF-NN and LM-NN, respectively. Similarly, Fig. 6(c) gives the success rate of the proposed model, which is 4.40, 7.80 and 59.63% superior to GWO-NN, PSO-NN and LM-NN, respectively, for video signal handoff, without load balancing.

Figure 7 shows the success rate of the proposed and the conventional vertical handover models of hidden neurons. In Fig. 7(a), the success rate of the proposed model for voice signal handoff, without load balancing, is shown. Here, the proposed method is 38% better than LM-NN, 30% better than FF-NN, 53% better than PSO-NN and 56% better than GWO-NN. In Fig. 7(b), the success rate of the proposed model over the other methods for voice signal handoff, with load balancing, is demonstrated. Here, the

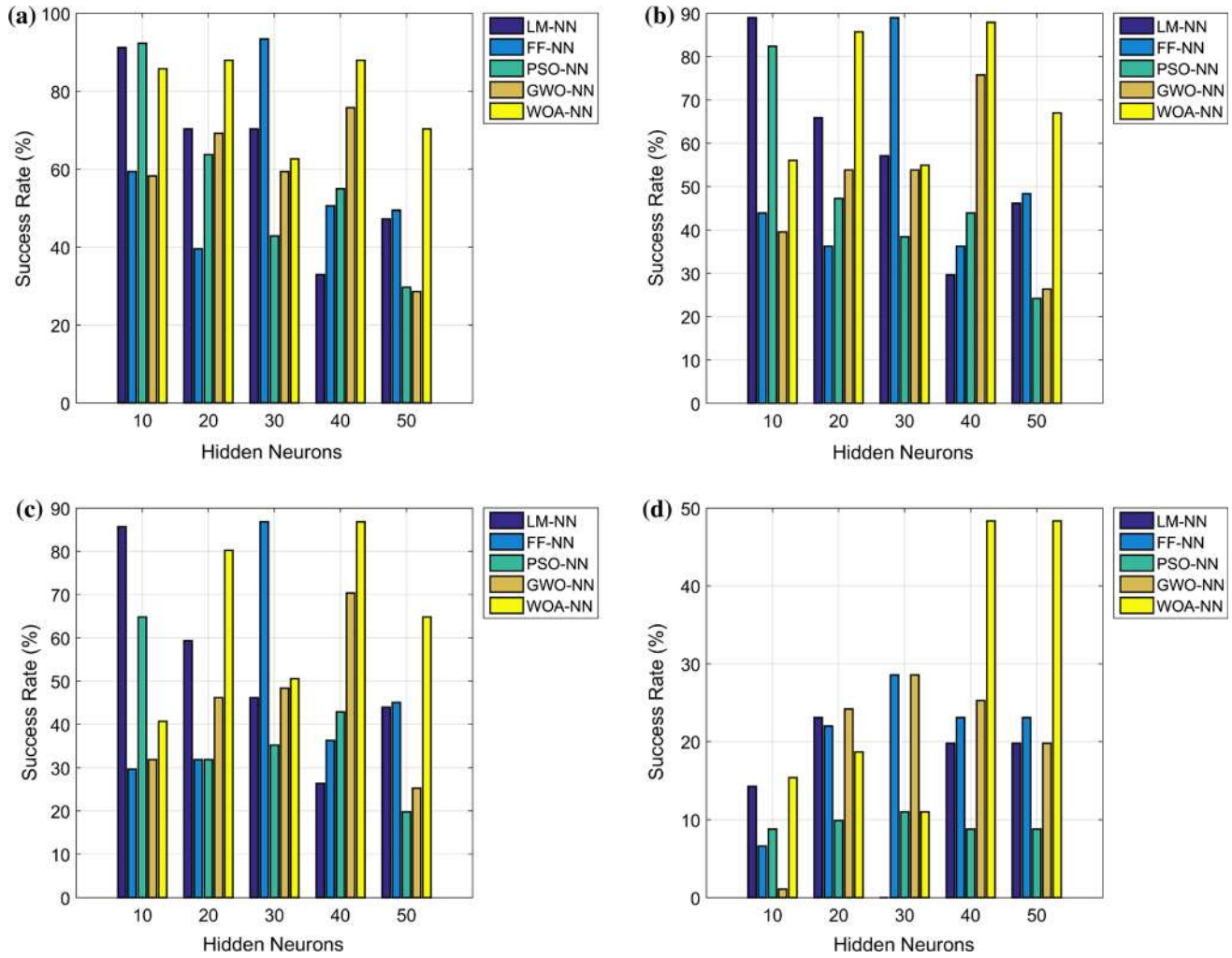

Fig. 7 Success rate of the proposed and the conventional vertical handover models of hidden neurons **a** voice signals without load balancing conditions, **b** voice signals with load balancing conditions, **c** video signals without load balancing conditions, **d** video signals with load balancing conditions

proposed model is 46% better than LM-NN, 27% better than FF-NN, 66% better than PSO-NN and 63% better than GWO-NN. Figure 7(c) illustrates that the proposed model is 35, 30, 70 and 56% better than the LM-NN, FF-NN, PSO-NN and GWO-NN models, respectively. Figure 7(d) demonstrates that the proposed model is orderly 59, 48, 79 and 63% better than the LM-NN, FF-NN, PSO-NN and GWO-NN models.

6 Conclusion

This paper has presented a vertical handover model for the heterogeneous network with WiMax and WiFi, using the WOA-NN method. In fact, ANN has been used to get the knowledge regarding the characteristics of the network, in order to determine the handover points. Initially, the RSS of the heterogeneous network has been noted and further, the training library has been constructed. As a result, RSS has been predicted by the trained network. Moreover, WOA optimization has been used to ensure the precise learning of the neural network about the RSS characteristics of the network. Once simulated, the performance of the proposed WOA-NN model has been compared with the conventional LM-NN, FF-NN, PSO-NN, and GWO-NN models. In the performance analysis, the throughput, handover predicted RSS and MAE have been analyzed. The MAE of the proposed WOA-NN model has been observed as 73.88% lesser than LM-NN, 36.91% lesser than FF-NN, 11.52% lesser than PSO-NN and 19.86% lesser than the GWO-NN models for the network configuration with WiMax 5, WiFi 15 and users 30. Thus, it has been observed that the RSS predicted by the proposed WOA-NN model is better than the traditional models, in providing powerful handoff. In the near future, the same experiment can be

performed in real-time by exploiting more advanced optimization methods.

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Analysing MPLS Performance by SDN

Snehal Patil and Mansi S. Subhedar

Abstract Nowadays, MPLS has become the first choice for enterprises to connect remote branch offices as it offers several benefits to packet forwarding. MPLS-VPN combines the features of both overlay and peer-to-peer VPNs thus offering the most robust connectivity. However, MPLS-TE faces the problem of creating backup path immediately when the best path goes down or gets congested. At some point of time in near future, all IP networks will be converted into programmable networks. During this transition, there should be some sort of mechanism which will couple the MPLS network to software-defined networking (SDN). This paper analyses the performance of SDN when coupled with MPLS. By using some of the core features of SDN, MPLS performance is enhanced for the tunnel creation. It has been found that coupling SDN with MPLS offers better performance in terms of latency, response time and bandwidth utilization.

1 Introduction

Enterprises use VPN technologies for increasing their working efficiencies by connecting different branch offices to each other. MPLS is fast, but it derives its operations from interior gateway protocol (IGP). Most of the Internet service providers (ISP) use OSPF for their intra-autonomous system (AS) operations. The convergence of MPLS and path selection totally depends on OSPF convergence and its reliability. Companies are always concerned about cost-effectiveness, downtime, security, traffic shaping, traffic aggregation and extensibility. Multi-protocol label switching is the most efficient forwarding mechanism used by many service providers currently in the world. It offers robust, fast and secure connectivity for VPNs. Basically,

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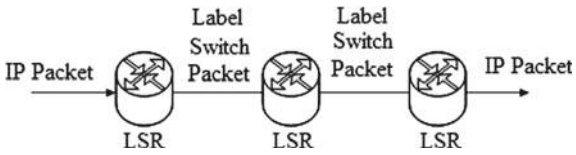

Fig. 1 MPLS mechanism

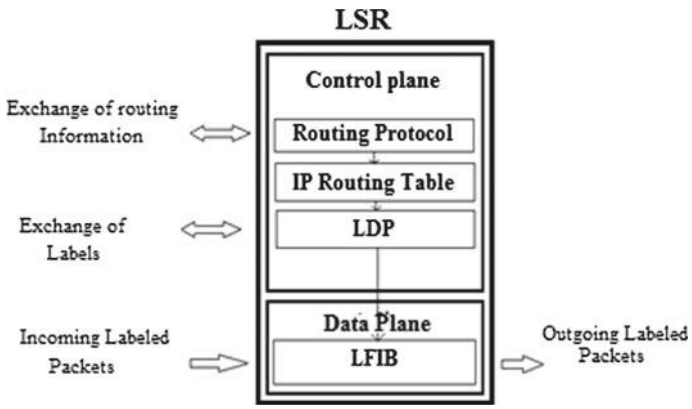

Fig. 2 MPLS operation in a router

MPLS divides the machine into two planes, control plane and data plane. MPLS creates a Label Forwarding Information Base (LFIB) table in data plane and forwards data based on the entries in this table. It does not take into consideration IP address unless the specified action is 'pop'. Data is forwarded based on the labels and not IP address. The label resides in between Layer 2 and Layer 3 headers. Since control plane lookup and data plane processing are avoided, minimal latency and transmission become secure. The use of MPLS-TE makes alternate tunnel creation very simple. Figure 1 shows MPLS switching mechanism that uses labels to forward packets. Usage of label allows edge routers to perform a routing lookup; all the core routers simply forward the packet based on labels assigned at the edge.

Figure 2 shows MPLS operation in routers. Label switch routers exchange routing information and labels in control plane. In data plane, LSR forwards packets. Exchanged routing information and labels are part of the control plane, while forward packets are part of the data plane.

2 Related Work

Variety of studies have been proposed in the literature for improving the performance of MPLS-TE tunnel creation. However, intelligence is provided on routers and SDN is not considered effectively in these studies. The minimum interface routing algo-

rithm (MIRA) proposed in [1] uses Dijkstra's algorithm for calculating the best path. It uses residual bandwidth under consideration on alternative path calculations by identifying critical links which will interfere with future request of other ingress–egress pair. Earlier, people were using offline algorithm for providing alternating paths to IP-VPN. It came up with the solution of online computation of alternating path when actual path gets crowded. MIRA provides alternating path dynamically but convergence is slow. The online dynamic routing algorithm proposed in [2] uses two types of information models which gives low and high bounds so that better routing can be done. There are defects in scenario. The first defect gives inaccurate output, and the other defect applicable to complete information scenario results in loops and network becomes inefficient [3]. Hop-constrained adaptive shortest path (HCASP) provides bandwidth guaranteed routing of MPLS-based tunnels [4]. This method uses OSPF extension information, but it can be transmitted within same area only. They worked on MIRA algorithm to reduce the time required to calculate alternate path when best path goes down. The OSPF extension information traverses in area of origination only and because of that tunnel establishment is difficult [5]. Here, they have suggested storing ten LSA type information in LSDB of ABR and then advertising in cross regional. The main aim was to boost performance of CSPF. Even if we transmit all LSA types by using BGP extended communities between remote sites of customer, sham-link between the links needs to be provided to bring two customer sites in single area. Tu et al. discussed splicing of MPLS with open flow tunnel on SDN conception. A central controller, path translator and command installer are responsible for making MPLS-based routing policies and open flow entries of the available routers. Traffic is split into best effort traffic and diffserv traffic which needs QoS. When QoS data traffic increases, best effort delivery traffic rate decreases in CSPF. For best effort traffic, best path is longest—widest path. If all paths under consideration fail to fulfil above consideration, CSPF is considered. Authors have developed online algorithm based on offline optimal computations which increases best effort traffic rate even if QoS traffic increases as compared to CSPF. If aggregated traffic matrix provided for offline calculations is not accurate, decision goes to CSPF. In [6], an auto-QoS feature of Cisco is employed that provides alternate paths for MPLS VPNs by using RSVP. Cisco methodology takes around 2–3 s for new tunnel path establishments. They have proposed fast reroute algorithm (FRR) which calculates preferred tunnels and alternative tunnels. Bandwidth allocation of concern link, serving other alternative tunnels [9].

3 Software-Defined Networking

Figure 3 shows SDN architecture. The SDN-based centralized controller provides open interface which gives automatic control on entire network. The open SDN uses two types of open flow APIs, namely northbound API and southbound API. Controller uses the southbound interfaces to program devices. Northbound interfaces consist of applications to be loaded into controller and so that algorithms and pro-

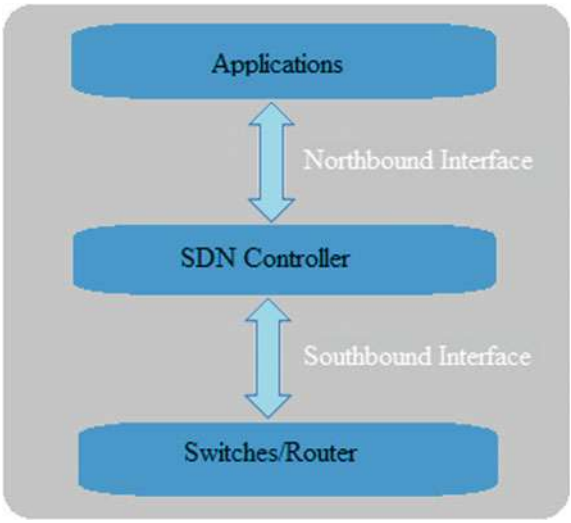

Fig. 3 Software-defined networking architecture

tocols can be provided to proceed network efficiently. When flow entry does not match, packet is forwarded to the controller, depending on the nature of application; it may even drop the packets [7]. SDN gives physical separation of the network control plane from data plane same as MPLS and even provides network virtualization. SDN architecture is accommodative, productive, feasible and profitable and is suitable for applications that require more bandwidth. Vigorous nature of SDN addresses the fact that static architecture of conventional networks is less suited for contempo data centres, campuses and carrier environments.

SDN devices constitute forwarding functionality for taking decisions on packet forwarding. Controller defines the flows which represents the data. A flow describes packets set forward from a particular set of endpoint to another endpoint. The packet forwarding actions belonging to a particular flow is described by one set of rule. Flows are represented by the term flow entry. A flow table consists of chain of flow entries and packet forwarding actions to be taken by network device. The flow entry is programming expression of control plane calculations done by the controller.

4 MPLS Provision in Different SDN Versions

First version of OpenFlow provides full VLAN support, and it also permits modification of a going tag whether it is MPLS header or virtual LAN. Level of VLAN requires energetic support for popping and pushing of various steps of tags and MPLS. A new tag is added by PUSH action. When PUSH is run, a new header of a

specific type is added in front of ongoing outermost header. Current outermost tag is removed by POP action. A field containing newly added header is copied from existing field in current outermost header. If it not found, it is started to zero. By SET action, fresh values are then assigned to this outermost header. If contact with controller is lost, switch will be entered in either fail secure mode or fail standalone mode. The next version is uprated to maintain simultaneous connection with multiple controllers and the switch. The switch must ensure that it only sends messages to controller that corresponds to a command sent by that controller. Here, message is duplicated and a copy is sent to each controller. A controller may be one of the three following roles to a switch—Equal, Slave or Master. Equal and Master modes enable the controller to configure the switch. In case of Master mode, switch invokes that only one switch should be in Master mode and remaining in Slave mode. The multiple controller is for high availability requirements.

5 SDN and MPLS Operation

In open SDN environment, only controller is credible for all the operations of whole network. As controller itself contains a control plane, SDN switch forwards the packet matching with the presently defined flows. Only controller can make changes to flow table. As a network is not able to do any changes and controller can felt SOF (single point of failure). But here upon detecting a failed node by using distributed intelligence of network, it will reconfigure itself to overcome single point of failure problem. The network will use an alternate route which is calculated by controller using IGP extractions.

MPLS is not an encapsulation technique; it works on label swapping method for data forwarding. In architectural framework of MPLS, it decouples transport from services. Decoupling might be done by encoding instructions in packet headers. Instruction stacking is another important feature of MPLS. Stacking resembles to providing chain of instructions. SDN era started with OpenFlow protocol. OpenFlow works by assuming that there is a central controller software running as virtual machine or directly on host OS of server. There must be IP connectivity between controller and switches by using either out-of-band signalling or in-band signalling. Flow table is an important state of OpenFlow switch. Let one host send packet to another host. When packet arrives at a port connecting to the switch, switch realizes that this particular flow is not programmed on its flow table and then its control agent sends packet to controller. Controller had previously learnt location of the host and programs new accordingly on the switch. Afterwards, the switch can forward flow packets to destination host. Label edge routers (LERs) compute traffic engineering database (TED) according to distributed link state database. When it has TED view, controller performs path calculations and asks different LERs of the network to signal, resignal or tear down LSPs in the proper manner. To do this, controller can use a method of protocol abstraction to signal LSPs which is much more scalable

and preferred way. Such protocols are called as Path Computation Element Protocol (PCEP). The Provider Edge (PE) function is distributed in service endpoints. The device with Virtual Forwarding and Routing or terminate psuedowire (PW) link becomes service endpoint.

In IGP domain, many path reservation techniques are available such as Resource Reservation Protocol (RSVP), Source Packet Routing in Networking (SPRING), Label Distribution Protocol (LDP). Four MPLS-TE builders are LDP, RSVP-TE, BGP and IGP. When two neighbours establish LDP sessions, they start to exchange label mapping messages which are associated with IPv4 prefixes to MPLS labels. It helps in forming label information base (LIB). RSVP-TE reserves resources along paths in Internet [8]. It is most powerful, robust and flexible MPLS signalling protocol. The constraint shorted path (CSPF) procedure initiated at very first router (head-end router) to create best path (LSP) by using RSVP [9]. For tunnel establishment, two types of RSVP messages are used, RSVP- PATH and RSVP- RESV. The very first router sends PATH message to last router (tail-end router) which contains tunnel creation information. Tail-end router then replies to head-end router by forwarding RESV message which follows similar reversed path to the head-end router. Bandwidth is the significant parameter to be considered while creating tunnel. If available bandwidth is not sufficient to fulfil requirement of tunnel, then PATH message will stop at immediately not reverting to source and ERROR message will be forwarded to last (tail-end) router. In such events, it does not create tunnel. To elect best path, CSPF uses IGP extractions [9]. The discovered shortest path may not be best to be used currently. Cisco's auto-bandwidth allocator is used to adjust bandwidth automatically. At every interval, applied flow data rate is monitored, and highest value is recorded and is used as a reference value to modify tunnel bandwidth of upcoming interval. Path alteration is done by first router. Whenever topology changes or congestion occurs, first router obtains message by RSVP that the path will not be preserved. Then, it removes faulty links and creates new TE database [10].

6 Our Contribution

The latency of plain-vanilla MPLS-VPN network that offers the fastest tunnelling method amongst currently available methods in the industry is observed. Figure 4 shows MPLS-VPN network. All routers are running OSPF, and MPLS is enabled on all the interfaces. Let there are three customers, viz. Customer A, Customer B and Customer C. Tunnels are reserved for all the customers for connecting their branch offices as shown in Fig. 4. RSVP is enabled on all interfaces for reserving tunnel path. When different load conditions are applied, time required for end-to-end packet delivery was found to be varying. R1-R2-R3 is the best path for Customer A which is currently being used if link R2-R3 is congested. When Customer B is forwarding traffic on its site using path R1-R2-R3-R6, controller will sense congestion on link

R2-R3 and notify R1 to forward traffic to path R1-R4-R5-R6-R3. Now, if link R4-R5 gets congested or damaged then controller will sense congestion through R4 and notify R1 to forward traffic via R1-R4-R7-R8-R9-R6-R3. With this, there is no latency as controller is already programmed with all possible routes to reach all customer sites, and therefore, path allocation is dynamic and random. Path reservation is not used. The said process is very fast as it saves the time required for creating MPLS tunnels, readjustment of MPLS tunnels, removing tunnels, path allocation by RSVP or some other reservation method.

The same scenario is implemented using OpenvSwitches and SDN controller and is depicted in Fig. 5. The SDN controller was preprogrammed with the flow entries, and it had reserved the resources for all customers with respect to the bandwidth requirements of the customers. Figure 6 exhibits the entire operation for controlling routers through SDN controller. Routers just keep the record of bandwidth utilization. But they are not concerned for backup path creation, as statistics collected from OSPF extension headers are calculated by SDN.

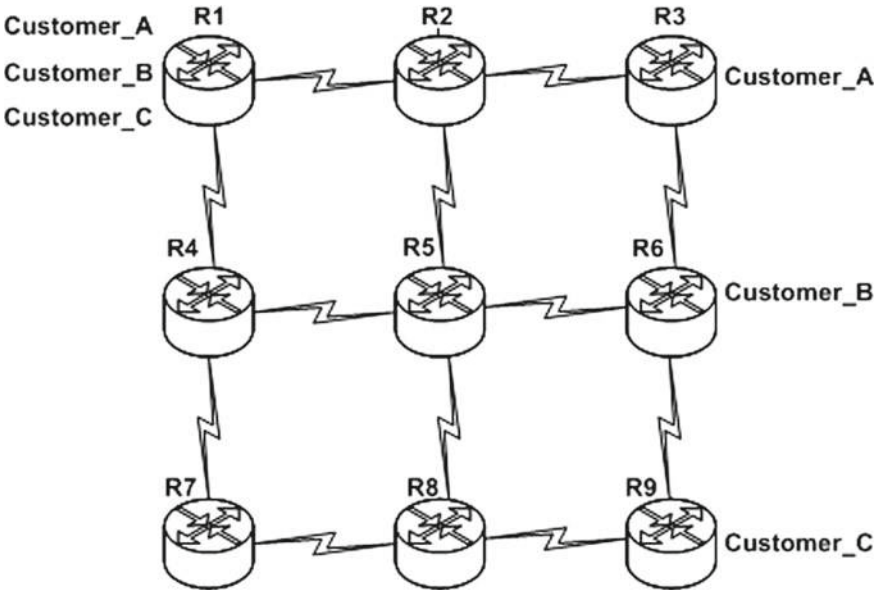

Fig. 4 MPLS-VPN network

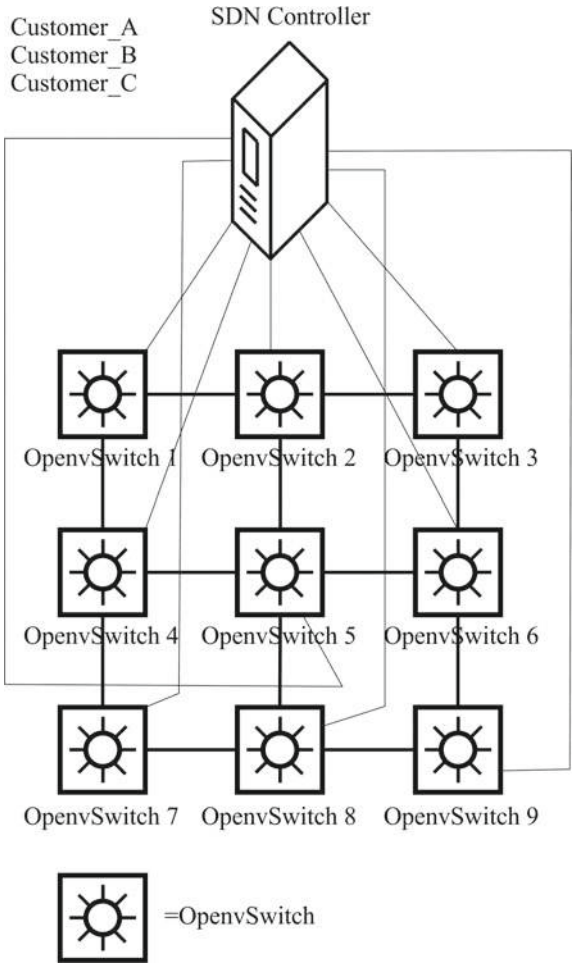

Fig. 5 Network with OpenvSwitches and SDN controller

Figure 7 shows comparison of bandwidth vs. latency for a SDN controller and MPLS. It proves that increase in latency reduces the available bandwidth in MPLS whereas bandwidth availability increases in SDN. However, if one particular link is shared by all the customers then efficiency of that link will be degraded. Our future work will propose a solution to this problem.

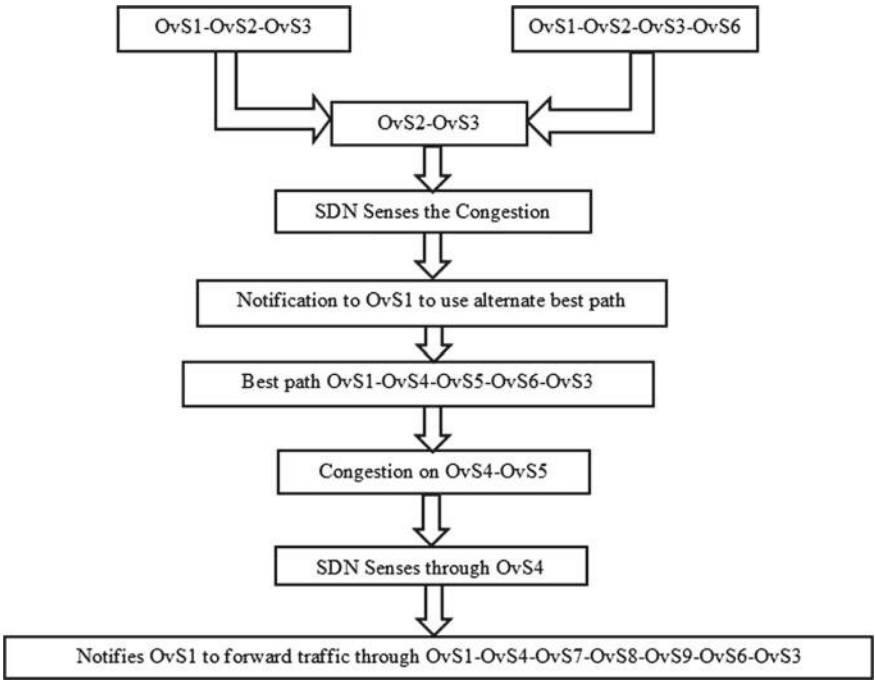

Fig. 6 Controlling OvS through SDN

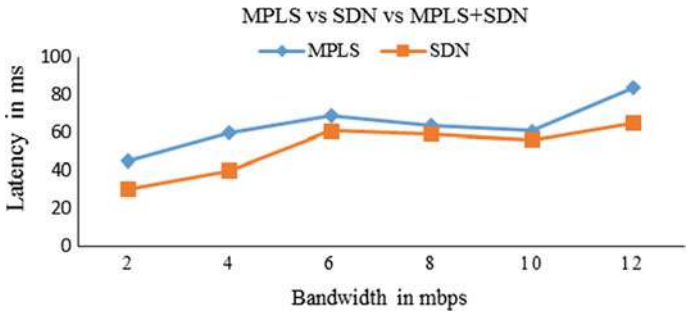

Fig. 7 Bandwidth versus latency comparison of SDN and MPLS

7 Conclusion

The active formation of MPLS tunnels using conventional method is fast, but when applied load increases, tunnel creation time gets affected. Also, increase in latency reduces the available bandwidth and the network requires high duration of time to manipulate the path of MPLS tunnel if modern path passes via some number of sources and/or there is heavy load over the network. To address these issues, use

of software-defined networking controller is suggested to take packet forwarding decisions. This helps to achieve less latency in spite of heavy loads. SDN programming makes the network more responsive than it was with conventional MPLS-TE environment.

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Enhanced Surveillance Using Integration of Gait Analysis with Iris Detection

Authors Authors and affiliations

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Abstract

The programmed way of establishing and validating the existing person upon their corporal and observable characters are termed as biometric technology. Due to the accuracy of the iris recognition, it becomes more dominant in the available biometric techniques. The current study aims at a new technology for iris recognition which helps us to identify a human by the iris from various places. This method is more valid and protected when compared with the other biometric technologies. In this biometric, the human characters are used which will not change during the lifetime of that particular individual. The time taken for identification of individual human is very less. Iris recognition uses the uniqueness of the eye and the information is stored in the iris database. The movement of the human individual is recognized by the gait analysis and iris recognition is more liable in the existing biometric systems. The study mainly focuses on the iris preprocessing, edge detection, and feature extraction, finally gait and iris fusion classification techniques in the research area. Without the help of a particular individual, we can use the gait analysis for iris recognition. The security places such as banks, places which are used in elections, military installations and even airport, where more restriction to provide the details of the human use this biometric technology.

Keywords

Human identification Biometric recognition Challenge–response test
Iris image acquisition Normalization Feature extraction

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Image steganography using contourlet transform and matrix decomposition techniques

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Abstract
This paper presents the transform domain image steganography schemes using three popular matrix factorization techniques and contourlet transform. It is known that security of image steganography is mainly evaluated using undetectability of stego image when steganalyzer examines it in order to detect the presence of hidden secret information. Good imperceptibility only suggests eavesdropper's inability to suspect about the hidden information; however stego image may be analyzed by applying certain statistical checks when it is being transmitted through the channel. This work focusses on improving undetectability by employing matrix decomposition techniques along with transform domain image steganography. Singular value decomposition (SVD), QR factorization, Nonnegative matrix factorization (NMF) are employed to decompose contourlet coefficients of cover image and secret is embedded into its matrix factorized coefficients. The variety of investigations include the effect of matrix decomposition techniques on major attributes of image steganography like imperceptibility, robustness to a variety of image processing operations, and universal steganalysis performance. Better imperceptibility, large capacity, and poor detection accuracy compared to existing work validate the efficacy of the proposed image steganography algorithm. Comparative analysis amongst three matrix factorization methods is also presented and analyzed.

Keywords Image steganography · Contourlet transform · Singular value decomposition · QR factorisation · Non-negative matrix factorisation · Universal steganalysis

1 Introduction

With the rapid growth of multimedia technology, computer networks are subjected to malicious attacks. Privacy and security of information is the most promising issue in our digital life. One of the traditional ways to secure information while it is being transmitted through the channel includes its encryption. However, encrypted messages are obvious and reveal

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secret communication when intercepted. Preprocessing overhead is an additional burden to obtain an encrypted form of secret information. These constraints pose a serious demand for an alternative for secure information transfer over the Internet. Here, steganography can provide the solution as it hides the message in a multimedia object such that its very presence is not revealed.

Steganography is the art and science of hiding the secret message in the suitable multimedia carrier such that it is unseen for everyone except the intended recipient. It is the branch of information hiding that deals with covert communication. Another branch of information hiding is watermarking, though looks similar to steganography, works on different perspectives and hence different design problems. Image steganography deals with hiding secret information in a digital image. Due to redundancy, images are the most popular file format used for hiding the secret. In image watermarking, primary importance is to the cover as mostly employed for copyright protection and similar authentication schemes whereas in image steganography significant is the covert message and not the cover(here a digital image). So embedder is free to choose any cover that may not be related to the secret message and will result in the least detectable stego [34].

Image steganography is broadly classified into two classes; the spatial domain where the secret is embedded by replacing pixel values of the cover image directly and transform domain where the secret is embedded in transform coefficients of the cover image. The later is the scope of this study(and not the pixel based strategies). Several studies available in transform domain image steganography are reviewed and significant studies are only discussed here. Transform domain image steganography was evolved with embedding in Discrete Cosine Transform (DCT) domain; JPEG being the most popular file format on the Internet. A global adaptive region based embedding in the DCT domain was put forward by Rabie et al. [26]. Imperceptibility results were obtained using a variety of block sizes and capacities. To summarise the results, it was observed that a cover image of size 512×512 when embedded with the secret image of size 430×430 and a block size of 64×64, offered a stego image with PSNR of 32.2 dB. Since image quality metric for particular capacity possesses quiet low value, a scope for improvement exists.

Another DCT based steganography scheme was discussed by Saidi et al. [27]. DCT decomposition of cover and scanning DCT coefficients in a zigzag form from least significant to most significant one yielded AC coefficients of interest. Using a chaotic map, embedding locations were selected and bit by bit embedding was carried out. The scheme was shown to have good imperceptibility.

With the development of JPEG2000, usage of Discrete Wavelet Transform (DWT) is explored in many image processing applications. DWT based steganography schemes in which secret information was embedded in either of the DWT sub-bands with some pixel-based embedding strategies could be found in the literature. RDWT-QR based image steganography scheme was discussed by Subhedar et al. [35]. They proposed a cover selection method based on statistical texture analysis to choose the cover from the image database in such a way that it gives the least detectable stego image. Steganalysis results were obtained and found to be satisfactory.

Curvelet transform is also being employed in the domain of image steganography. The curvelet transform is a multiscale directional transform that allows an almost optimal non-adaptive sparse representation of objects with edges. As curvelet transform has a sparse representation and offers improved compression possibilities, it also has better denoising performance. Very few curvelet-based schemes were presented in literature and include [9] and [21]. Image Steganography based on hybrid curvelet transform and genetic algorithm was proposed by Mohamed et al. [22]. LSB based embedding was employed and genetic

algorithm based choice was made to embed secret bits so as to achieve better results in terms of imperceptibility.

Recently, some steganography techniques were discussed using Fresnelet transform. This transform has been used for reconstruction of the image from FT hologram with various parameters like wavelength, a distance between object and image plane and resolution of an image. Blind data hiding method using Fresnelet transform was presented in [20]. A coded pattern of information was embedded in particular framelet sub-band. For payload of 263,222 bits, PSNR value was observed to be 32.90 dB. High capacity image steganography based on framelet transform and compressive sensing was proposed by Xiao et al. [41]. Compressive sensing was applied to secret data and its singular values were embedded in low-frequency sub-bands of cover. Stego image was obtained by hiding the secret image of size 256×256 in the cover of size 512×512. It has been observed that, as the sampling rate was varied from 1 to 0.6, PSNR value was increased from 41 dB to 43 dB; however normalized correlation value dropped from 1 to 0.9927. Furthermore, authors have not commented on robustness to attacks and steganalysis performance of their scheme.

Ogiela et al. presented false and multi secret steganography [23]. As the system consists of multiple secrets, steganography will be broken once the real or true messages are revealed. Revealing the false message will not lead to any information loss. Ker presented theoretical and practical aspects of the square root law of steganography [14]. Denmark et al. proposed steganography with multiple JPEG images [6]. Security comparison was made when a single JPEG image and multiple JPEG images were employed for steganography.

For large-scale multimedia applications, image steganography was proposed by Li et al. in which Cosine transform was employed and capacity of 21.5 bpp was obtained with SNR of 38.24 dB [18]. Another high capacity image steganography scheme was proposed by Rabie et al. [25] A multiscale Laplacian pyramid of the cover image in the wavelet domain was employed to achieve data embedding. They found appropriate hiding locations using a curve - fitting adaptive region approach in the DCT domain. Results quoted high embedding capacity. Thanki et al. presented an image steganography technique based on Finite Ridgelet Transform (FRT) and DWT. Arnold scrambling was applied to the secret image and this hybrid scheme demonstrated results in terms of imperceptibility, robustness and computational complexity [38]. However, the authors did not provide any comments with respect to the scheme's steganalysis performance.

A hybrid and high capacity image hiding technique for secure transmission and integrity of color radiological images was proposed by Borra et al. [3] Imperceptibility results were good and capacity of 8 bpp was obtained. Coverless information hiding based on generative model was presented by Duan et al. They generated a meaning-normal and independent image different but visually the same from the secret image. The meaning-normal image was only required to be transmitted hence the model was named as coverless [8]. Subramanian et al. proposed a steganography scheme wherein skin tone regions were identified and secret image encrypted using Lagrange interpolation was embedded. The method resulted in good imperceptibility [36]. Fakhredanesh et al. presented DWT HVS based scheme. Here, message size was very less and no comments were observed regarding detectability and robustness [10]. Another DCT based approach discussed by Debnath et al. includes pixel based embedding scheme. Imperceptibility was good but on steganalysis performance was not verified [5]. Another similar approach based on DCT was proposed by Ghosh et al. [11]. PSNR values were found to be poor and no steganalysis performance was exhibited by the authors.

In spite of the availability of several schemes in transform domain image steganography; less detection accuracy by steganalyzer is not guaranteed suggesting poor security. In steganography, the major attribute is the ability of stego image to remain undetectable. Though some of the schemes discuss steganalysis results using only steganalysis tools developed for pixel based embedding styles, security results are not promising while maintaining high capacity. Performance judged using blind steganalysis methods can be proved to be optimum to validate the security of stego images in terms of undetectability. In literature, very few schemes are found to apply these methods for verifying detectability. This paper addresses these issues and presents comparison of three different secure and high capacity image steganography schemes in the transform domain using various matrix decomposition techniques.

2 Contourlet transform

An image is the best candidate for cover media during secret communication. Images can be effectively modeled and analyzed hence images are widely employed to implement steganography image steganography is more popular. In transform domain steganography, choice of transform plays a significant role as imperceptibility depends on suitable embedding locations which are transform coefficients. Wavelet transform offers a multi-scale and time-frequency localized image representation. The wavelets provide a very sparse representation for piecewise smooth signals due to which wavelets are used in many signal processing applications. However, the separable wavelet transform does not work efficiently in higher dimensions. Wavelets are good at catching edge points but do not prove optimum for smoothness along contours. It demands the need for more powerful representation rich in directions. Wavelet transform suffers from the drawback of subband mixing. If we alter one coefficient in diagonal subband it will have an effect on the value of relevant coefficients in other directions too. To overcome this drawback, Contourlet Transform (CT) is the best solution as it allows for image decomposition at separate directions. One of the measures of sparsity is the decay of coefficient magnitude. In wavelets, coefficients decay as $O\left(N^{-1}\right)$ and in contourlets, coefficients decay as $O\left(N^{-\frac{3}{2}}\right)$. So wavelets provide suboptimal sparse representation and contourlets have sparser representation.

Contourlet not only possesses the main features of wavelets but also offers a high degree of directionality and anisotropy [7]. CT mainly consists of two-dimensional non-separable filter banks. The first filter bank is known as Laplacian pyramid and second is called a directional filter bank as shown in Fig. 1. Burt and Adelson introduced the concept of the Laplacian Pyramid (LP) to achieve multiscale decomposition. The original signal is first lowpass filtered and then downsampled to obtain the coarse approximation. It is further employed to predict the original signal by calculating the difference as the prediction error that results in a bandpass image. LP involves implicit oversampling whereas wavelet transform is the critically sampled scheme and is an orthogonal decomposition. In wavelet filter bank, the highpass channel is folded back into low-frequency band and hence the spectrum is reflected resulting into scrambled frequencies. Though implicit oversampling is a drawback of LP, it also has the distinguishing feature of generating only one bandpass image at each pyramid which has no scrambled frequencies as that of the wavelet transform. These bandpass images can now be fed to Directional Filter Bank (DFB) to reveal directional information. Bamberger and Smith constructed a 2-D DFB that can be maximally decimated while achieving perfect reconstruction.

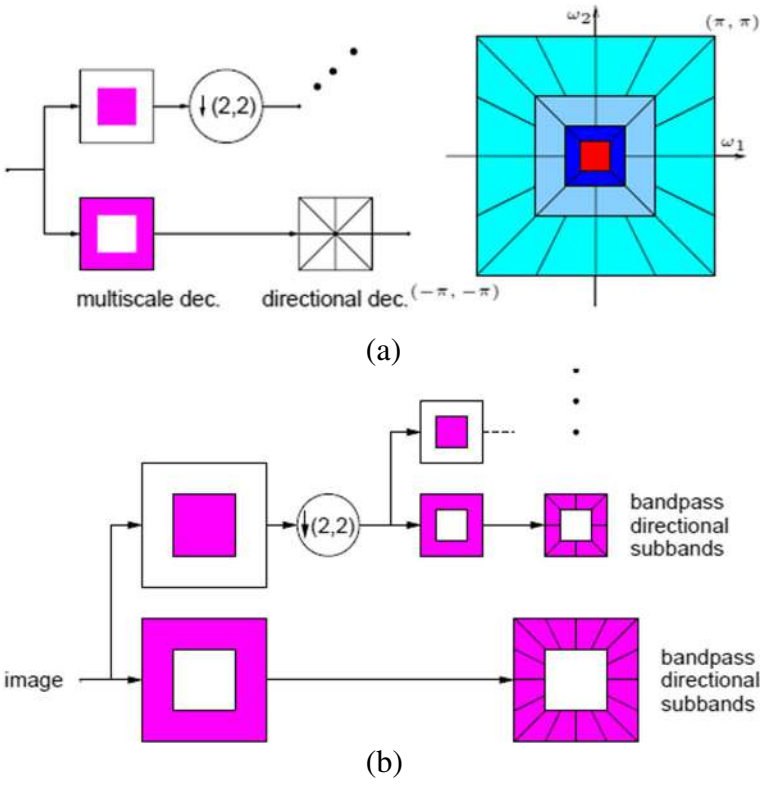

Fig. 1 **a** Frequency response **b** Contourlet filter banks

Level of the transform decides the number of directional sub-bands. The contourlet decomposition gives one coarse image approximation and sub-bands depending on the number of levels. It involves basis functions that are oriented at any power of twos number of directions with flexible aspect ratios. Hence, Contourlets can represent a smooth contour with fewer coefficients as compared with wavelets as they can capture segments of contours with elongated supports.

Each contourlet sub-band is represented as sub-image $\{C_{ld}(a, b), a = 1 \ldots M, b = 1 \ldots N\}$, where l is the scale level used by low pass filter and d is the frequency direction of filter bank. Figure 2 illustrates Level 2 contourlet decomposition of Peppers image. At each successive level, the number of directional sub-bands is 2, 4, 8, and 16. For Peppers image of size 512×512, with level two contourlet decomposition we get total 327680 contourlet coefficients.

3 Matrix factorisation techniques

3.1 SVD overview

SVD is one of the most important analysis tools in linear algebra and is specially used for the analysis of matrices. It is related to the theory of diagonalizing a symmetric matrix in

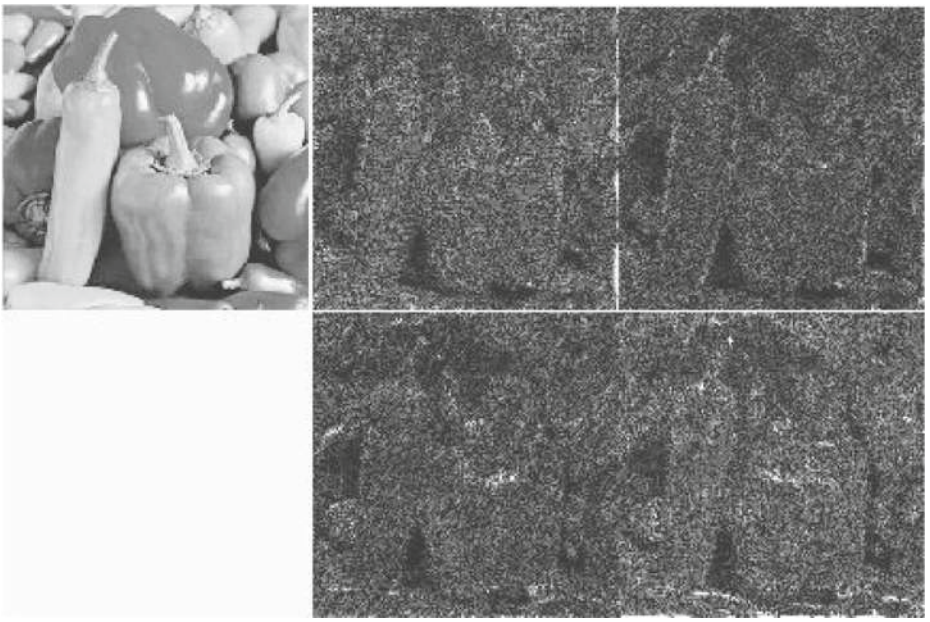

Fig. 2 Level 2 contourlet decomposition for Peppers showing coarse image and directional sub-bands

which a matrix can be decomposed into three sub-matrices, U, S and V^T. U and V are the orthogonal square matrices and S is the rectangular diagonal matrix. Any real matrix A can be represented as,

$$\begin{aligned} A &= USV^T \\ A &= \begin{bmatrix} u_{1,1} & .. & u_{1,N} \\ ... & .. & ... \\ u_{N,1} & ... & u_{N,N} \end{bmatrix} \begin{bmatrix} \sigma_1 & .. & 0 \\ ... & .. & ... \\ 0 & .. & \sigma_N \end{bmatrix} \begin{bmatrix} v_{1,1} & .. & v_{1,N} \\ ... & .. & ... \\ v_{N,1} & ... & v_{N,N} \end{bmatrix} \end{aligned} \tag{1}$$

The columns of U are the eigen vectors of AA^T; columns of V are the eigen vectors of A^TA; D is the diagonal matrix that consists of non-negative, real values called the singular values arranged diagonally in the descending order such that $\sigma_1 \geq \sigma_2 \geq \ldots \geq 0$. Singular values can be calculated as the square roots of eigen values. Due to extensive mathematical properties and stability against certain image processing operations, SVD is the most popular tool used in applications like steganography, watermarking, image compression, recognition systems etc.

3.2 QR factorisation overview

Several matrix factorisation techniques like singular value decomposition, LU decomposition, QR decomposition, Schur decomposition etc. result from solutions of linear equation. QR decomposition or QR factorisation [2] is a decomposition of the matrix into an orthogonal matrix and a triangular matrix. Any real matrix A can be expressed as,

$$[\text{Q R}] = \text{qr(A)} \tag{2}$$

where 'Q' is the orthogonal matrix and 'R' is the upper triangular and invertible matrix such that $A \in R^{n\times k}$, $Q \in R^{n\times k}$ and $R \in R^{k\times k}$. Similar to QR factorisation is LU factorisation

however, QR factorisation proves to be more accurate for least square problems. Also, LU factorisation can be applied to only square matrices whereas QR factorisation can be applied to the rectangular and square matrices. The first row elements in matrix R have much larger absolute values and contribute to most of the energy. Another interesting feature is their resistance to several signal processing operations, such as lossy compression, noise addition and filtering.

3.3 Non-negative matrix factorisation overview

Non-negative matrix factorization (NMF) is developed as a matrix factorization technique, which decomposes non-negative matrices into physically meaningful data in two dimensional signal analysis, and has been used for image representation, document analysis and clustering for its parts based representation property. NMF results in a reduced representation of the original data. Thus, NMF can also be a feature extraction or a dimensionality reduction technique. One major drawback of SVD is that the basis vectors may have both positive and negative components, and the data are represented as linear combinations of these vectors with positive and negative coefficients. In many applications, the negative components contradict physical realities. To address this problem, the NMF approach was proposed to search for a representative basis with only non-negative vectors.

The NMF approach can be formulated as follows. Given a cover image C of size $m \times m$, we can approximately factorize C into the product of two non-negative matrices B and H with sizes $m \times r$ and $r \times m$ respectively, that is $C = B \times H$. The non-negative matrix B contains the NMF basis vectors, and the non-negative weight matrix H contains the associated coefficients (non-negative weights). To measure the quality of the approximation factorization $C = B \times H$, a cost function between C and BH needs to be optimized subject to non-negativity constraints on B and H.

In the embedding process, due to good capability of local decomposition for non-negative matrix factorization, the maximum elements in the matrix H denotes the local most distinct features under the basis matrix W. Thus, the scheme can achieve a better local embedding algorithm, and the robustness [16, 17].

4 Proposed methods

This section presents three transform domain image steganography schemes designed with SVD, QR and NMF decomposition techniques. These schemes benefit from goodness of contourlet transform and mathematical properties of respective decomposition techniques. Multiscale and multidirectional nature of contourlet transform allows smooth contours to be captured for the images rich in directional details. This section is divided into three subsections; one each for embedding and extraction algorithm using each matrix decomposition technique and contourlet transform. Framework is exhibited in Fig. 3.

4.1 CT-SVD algorithm

Any image is basically a matrix of non negative scalar values hence SVD can be applied to process digital image. Before the actual embedding process, coefficients of fourth directional band are further decomposed in a set of uncorrelated coefficients and then the embedding is carried out. A stepwise approach for embedding and extraction algorithm is presented below:

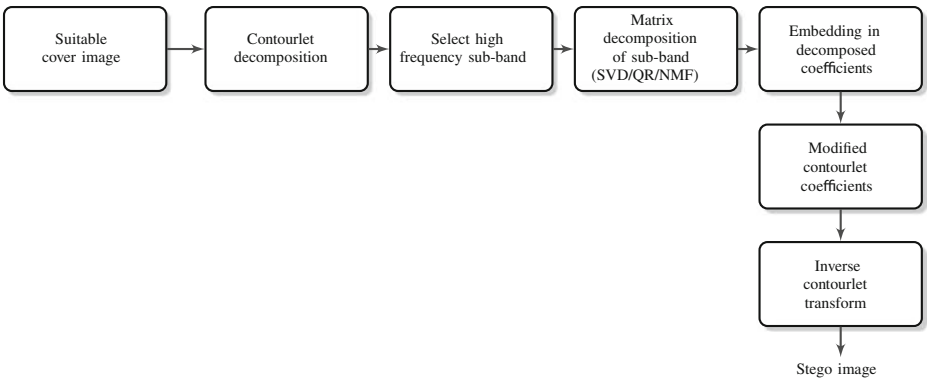

Fig. 3 Framework for proposed embedding algorithm

1. Perform level 2 contourlet transform on cover image $C(i, j)$. It gives one coarse image and four directional sub-bands. Here, size of image is 512 × 512. Level two contourlet decomposition results in four directional sub-bands, each of size 256 × 256. Total contourlet coefficients are 327680; out of these fourth sub-band consists of 65536 coefficients. Choice of sub-band to embed data matters in embedding phase. We have selected highest frequency sub-band for embedding as it consists maximum energy suggesting the presence of directional edges.
2. In order to increase security, scrambling operation is performed. Arnold transformation is most popular way to achieve scrambling. A two dimensional Arnold transform is given by,
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (mod N) \tag{3}$$
where x and y are pixel coordinates and N is height or width of image. Level of scrambling is known as period of Arnold transformation. The best degree of scrambling refers to number of iterations when scrambling is optimized. Here, this period is used as secret key. It offers second layer of security to proposed scheme. Without knowledge of secret key, exact retrieval of secret information can not be guaranteed.
3. Let $C = f(x, y), 0 \leq x \leq M, 0 \leq y \leq N$ denotes original cover image where $f(x, y)$ is intensity of image at point (x, y). Similarly, let $I = f(z, w), 0 \leq z \leq M, 0 \leq w \leq N$ be secret image to be embedded in cover.
4. Preprocessing: RGB cover image of size 512 × 512 is converted to grayscale. We have used cameraman grayscale image from USC-SIPI image database as secret image. It is resized to 256 × 256.
5. CT decomposition: Contourlets can represent a smooth contour with fewer coefficients as compared with wavelets as they can capture segments of contours with elongated supports.CT decomposition of cover image results in one coarse image and four sub-bands each of size 256 × 256.
$$\mathrm{C}^{\theta} \Leftarrow \Im(C), \tag{4}$$
where $\Im(.)$ denotes the CT decomposition.
6. SVD factorisation of sub-band: Fourth directional subband is further decomposed into U, S and V matrices.
$$[\mathrm{U} \times \mathrm{S} \times \mathrm{V}] \Rightarrow \mathrm{svd}[\mathrm{C}^{\theta}] \tag{5}$$
Here, θ refers to fourth directional sub-band.

7. Embedding secret information: Secret information is embedded in S matrix.

$$S' \Rightarrow (S + \alpha * I) \tag{6}$$

Scaling factor (α), also known as embedding strength is chosen experimentally to achieve better imperceptibility.

8. Obtain stego: Obtain modified sub-band coefficients and apply inverse CT to form stego image.

$$\mathrm{S} \Leftarrow \Im^{-1}(\mathrm{C}^{\theta}) \tag{7}$$

4.1.1 Extraction algorithm

When stego is transferred over insecure public channel, it may undergo some common image processing attacks in an attempt to either detect or extract secret information. These operations will degrade perceptual quality of image. Steganography algorithm should be designed in such a way that a scheme should survive in presence of all such attacks and do not allow an attacker to suspect data hiding locations. Transform domain steganography helps to achieve this goal and provides better robustness as compared to spatial domain schemes. Secret information can be recovered as follows.

1. Decompose Stego: Compute level 2 CT of stego image and obtain modified sub-band.

$$\mathrm{S}^{\theta} \Leftarrow \Im(\mathrm{S}), \tag{8}$$

2. Apply SVD decomposition: Compute modified singular value coefficients and extract secret using,

$$[\mathrm{U}_1 \times \mathrm{S}_1 \times V_1] \Rightarrow \mathrm{svd}[\mathrm{S}^{\theta}] \tag{9}$$

$$S' = \frac{1}{\alpha}(S_1 - S') \tag{10}$$

where S' is extracted secret information.

3. Using secret key in Arnold transformation, retrieve secret image.

4.2 CT-QR algorithm

In this subsection, image steganography based on CT and QR decomposition is explained. Proposed scheme benefits from Multiscale and multidirectional nature of contourlet transform and low computational complexity of QR factorisation. Embedding and extraction procedure can be summarized as follows.

1. Steps 1 to 4 explained in CT-SVD algorithm subsection are performed.
2. CT decomposition: CT decomposition of cover image results in one coarse image and four sub-bands each of size 256×256.

$$\mathrm{C}^{\theta} \Leftarrow \Im(\mathrm{C}), \tag{11}$$

where $\Im(.)$ denotes the CT decomposition.

3. QR factorisation of sub-band: QR factorisation is one of the matrix decomposition techniques like SVD. However, it's less computational complexity $O(n^2)$ and properties of R matrix make it suitable candidate for image steganography. In addition, it solves false positive issue in SVD based information hiding schemes and is suitable for real life applications. Fourth directional sub-band is further decomposed into Q and R matrices.

$$[\mathrm{Q} \times \mathrm{R}] \Rightarrow \mathrm{qr}[\mathrm{C}^{\theta}] \tag{12}$$

4. Embedding secret information: Secret information is embedded in R matrix.

$$R' \Rightarrow (R + \alpha * I) \tag{13}$$

5. Obtain stego: Obtain modified sub-band coefficients and apply inverse CT to form stego image.

$$\mathrm{S} \Leftarrow \Im^{-1}(\mathrm{C}^{\theta}) \tag{14}$$

4.2.1 Extraction algorithm

Secret information can be recovered as follows.

1. Decompose Stego : Compute level 2 CT of stego image and obtain modified sub-band.

$$\mathrm{S}^{\theta} \Leftarrow \Im(\mathrm{S}) \tag{15}$$

2. Apply QR decomposition: Compute R coefficients and extract secret using,

$$[\mathrm{Q}_1 \times \mathrm{R}_1] \Rightarrow \mathrm{qr}[\mathrm{S}^{\theta}] \tag{16}$$

$$S' = \frac{1}{\alpha}(R_1 - R') \tag{17}$$

where S' is extracted secret information.

3. Using secret key in Arnold transformation, retrieve secret image.

4.3 CT-NMF algorithm

1. CT decomposition: Contourlets can represent a smooth contour with fewer coefficients as compared with wavelets as they can capture segments of contours with elongated supports. CT decomposition of cover image results in one coarse image and four sub-bands each of size 256×256.

$$\mathrm{C}^{\theta} \Leftarrow \Im(\mathrm{C}), \tag{18}$$

where $\Im(.)$ denotes the CT decomposition.

2. NMF factorisation of sub-band: Fourth directional sub-band is further decomposed into w and h matrices.

$$[\mathrm{w} \times \mathrm{h}] \Rightarrow \mathrm{nmf}[\mathrm{C}^{\theta}] \tag{19}$$

3. Embedding secret information: Secret information is embedded in h matrix.

$$h' \Rightarrow (h + \alpha * I) \tag{20}$$

4. Obtain stego: Obtain modified sub-band coefficients and apply inverse CT to form stego image.

$$\mathrm{S} \Leftarrow \Im^{-1}(\mathrm{C}^{\theta}) \tag{21}$$

4.3.1 Extraction algorithm

Secret information can be recovered as follows.

1. Decompose Stego : Compute level 2 CT of stego image and obtain modified sub-band.

$$\mathrm{S}^{\theta} \Leftarrow \Im(\mathrm{S}), \tag{22}$$

2. Apply NMF decomposition: Compute h_1 coefficients and extract secret using,

$$[\mathrm{w}_1 \times \mathrm{h}_1] \Rightarrow \mathrm{nmf}[\mathrm{S}^{\theta}] \tag{23}$$

$$S' = \frac{1}{\alpha}(h_1 - h') \tag{24}$$

where S' is extracted secret information.

3. Using secret key in Arnold transformation, retrieve secret image.

5 Simulation results

An efficient steganography scheme should have high embedding capacity, better imperceptibility and high security. Increase in embedding capacity may cause noticeable distortions in stego and degrades visual quality. A trade-off must be obtained in embedding capacity and imperceptibility while maintaining security. In this section, performance of proposed steganography algorithm is verified in terms of imperceptibility, robustness to image processing attacks and undetectability in the presence of steganalyzer. Various image quality metrics used to assess visual quality of stego images are listed below.

5.1 Quality metrics

– Peak signal to noise ratio (PSNR): It is the most popular image quality metric used for assessment stego image quality and is given by,

$$\mathrm{PSNR} = 20\log_{10}\frac{255}{\mathrm{RMSE}} \tag{25}$$

– Structural similarity index (SSIM): It compares local patterns of pixel intensities that have been normalized for luminance and contrast. The MSSIM metric is calculated on various windows of an image. The measure between two windows x and y of common size $N \times M$ is computed as:

$$\mathrm{MSSIM(X,Y)} = \frac{1}{M}\sum_{j=1}^{M}\mathrm{SSIM}(\mathrm{x_j}, \mathrm{y_j}) \tag{26}$$

Where X and Y are cover and stego images respectively, x_j and y_j are image contents at j^{th} local window, and M is number of windows. SSIM is computed as,

$$\mathrm{SSIM}(x, y) = \frac{(2\mu_{\mathrm{x}}\mu_{\mathrm{y}} + \mathrm{C_1})(2\sigma_{\mathrm{xy}} + \mathrm{C_2})}{(\mu_{\mathrm{x}}^2 + \mu_{\mathrm{y}}^2 + \mathrm{C_1})(\sigma_{\mathrm{x}}^2 + \sigma_{\mathrm{y}}^2 + \mathrm{C_2})} \tag{27}$$

where σ_x is mean intensity of x, σ_y is mean intensity of y, σ_x^2 is variance of x, σ_y^2 is variance of y, σ_{xy} is variance of x and y, $C_1 = (K_1 L)^2$, $C_2 = (K_2 L)^2$ are two variables to stabilize division with weak denominator, L= dynamic range of pixel values (255 for 8-bit gray scale image), K_1=0.01 and K_2=0.03 by default. As SSIM compares two images based on luminance, contrast and structure, it is worth to validate the algorithm.

– Universal image quality index (UQI): Here, quality measurement is independent of images being tested, viewing conditions and observers. So quality assessment with this metric is more meaningful than traditional metrics. This metric models any distortion as a combination of three different factors; loss of correlation, luminance distortion and

contrast distortion. Let $x = x_i | i = 1, 2, \ldots N$ and $y = y_i | i = 1, 2, \ldots N$ be original and test image respectively. It is given by,

$$Q = \frac{\sigma_x y}{\sigma_x \sigma_y} \frac{2\bar{x}\,\bar{y}}{(\bar{x}^2) + (\bar{y}^2)} \frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2} \tag{28}$$

The first component represents correlation coefficient between x and y, second component measures how close mean luminance is between x and y. The third component measures how similar the contrast of images are.

– Normalised correlation coefficient (NCC): It suggests degree of similarity between cover and stego. It's value lies between -1 and 1. If two images are exactly identical, value will be 1; if they are completely opposite, value will be -1. The value will be 0 if two images are uncorrelated. Let $C(i, j)$ represents cover, $C'(i, j)$ is the stego image.

$$NCC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[C(i, j) - \mu_c][C'(i, j) - \mu_{c'}]}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[(C(i, j) - \mu_c)^2]}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[(C'(i, j) - \mu_{c'})^2]}} \tag{29}$$

where μ_c & $\mu_{c'}$ is mean of cover and stego respectively.

– Image fidelity (IF):

$$IF = 1 - \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}(C(i, j) - C'(i, j))^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}(C(i, j))^2} \tag{30}$$

Fig. 4 Cover Images from USC-SIPI image database

(a) (b) (c)

Fig. 5 Stego images **a** Airplane **b** Lake **c** Peppers obtained with proposed CT-SVD, CT-QR and CT-NMF methods

– Bit error rate (BER):

$$BER(C, C') = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} C'(i,j) \oplus C(i,j)}{M \times N} \times 100 \tag{31}$$

5.2 Imperceptibility assessment

Test images from USC-SIPI image database [40] are used to verify imperceptibility and robustness offered by proposed image steganography method. Cover images used to carry secret image are depicted in Fig. 4. All cover images are gray scale images of size 512 × 512. It includes Splash, Tiffany, Mandrill, Airplane, Peppers, Lena, Pirate, Boat and Elaine. Grayscale Cameraman image of size 512 × 512 is used as secret image and is embedded in each cover image using embedding algorithms discussed in Section 4. Figure 5 shows stego images for visual quality assessment. Subjective measurement includes identification of any noticeable distortions in stego images with naked eye. From Fig. 5, it is evident that all stego images are of good visual quality and it is difficult to suspect about the presence of hidden information in them for all three proposed steganography schemes. Figure 6 exhibits secret images extracted from stego image for three schemes respectively.

(a) (b) (c)

Fig. 6 Extracted secret images from **a** CT-SVD, **b** CT-QR and **c** CT-NMF scheme

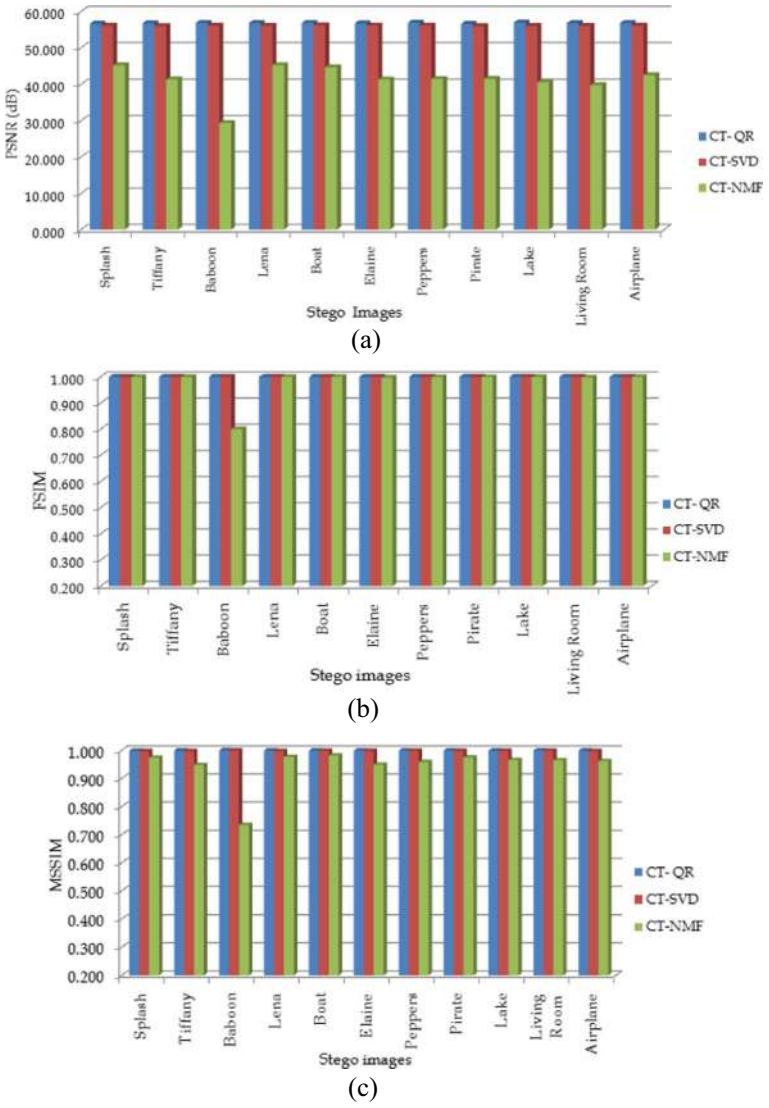

Fig. 7 Imperceptibility assessment using image quality metrics **a** PSNR **b** FSIM **c** MSSSIM

Figures 7 and 8 demonstrate objective assessment using image quality metrics PSNR, MSSIM, FSIM, IF, NC and UQI values for stego images shown in figure Fig. 5. It is known that MSE and PSNR are inconsistent with the HVS and UQI evaluates the loss of correlation, luminance distortion and contrast distortion. SSIM considers image degradation as perceived change in structural information. Hence, the performance measure of UQI and SSIM are better than the MSE and PSNR. MSSIM, IF, NC and UQI should be ideally 1 and PSNR should be more than 25 dB. As can be seen from Figs. 7 and 8, all quality metrics have values in desired range and confirm better imperceptibility. Average PSNR for CT-QR, CT-SVD and CT-NMF was 57 dB, 57 dB and 42 dB. PSNR in CT-NMF was obtained with

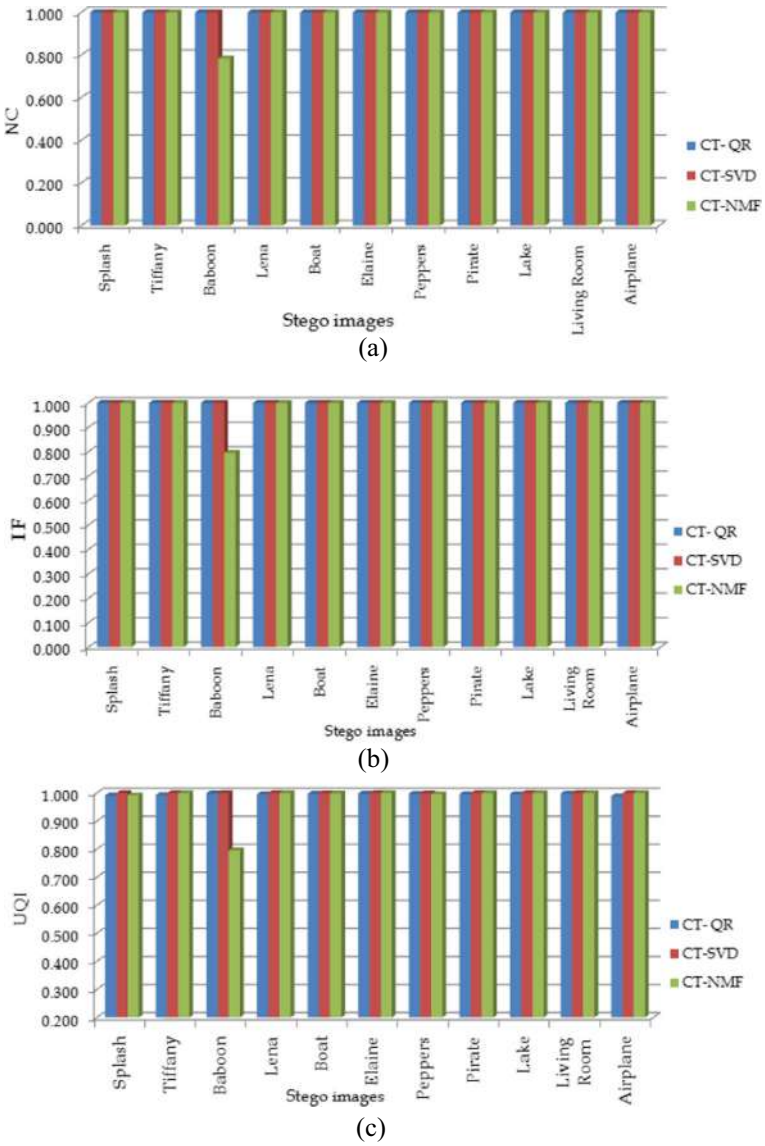

Fig. 8 Imperceptibility assessment using image quality metrics **a** NC **b** IF **c** UQI

same scaling factor as that used in other two schemes so as to compare results on similar ground. However, it can further be improved by modifying the scaling factor as per cover image. Similarly other metric values can also be improved.

Imperceptibility performance of proposed steganography algorithm is also verified for test images from two popular image databases; UCID database [30] and Washington image database [1]. 1000 test images from UCID database and 500 test images from Washington database are selected randomly. Using three proposed image steganography algorithms, stego images were obtained and quality of stego images was evaluated. Table 1 exhibits

Table 1 Image quality metrics for UCID and Washington database

Algorithm	PSNR	MSSIM	IF	UQI	FSIM	NC
UCID image database						
CT-QR	76.78	1	1	0.9904	1	1
CT-SVD	53.75	0.9981	1	0.9629	1	1
CT-NMF	38.36	0.9767	0.9995	0.8996	0.9982	0.9989
Washington image database						
CT-QR	76.79	1	1	0.9896	1	1
CT-SVD	53.77	0.9983	1	0.9668	1	1
CT-NMF	38.06	0.99	0.999	0.8814	0.9985	0.9987

average PSNR, MSSIM, IF, UQI, FSIM and NC values. It can be confirmed that stego quality is superior for all the images in two image databases and validates the proposed steganography algorithms. It was found that CT-QR is superior than CT-SVD and CT-NMF schemes in terms of imperceptibility.

5.3 Robustness to attacks

When stego images are passed over the network, intruder may try either to retrieve secret information or to destroy it. For a steganographer, it is crucial to design the steganography algorithm robust to all such attacks. Stego images were exposed to variety of image processing and geometric attacks. A list of attacks includes rotation by 85° sharpen, addition

Table 2 Robustness evaluation using peak signal to noise ratio

Nature of attack	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
Rotate by 85	27.29	27.29	27.29	27.32	27.32	27.31	26.89	26.90	26.89
Crop	26.97	26.97	26.97	29.20	29.20	29.19	27.52	27.52	27.52
Resize [1024 1024]	48.17	48.09	44.66	45.04	45.04	41.59	47.15	47.14	44.40
Gaussian noise [0.0.01]	28.81	28.81	28.81	28.77	28.76	28.75	28.76	28.74	28.74
S and P noise [0.01]	46.96	46.60	43.05	46.76	46.63	40.33	46.79	46.58	43.02
Speckle noise [0.01]	30.06	30.05	30.00	28.09	28.10	28.09	29.42	29.40	29.39
Poisson noise	32.23	32.22	32.26	30.31	30.32	30.30	31.67	31.66	31.64
Sharpen	33.00	32.78	32.08	31.58	31.46	29.84	31.22	31.13	30.60
Dithering	58.93	56.14	45.20	58.77	56.00	41.35	58.67	56.07	45.25
Hist. Equalisation	35.56	78.25	48.20	68.35	78.25	78.25	55.35	78.25	78.25
Median filtering	39.97	39.95	39.94	37.60	37.60	37.08	36.53	36.53	36.50
Wiener filtering	40.65	40.63	40.31	37.70	37.71	37.22	37.89	37.89	37.70
Soft thresholding	18.48	18.48	18.46	9.24	9.24	9.24	18.38	18.38	18.38
Hard thresholding	55.59	53.13	41.06	55.82	52.99	36.64	55.82	53.07	42.36

Table 3 Robustness Evaluation using image fidelity

Nature of attack	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
Rotate by 85	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.85	0.85
Crop	1.02	1.02	1.02	1.00	1.00	1.00	1.00	1.00	1.00
Resize [1024 1024]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Gaussian noise [0,0.01]	0.98	0.98	0.98	1.00	1.00	1.00	0.99	0.99	0.99
S and P noise [0.01]	1.00	1.00	0.99	0.99	1.00	0.99	1.00	1.00	0.99
Speckle noise [0.01]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
Poisson noise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sharpen	0.99	0.99	0.99	1.00	1.00	1.00	0.99	0.99	0.99
Dithering	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hist.equalisation	1.02	1.02	1.02	1.00	1.00	1.00	1.00	1.00	1.00
Median filtering	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wiener filtering	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Soft thresholding	0.82	0.82	0.82	0.59	0.59	0.59	0.82	0.82	0.82
Hard thresholding	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

of different types of noise like Gaussian noise (mean=0, var=0.01), salt and pepper noise (0.01), speckle noise (0.02), poison noise with different amount of intensities, soft and hard thresholding, median and wiener filtering with a mask of 3×3, cropping, histogram equalization and JPEG compression with various quality factors etc. Resistance to these attacks is evaluated using quality metrics e.g. IF, NC, PSNR and BER. Tables 2, 3 and 4 depict metric values for three stego images Splash, Tiffany and Lena. It can be seen that PSNR values are high, IF and NC is close to 1 and BER is close to 0 in most of the cases; suggesting strong correlation and rare chances of error in spite of embedding large payload. It validates proposed scheme and it could resist all image processing attacks effectively. Further, it was observed that CT-QR method can withstand better in the presence of attacks compared to CT-SVD and CT-NMF schemes.

5.4 Effect of JPEG compression

Robustness to JPEG compression is another attribute for validation of proposed scheme. Results were obtained for quality factor ranging from 30 to 90. Tables 5, 6 and 7 depict PSNR, NC and IF values obtained after JPEG compression for all three schemes. These quality metrics are obtained using original cover and JPEG compressed stego image. As PSNR values are high and NC, IF values are close to 1, it is evident that proposed schemes are immune to JPEG compression.

5.5 Steganalysis performance

Steganalysis is the art of discovering whether or not a secret message is exist in a suspected image. Steganalysis does not however consider the successful extraction of the message. Steganalysis is a two class classification problem that classifies input image as either clean

Table 4 Robustness evaluation using bit error rate

Nature of attack	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
Rotate by 85	0.151	0.151	0.151	0.150	0.150	0.150	0.150	0.150	0.150
Crop	0	0	0	9.69E-04	9.69E-04	9.69E-04	0	0	0
Resize [1024 1024]	0	0	0	9.69E-04	9.69E-04	9.69E-04	0	0	0
Gaussian noise [0,0.01]	0.023	0.023	0.022	4.84E-04	4.84E-04	9.61E-04	5.33E-03	5.54E-03	0.005
S and P noise [0.01]	0.004	0.005	0.005	5.34E-03	5.10E-03	6.05E-03	4.99E-03	4.98E-03	0.005
Speckle noise	0	0	1.14E-04	3.01E-04	1.91E-04	9.69E-04	0	0	0
Poisson noise	0	0	1.34E-04	1.75E-04	1.14E-04	9.69E-04	0	0	0
Sharpen	0.006	0.006	7.37E-03	6.14E-04	6.03E-04	5.65E-04	0.007	0.007	7.04E-03
Dithering	0	0	1.14E-04	3.01E-04	1.91E-04	9.69E-04	0	0	0
Hist. equalisation	0	3.81E-06	3.81E-06	0	9.73E-04	9.73E-04	0	3.81E-06	3.81E-06
Median filtering	4.58E-05	4.58E-05	6.87E-05	3.20E-04	1.34E-04	1.01E-03	4.58E-05	4.58E-05	4.58E-05
Wiener filtering	0	0	0	9.69E-04	9.69E-04	9.69E-04	0	0	0
Soft thresholding	0	0	1.14E-04	3.01E-04	1.91E-04	9.69E-04	0	0	0
Hard thresholding	0	0 1.14E-04	3.01E-04	1.91E-04	9.69E-04	0	0	0	0

Table 5 Robustness to JPEG compression using PSNR

Quality factor	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
90	42.42	42.42	39.05	40.68	40.66	35.41	40.73	40.70	38.72
80	40.55	40.57	38.62	38.05	38.05	34.70	38.49	40	37.92
70	39.56	39.58	38.05	36.72	36.73	34.51	37.30	40.70	36.93
60	38.69	38.71	37.45	35.85	35.85	34.05	36.44	40.70	36.18
50	38.02	38.03	36.96	35.22	35.22	33.63	35.80	40.70	35.60
40	37.31	37.31	36.43	34.57	34.57	33.18	35.12	40.70	34.97
30	36.38	36.39	35.74	33.79	33.79	32.63	34.28	40.70	34.17

or stego. When test image is applied for decision of a class whether it belongs to cover or stego, classifier observes the feature statistics and takes decision according to,

$$decision = \begin{cases} I \in cover P(I \in cover \mid F_I > 0.5) \\ I \in stego P(I \in stego \mid F_I > 0.5) \\ No decision P(I \in cover \mid F_I = 0.5) \end{cases} \tag{32}$$

where $P(I \in stego|F_I)$ is the posterior probability of an image having feature vector F_I carrying a secret information. ROC based detection accuracy is computed using True Positives (TPs), True Negatives (TNs), False Positives (FPs) and False Negatives (FNs).

5.5.1 Blind steganalysis results

Blind steganalysis is a method used to detect whether there is a hidden message in a media without having to know the steganography algorithm behind it. This method consists of two steps feature extraction and classification. Here, five such methods are applied to test detectability of stego image. They are explained as follow:

1. Wavelet based steganalysis (WBS): This method was proposed in [19]. Stego image was decomposed using separable Quadrature Mirror Filters (QMFs). It divided frequency

Table 6 Robustness to JPEG compression using NC

Quality factor	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
90	1.000	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000
80	1.000	1.000	0.999	1.000	1.000	0.999	1.000	1.000	1.000
70	1.000	1.000	0.999	1.000	1.000	0.999	1.000	1.000	1.000
60	1.000	1.000	0.999	1.000	1.000	0.999	0.999	0.999	0.999
50	1.000	0.999	0.999	1.000	1.000	0.999	0.999	0.999	0.999
40	1.000	1.000	0.999	1.000	1.000	0.999	1.000	1.000	1.000
30	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Table 7 Robustness to JPEG compression using IF

Quality factor	Splash			Tiffany			Lena		
	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF	CT-QR	CT-SVD	CT-NMF
90	0.963	0.973	0.918	0.962	0.962	0.918	0.964	0.963	0.943
80	0.947	0.943	0.906	0.940	0.941	0.906	0.947	0.947	0.942
70	0.936	0.919	0.912	0.925	0.925	0.912	0.936	0.936	0.933
60	0.925	0.899	0.901	0.913	0.913	0.901	0.927	0.926	0.924
50	0.916	0.881	0.892	0.902	0.902	0.892	0.919	0.919	0.916
40	0.906	0.860	0.881	0.890	0.890	0.881	0.909	0.909	0.907
30	0.890	0.832	0.867	0.876	0.875	0.867	0.896	0.896	0.895

space into multiple scales and orientations using separable lowpass and highpass filters applied along image axes. First set of statistics included mean, variance, skewness and kurtosis of sub-band coefficients at each orientation and scale. The second set of statistics was based on errors in an optimal linear predictor of coefficient magnitude. The error statistics was computed for the vertical, horizontal and diagonal bands resulting in 4 dim feature vector. Non-linear SVM was used for classification. Detection accuracy was computed in terms of ROC.

2. Contourlet based steganalysis (CBS): This method was proposed in [29]. In CBS, each image was decomposed using Level 3 contourlet transform. For each of the eight sub-bands in third level, first four moments i.e. mean, variance, skewness and kurtosis of eight sub-bands and difference between actual and linear predicted coefficients result in 64 dimension feature vector. Non-linear SVM was used for classification.
3. The third steganalysis algorithm employed to verify detection accuracy is Gabor filter based steganalysis [33]. Features were extracted for the same set of cover and stego images. Here, feature dimension was 17000 for each image. Ensemble classifier was used to classify each test image as either clean or stego image.
4. Another steganalysis algorithm that works in JPEG domain is Markov process (MP) based JPEG steganalysis scheme. It utilizes both the intrablock and interblock correlations among JPEG coefficients [4, 15]. A feature vector of 486-dim was used and SVM was employed for classification.
5. Similar JPEG domain scheme was employed in [24]. Using DCT features and Markov features, blind steganalysis was carried out. Here, the feature vector size was 548 and SVM was used for classification.

To check steganalysis results, 500 test images from Washington image database were randomly chosen. Stego images were obtained for all these test images using proposed three image steganography schemes. A cameramen image was used as secret image. It is of size 512×512. Cover and stego features were extracted as per steganalysis scheme mentioned above and training dataset was generated. A set of 200 unseen cover and stego images was used for testing purpose. Non-linear SVM classifier classified sample image into cover or stego class. Figure 9 shows the effect of steganalysis using ROC based detection accuracy. It is said that when steganalyzer has detection accuracy of less than 0.6, steganography scheme is considered to be statistically undetectable against that steganalyzer. As is evident from Fig. 9, proposed steganography systems were highly secure as undetectable and validated the performance.

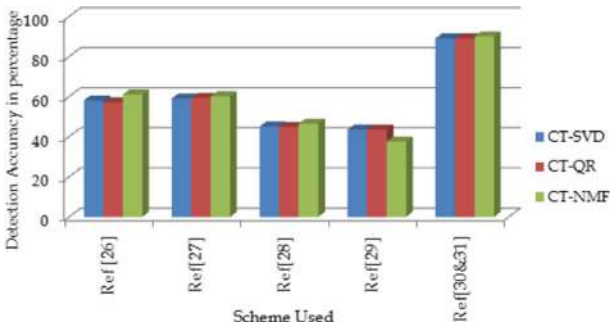

Fig. 9 Effect of steganalysis

5.6 Computational complexity

Figure 10 depicts comparison of computational complexity between CT - SVD, CT-QR and CT - NMF schemes. Embedding time, extraction time and total time required is computed for all three schemes. It was observed that CT-QR scheme requires lowest computational time amongst three. CT-NMF scheme requires more time than other two methods. However, it is also acceptable and less compared to existing works.

5.7 Comparison with existing works

Simulation results were compared with most of the existing works in transform domain. It was found that most of the transform domain schemes presented in literature have not commented on steganalysis performance of their schemes and hence steganalysis performance could not be compared. Also, in many schemes like [11] and [5], standard dataset images are not employed as cover for result analysis. Hence such comparisons are not included here. Image quality metrics comparison is depicted in Table 8. Results were also compared with Subramanian et al. scheme [36](2018). They found average PSNR equal to 52.25 dB which is low than offered by our CT-QR and CT-SVD methods. Though it is higher than our CT-NMF method, the amount of secret information embedded is very high in our work. So PSNR offered by CT-NMF is also acceptable. Authors did no mention clearly the size

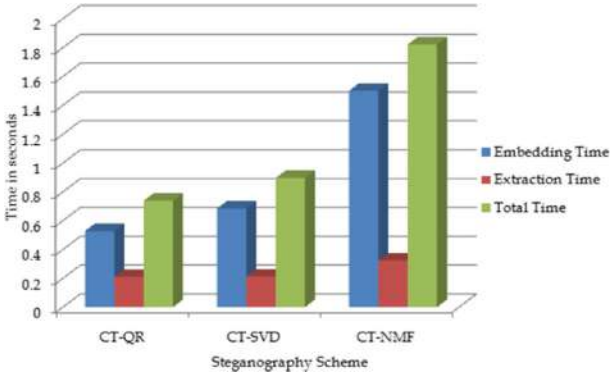

Fig. 10 Computational complexity

Table 8 Comparison of proposed scheme with existing methods

Algorithm	Secret size	Cover image	PSNR	SSIM	NCC	UQI	FSIM	IF
Thabit et al. [37]	49152 bits	Lena	43.29	–	–	–		
		Airplane	40.27	–	–	–	–	–
		Baboon	34.33	–	–	–	–	–
		Peppers	41.71	–	–	–	–	–
Sajasi et al. [28]	256 × 256	Lena	47.78	–	–	–	–	–
		Baboon	49.98	–	–	–	–	–
Kanan et al. [13]	256 × 256	Lena	45.12	–	–	–	–	–
		Airplane	45.18	–	–	–	–	–
		Peppers	45.13	–	–	–	–	–
		Baboon	45.12	–	–	–	–	–
Xiao et al. [41]	256 × 256	Framelet + SVD Lena (1)	41.23	–	1	–	–	
		Framelet +SVD + CS Lena (0.9)	41.30	–	0.9981	–	–	–
		Framelet +SVD + CS Lena (0.8)	42.17	–	0.9971	–	–	–
		Framelet +SVD + CS Lena (0.6)	43.12	–	0.9927	–	–	–
Subhedar et al.[35]	256 × 256	Lena	49.0369	0.9963	0.9996	0.9999	–	
		Airplane	49.2608	0.9971	0.9997	–	1	–
		Peppers	50.1480	0.9966	0.9997	−0.9999	–	
		Baboon	37.7031	0.9917	0.9966	–	–	–
		Splash	54.8019	0.9975	0.9996	–	1	–

Table 8 (continued)

Algorithm	Secret size	Cover image	PSNR	SSIM	NCC	UQI	FSIM	IF
Gulave et al[12]	78.7Kb	Lena	39.84	0.953	–	0.806	–	–
		Peppers	40.29	0.932	–	0.8	–	–
		Barbara	39.70	0.964	–	0.857	–	–
		Elaine	40.01	0.956	–	0.890	–	–
		Baboon	39.62	0.979	–	0.961	–	–
Mohammad et al.[32]	12288 bits	Lena	53.78	0.9959	–	–	–	–
		Barbara	51.61	0.9961	–	–	–	–
		Airplane	54.17	0.9963	–	–	–	–
Proposed CT-SVD	512 × 512	Splash	56.13	0.99	1	1	1	1
		Baboon	56.12	0.99	1	1	1	1
		Lena	56.07	0.99	1	1	1	1
		Elaine	56.14	0.99	1	1	1	1
		Peppers	56.15	0.99	1	1	1	1
Proposed CT-QR	512 × 512	Splash	56.67	0.99	1	0.99	1	1
		Baboon	56.88	1.00	1	1.00	1	1
		Lena	56.85	0.99	1	0.99	1	1
		Elaine	56.75	0.99	1	0.99	1	1
		Peppers	56.95	0.99	1	0.99	1	1
Proposed CT-NMF	512 × 512	Splash	45.202	0.974	1.000	0.992	0.999	1.000
		Baboon	29.374	0.734	0.784	0.796	0.800	0.795
		Lena	45.248	0.976	1.000	1.000	1.000	1.000
		Elaine	41.291	0.948	1.000	1.000	0.997	1.000
		Peppers	41.443	0.958	1.000	0.997	0.999	0.999

of secret used for embedding and robustness performance. They also did not mention effect of steganalyzer.

The image steganography scheme presented by Maheshwari et al. [39] employs DCT, DWT and Contourlet transform and optimization techniques. This approach yielded an average PSNR of 52.56 dB and an embedding capacity of 902,136 bits. In present case average PSNR 57 dB , 57 dB and 42 dB which is quite high for all three schemes.

The scheme presented by Thanki et al.[38](2018) was also compared with proposed schemes. In Thanki et al. scheme, when inserting factor was 4, 2 and 0.2, average PSNR values were observed to be 38.10 dB, 32.12 dB, 58.42 dB and average NC value was 1. In proposed method, average PSNR values for CT-QR, CT-SVD and CT-NMF are 57 dB, 57 dB and 42 dB. PSNR in CT-NMF was obtained with same scaling factor as that used in other two schemes so as to compare results on similar ground. However, we can improve that PSNR by modifying the scaling factor. It shows that our scheme possess better PSNR than two sub schemes of Thanki et al. scheme. Embedding a secret 256×256 in a cover of 256×256 offered average PSNR of 41 dB in [31](2018). Proposed scheme offers PSNR of 76 dB, 53 dB and 38 dB for QR, SVD and NMF based algorithms. This suggests that proposed scheme has better imperceptibility than schemes presented in [31, 36, 38].

6 Conclusion

This work demonstrates a comparison of transform domain image steganography schemes using contourlet transform and three well-known matrix decomposition techniques SVD, QR, and NMF factorization. Three transform domain image steganography schemes were developed by embedding the secret image in matrix decomposed contourlet coefficients and stego was obtained. It was observed that the scheme based on QR decomposition provided better results in terms of imperceptibility and robustness as compared to schemes employing SVD and NMF techniques. SVD stood second amongst three and provided better imperceptibility results and is robust as compared to the NMF scheme. The all three schemes i.e. CT-QR, CT-SVD, and CT-NMF were found to possess poor detection accuracy by five blind, universal steganalysis schemes and suggested very high security while maintaining large payload of the secret image of size 512×512. The CT-QR scheme required very less time for embedding and extraction as compared to CT-SVD and CT-NMF schemes. All three schemes were computationally efficient.

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Optimizing MPLS Tunnel Creation Performance by Using SDN

Snehal Patil and Mansi S. Subhedar

Abstract In today's world, many high-speed enterprise links are running on MPLS. For enterprises, it is not possible to migrate to SDN technology directly and smooth transition of MPLS networks onto SDN needs to be ensured. This paper aims at optimizing the MPLS performance by coupling it with SDN. SDN controller uses some features of MPLS-TE to read network statistics. Based on the input of OSPF extension headers, SDN will reroute the traffic whenever there is congestion. The controller is preprogrammed with flows written from OpenFlow Manager. Whenever there is some change in topology or network statistics, packet header will be modified as per the flows and it will be rerouted.

Keywords MPLS · VPN · Traffic engineering · Software-defined networking OpenFlow controller

1 Introduction

Multiprotocol label switching (MPLS) can be implemented as per the network requirements, within Internet service provider (ISP) network. This will lead to the formation of MPLS labels for each network and creation of Label Forwarding Information Base (LFIB) on each provider router as well as and Provider Edge Router to enable multiprotocol label switching. For MPLS traffic engineering, tunnels need to be created through which particular customer data can be routed from source to destination [1]. The Resource Reservation Protocol (RSVP) let reserve resources for a particular customer. However, a dynamic allotment of resources can be set just to avoid wastage of resources in idle or low traffic hours. It may lead to a problem

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when the reserved resources are used by some other clients and at the same time the owning network of the reserved path has peak traffic hours. This would ultimately lead to congestion. It can be avoided by either dropping existing traffic or making the reserved resources free for the owning network or by providing an alternate path for the existing traffic and set the reserved path clear for new traffic of the owning network. To provide alternate paths to existing traffic and/or incoming traffic, we need to create alternate tunnels from source to destination. The alternate tunnels can be created statically or dynamically. In static method, ISP's network administrator has to learn the entire ISP network and configure alternate tunnels for each network (client). In dynamic method, alternate tunnels can be created automatically and can be brought into up state whenever required. However, this dynamic learning may take up some time to learn the current network status and pass it to other provider routers to form new tunnel [2].

In this work, practical implementation of software-defined networks (SDNs) in real-world networks and its ability to increase the efficiency of a network if working alongside MPLS or as a standalone application is demonstrated. High network availability and no congestion are most important criteria for ISPs, in order to meet service-level agreement (SLA) terms agreed by ISP and the client. We have primarily focused on avoiding congestion or link breakdown by providing alternate paths in case of congestion or link failure. Multiple paths must be made available to increase network availability, convergence and to maintain a proper flow. These paths can be learnt dynamically or statically [3].

2 SDN Architecture

The SDN framework is illustrated in Fig. 1 which is divided into three parts: southbound interface, northbound interface, and the controller. The southbound interface contains all the forwarding devices. The northbound interface consists of all the applications used to write flows. The controller is used to actually manipulate traffic or change the routing policies on the forwarding devices. The forwarding devices should run an agent to communicate with controller [3]. Here, the role of the agent is performed by Open Version Switch (OVS). The flows are instructions stating how the traffic should be forwarded or which modifications need to be done if required before forwarding. The flows are written into the OVS. It performs forwarding and path manipulation task on the basis of the written flows. OpenFlow Manager (OFM) which uses OpenFlow protocol is employed to write the flows. Southbound interface provides a way for SDN controller to communicate with network forwarding devices that includes packet handling instructions, loads, notification of links going up or down, and providing statistics like flow counters. Examples are OpenFlow, OVSDB, NETCONF, and SNMP [4, 5].

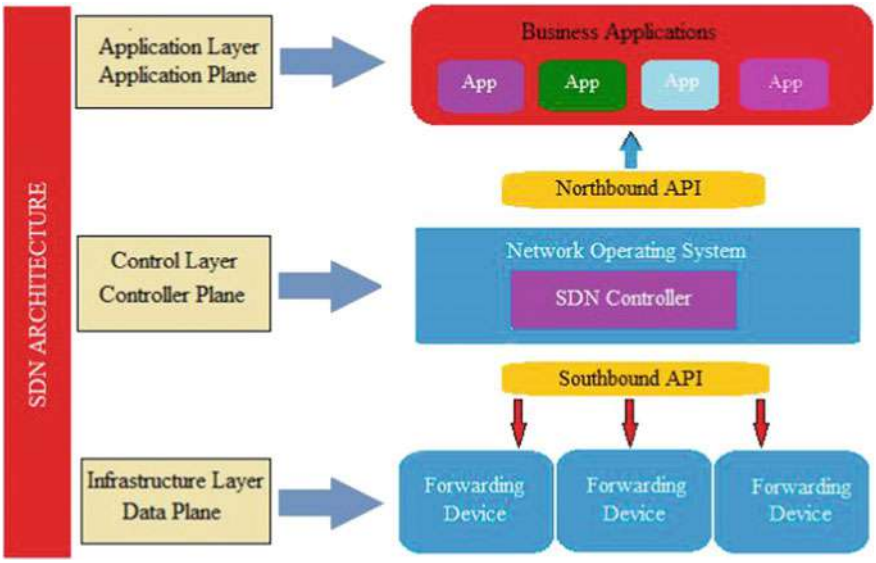

Fig. 1 SDN architecture

SDN controller provides services like:

1. Topology: It finds out connectivity between the devices. It basically describes the structure of the topology.
2. Inventory: It keeps record of devices which are enabled with SDN and itemization-related data of the same. This information includes rendition for the protocols that have been used and their capabilities.
3. Statistics: It reads counter information to monitor traffic on flows, interfaces, and flow table.
4. Host Tracking: It is used to determine where IP address or MAC address is located in a network.
5. Application interfaces include java API which forms the northbound interface (mostly RESTConf is used) [6]. It allows usage for https announcement approaching controller to govern system actions along with a collection of data. The network application lets us to write and/or edit network policies.

3 OpenFlow Protocol

The OpenFlow protocol module is depicted in Fig. 2 OpenFlow channel is used to form a connection between the switch and the controller. At a time, switch can be connected to one or more controllers. The OpenFlow channel carries basic Packet-IN, Packet-OUT, and Flow-MOD packets. There can be single otherwise additional flow

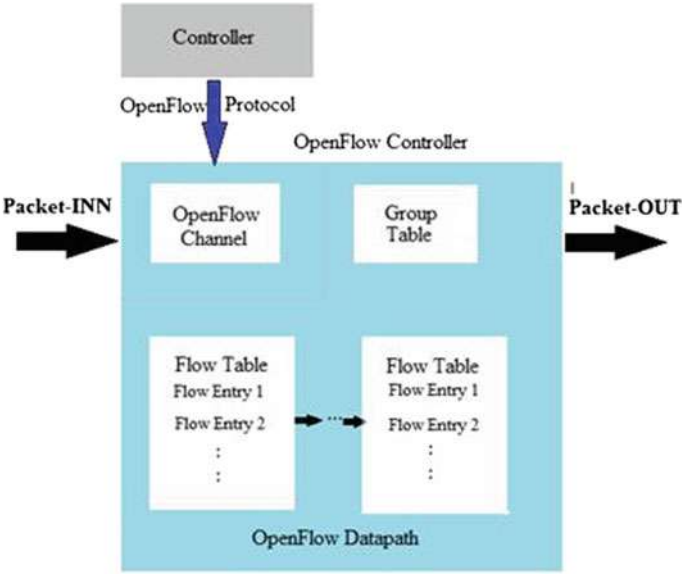

Fig. 2 OpenFlow protocol module and components of OpenFlow

tables within switch. Every flow table has a unique ID. By default, a flow table with 0 ID is created [7]. The flow tables are scanned in ascending sequence. Each group table has a unique identifier and an action bucket. The identifier is used to uniquely identify a group table, and action bucket contains a set of actions. Group tables are meant for same flow actions with different match criteria. This is similar to multicast. It allows you to change Flow-MOD for multiple flows in just one instance. Figure 3 exhibits working of OpenFlow protocol with controller. Whenever an OpenFlow switch receives a packet, it first checks its local flow table. If an entry is found, it takes the following action, else it is a table-miss and it passes packets to the controller which is the default action.

The switch forwards a Packet-IN report to the controller. This message might consist of either whole packet or a part of it along with a Buffer ID which is used as a reference to the packet. The controller now can send either:

- Packet-OUT: It is a normal forwarding information message.
- Flow-MOD: It instructs the switch to create a new entry and perform one or more actions on the packet.

Timers are basically used to restrict a count for entries of flow table which avoid flooding. Each timer can be disabled by setting it to 0. The switch might have multiple flow entries for the same packet. The choice is based on the priority of the flow [8, 9]. The flow having a numerically highest priority gets the first preference. Timers associated with the OpenFlow entries are:

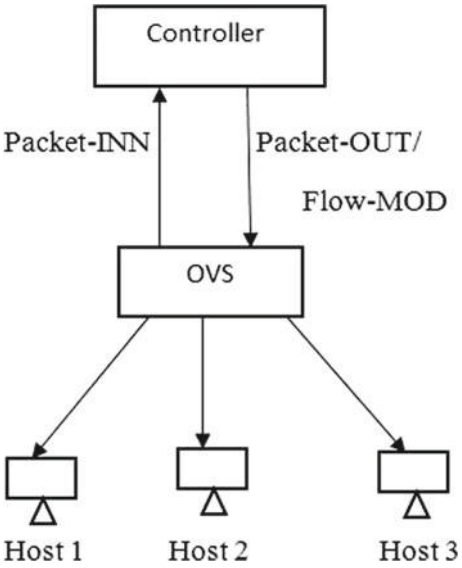

Fig. 3 OpenFlow protocol working with controller

1. Idle Timer: If no match is found for an entry, it will be removed from the table. Default timer value is 20 s.
2. Hard Timer: When this timer is over, entry is discarded irrespective of whether any match exists or not.

4 RSVP Operation and MPLS Traffic Engineering

RSVP is a Resource Reservation Protocol which retains routers (resources) beside the paths in network. It operates over an IPv4 and IPv6 Internet layer and gives recipient-originated setup for reservations of resources of multicast or unicast data flows with scaling and robustness. Application data is never transported by RSVP. However, it resembles protocols, like Internet Control Message Protocol (ICMP) or Internet Group Management Protocol (IGMP). Host or routers use RSVP to demand or hand over required level of quality of service (QoS) to application data streams or flows. RSVP specifies how applications keep reservations and how they can discontinue the reserved resources until the necessity of it has ended. RSVP actions commonly outcome in resources being reserved in each node along a path [10].

Traffic engineering is extremely important for service provider and Internet service provider (ISP) backbones. As high bandwidth availability and no latency are important criteria for ISP, they should take care of bandwidth availability. Also, a network should be highly flexible, therefore such backbones be able to bear up failures of link or node. MPLS is combination of data link layer and network layer technologies. By combining data link features with network layer, MPLS performs

traffic engineering. Hence, the one-tier system of connections should be obtained just by combining network layer connections with data link connections. MPLS traffic engineering [MPLS-TE] spontaneously builds and also retains label switched paths (LSPs) throughout the network by the use of Resource Reservation Protocol. The route utilized by a given LSP at indiscriminate bit of period is determined based on the LSP resource requirements and network resources, such as bandwidth. Available resources are flooded via extensions to a link-state-based Interior Gateway Protocol (IGP). Paths for LSP are calculated at LSP head based on a fit between required and available resources (constraint-based routing). IGP automatically routes the traffic onto these LSPs. Typically, a packet crossing MPLS traffic engineering backbone travels on a single LSP that connects the ingress point to the egress point.

MPLS-TE uses Interior Gateway Protocols like Intermediate System-to-Intermediate System, Open Shortest Path First, to inescapably map packets toward the proper traffic flows. It send traffic flows over the system by the use of MPLS expedition. The paths of packet flows throughout the backbone are determined based on required traffic flow resources also feasibility of resources. MPLS-TE also uses "constraint-based routing," where a route of a packet forwarding is the shortened route which appropriates resource needs (constraints) of the packet flow. Traffic flow has different requirements like bandwidth, media, and priority versus other flows. It repairs link or node breakdowns which alters connections of network by modifying to advanced set of constraints [10, 11].

5 Our Contribution

This paper aimed to optimize the procedure for dynamic learning of alternate paths or tunnels. The technic of optimizing the performance is explained as follows. Each P and PE router will be now connected to a central controller. The routers will inform their traffic statistics to the controller. For communication between controller and routers, an interface is required. Open Version Switch (OVS) is used for this function. The OVS instance will run for each network, i.e., for each interface of a router. Whenever a packet is going through the network which is running an instance of OVS, the packet is first sent to the controller and controller replies with the flows which are then populated in the flow table. These flows will decide the forwarding path for traffic.

Consider a topology consisting of nine routers. There are three customer sites, namely Customer-A, Customer-B, Customer-C. For customer-A to reach it's another site, there are nine possible paths. For customer-B to reach it's another site, there are nine possible paths. For customer-C to reach it's another site, there are 11 possible paths. These all paths are preprogrammed in SDN controller [12] (Fig. 4).

OpenFlow is about forwarding data to appropriate destination. In this approach, path reservation protocol like RSVP used in literature is not employed. Here, SDN controller dynamically provides the path to appropriate router obtained using OSPF extensions and by considering congestions. The role of router inside the network is

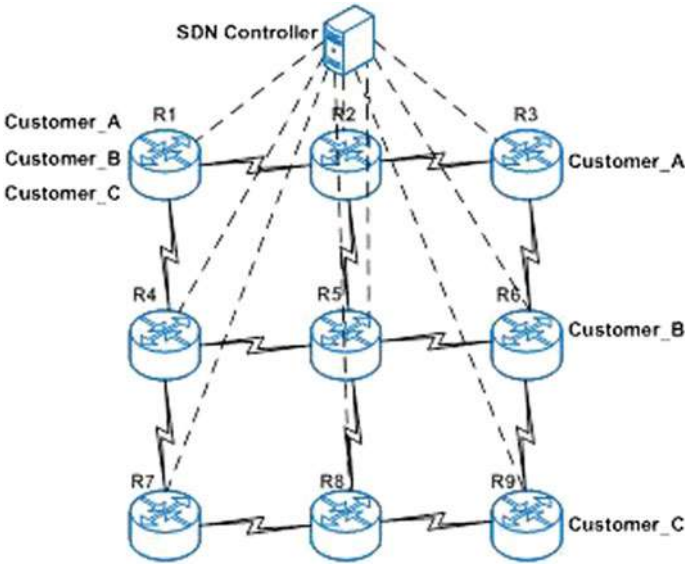

Fig. 4 Network with MPLS+SDN

to just keep records of link congestion based on available bandwidth and bandwidth utilization of the concerned outgoing interfaces and report the same to SDN controller. The controller is already programmed on how to calculate the best path based on different bandwidth requirements and associated SLAs. If a particular link gets crowded which is part of the best path, controller will sense the congestion and will notify to the penultimate congested router to use less congested path. SDN controller will be the only decision maker. It will notify the routers about the path to be used.

The northbound interface contains OpenFlow Manager (OFM) which uses OpenFlow protocol (OFP) as shown in Fig. 5.

The OVS is connected to the OFM through port 8080 which is a standard port for connectivity amid the controller and the switch. OFM's user interface can be obtained at port 9000. The OFM can be used to change network policies or write new flows on to the forwarding devices. The integration of OFM is done using C programming and Python and is an open-source platform. Figure 6 shows congestion control using SDN. The OFM together with OVS reads the network statistics from the forwarding device remotely. The new flows according to the changing traffic conditions through the OFM can be written. Every packet consists of the Explicit Congestion Notification (ECN) bit, which adopts the two rightmost bits of the Diffserv field in the IPv4 or IPv6 header for encoding the following code points:

1. Non-ECN Capable Transport, Non-ECT—00
2. ECN Capable Transport, ECT(0)—10
3. ECN Capable Transport, ECT(1)—01
4. Congestion Encountered, CE—11.

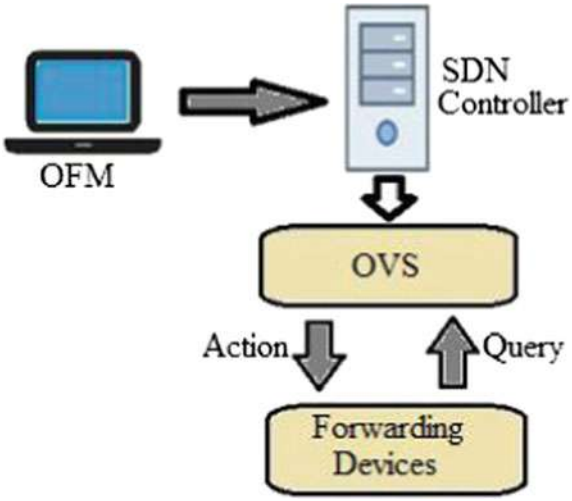

Fig. 5 SDN and OFM interaction

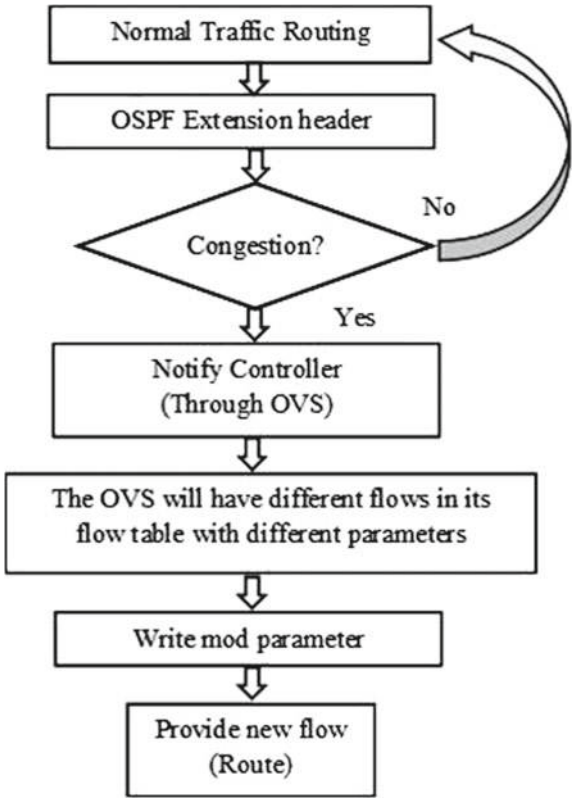

Fig. 6 Congestion control using SDN

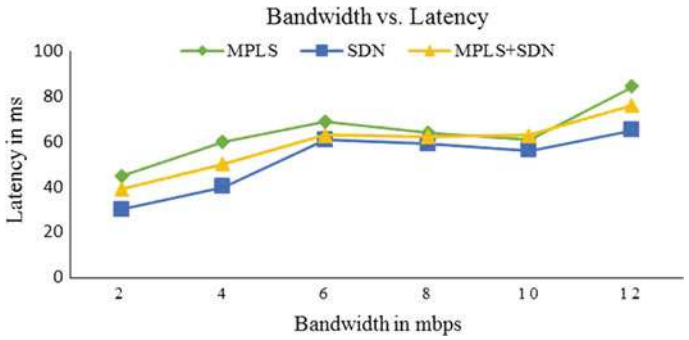

Fig. 7 Comparison of bandwidth versus latency of MPLS, MPLS+SDN, and SDN

If one and other extreme ends support ECN, their packets are stamped as ECT(0) or ECT(1) as congestion encountered intimation may only be managed efficiently by an upper-layer protocol that supports it. ECN is used in alliance with upper-layer protocols, such as TCP. Figure 7 displays a comparison of latency and bandwidth for MPLS, SDN, and MPLS+SDN. It can be observed that coupling with SDN yields better results and latency can be reduced considerably [13].

6 Conclusion

MPLS coupled with SDN responses to sudden topology changes at a faster rate as compared to conventional MPLS-TE performance. When SDN controller is used to calculate statistics collected from OSPF extension headers, latency for end-to-end packet delivery is reduced and response time of network to tackle congestion has also been reduced. Programming enables the administrator to control congestion at first time and write the flows based on the varying network statistics to maintain the requirements of service-level agreement.

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Pathological Brain Tumour Detection Using Ridgelet Transform and SVM

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Abstract. The identification, detection and classification of brain MRI images into abnormal and healthful is a main pre-clinical step for patients. Standard classification is tedious, valuable, inimitable, and time consuming. Using simple imaging techniques, it is very difficult to have vision about the normal and tumour cell due to the similarities between them. The proposed brain tumour detection method employs ridgelet transform and SVM to identify malignant and benign tumour. In this work, gray level co-occurrence matrix (GLCM) based texture analysis of discrete ridgelet transform coefficients is carried out. SVM classifier is trained using textural features and intensity based features. Principal component analysis (PCA) method is used to lessen the number of features used. SVM outputs the classified image and helps for automated detection. Experimental results demonstrated the efficacy with respect to precision, sensitivity, specificity and accuracy for tumour detection.

Keywords: MRI · Ridgelet transform · GLCM · SVM

1 Introduction

Brain tumour is common major factor for the increase in mortality among children and adults in the world. A brain tumour is abnormal and uncontrolled growth of cell in brain region leads or around the brain itself, or spread from cancers primarily located in other organs (metastatic tumours). Various types of brain tumours exist. Many brain tumours are low grade tumours (benign), and many are high grade tumours (malignant). Benign brain tumours have a well define shape with regular smooth margin. Most benign tumours have no encroachment in surrounding tissues. It does not comprise of cancer cells and may be either radiologically regulated or completely evacuated surgically and may not pursue again. The structure of malignant brain tumours has irregular margin and it contains cancer cells which can be healed with radiotherapy, targeted therapy or a combination of both, steroids and anti-seizure medication and are harmful to life. Craniopharyngiomas, astrocytoma and gliomas are the examples of low grade tumours. Most common example for high grade tumour is glioblastoma.

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The National Brain Tumour Foundation (NBTF) for research in United States computes that, in children, one quarter of all cancer deaths are caused due to brain tumour and the majority of the patients affected by brain tumours die within 9–12 months and less than 3% survive more than 3 years [1]. Explicit diagnosis and earlier prevision and detection of the brain tumour in an expedient time is vital and failing of which ends to death. Various studies have been carried out in literature using different image transforms and classifiers. Some of the significant transform based classification studies are reviewed and discussed here. Brain tumour segmentation technique was presented with the modified multitexton histogram features (MHF) and SVM classifier with hybrid kernel was employed to improve the classification accuracy. The authors achieved 86% of average classification accuracy using modified MHF [2]. Anantha et al. discussed another scheme that extracted features with Discrete Wavelet Transform (DWT), GLCM and law's texture features using Adaptive Neuro Fuzzy Inference System (ANFIS) classifier [3]. In another work presented in [4,15], textural features were extracted from curvelet transform and were reduced by PCA. Least square SVM was employed for classification which improved classification accuracy as compared to standard SVM. Fast Discrete Curvelet Transform (FDCT) based brain tumour detection was presented in a combination of a genetic algorithm and contourlet transform was used to extract texture and shape features with deep neural network and extreme learning employed for classification [5]. In order to improve detection accuracy further and obtain better classification, proposed work employed ridgelet transform based feature extraction. SVM is employed for classification. Figure 1 shows the different brain MR images.

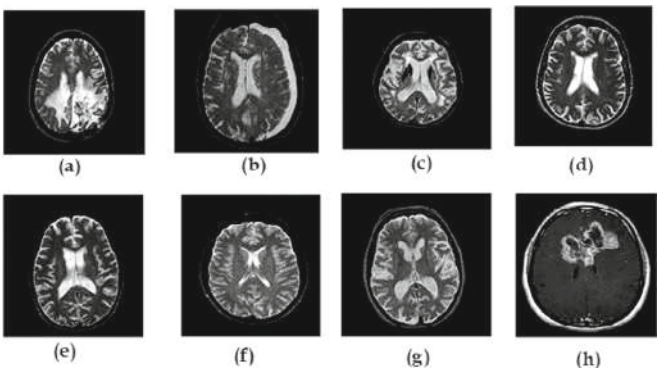

Fig. 1. Brain MR images: (a) Normal brain; (b) AIDS dementia; (c) Alzheimer's disease plus visual agnosia; (d) Alzheimer's disease; (e) Cerebral calcinosis; (f) Glioma; (g) Meningioma; (h) Glioblastoma

This article is arranged as follows. Section 2 represents details of proposed method. Section 3 deals with the simulation results and comparative analysis. In Sect. 4, a summary of the proposed work is presented.

2 Proposed Method

Use of computer aided technology for brain tumour detection is most popular domain nowadays due to necessity of the correct diagnosis. MRI images of patients are used here for analysis and study. Proposed method involves several steps like preprocessing, ridgelet decomposition, feature extraction and classification.

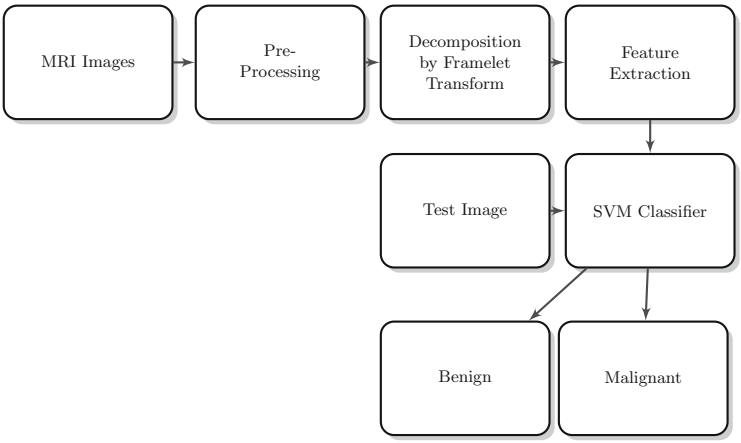

Fig. 2. Proposed method

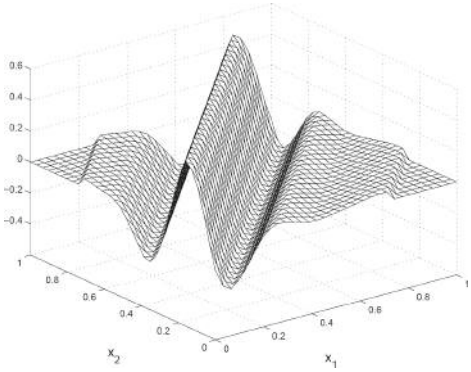

Fig. 3. An example of ridgelet function

Figure 2 shows the schematic for proposed method. In preprocessing, initially the input image is registered to a reference image. Multiplicative noise is present in the brain MRI image and its reduction is crucial to obtain better results. Noise removal is accomplished by median filter which enhances characteristic of brain

MRI images. Discrete wavelet transform is the well known tool for the analysis of images. The success of wavelets transform is due to the great achievement for piecewise smooth functions in 1-D. Two dimensional piecewise continuous signals show images have 1-D singularities. Smooth regions are separated by edges, and while edges are discontinuous across, they are ordinarily smooth curves. One dimensional wavelets tensor-product gives 2-D wavelets and they are thus excellent at differentiating the discontinuity across an edge, but will not see the smoothness along the edge. To influence the deficiency of wavelets in higher dimensions, Candes and Donoho invented a new system of representations named ridgelets which deal effectively with line singularities in 2-D [6]. Invertibility and non-redundancy both are achieved by discrete ridgelet transform. The transforms are related by,

$$Wavelets \rightarrow \psi_{scale};\ point\text{-}position \tag{1}$$

$$Ridgelets \rightarrow \psi_{scale};\ line\text{-}position \tag{2}$$

It needs the computation of fast Fourier transform (2D-FFT) first and then the application of radon transform. After that the data will be treated as one dimensional information. The ridgelet computation requires further the application of 1-D wavelet transform to the resultant data. The final coefficient obtained from the previous step will be called the ridgelet coefficients. Figure 3 shows the ridgelet function example. Ridgelet transform shows the connection with other transform in the continuous domain. The continuous ridgelet transform (CRT) in R^2 of integrable bivariate function $f(x)$ is given by,

$$CRT_f(a,b,\theta) = \int_{R^2} \psi_{a,b,\theta}(x) f(x) dx \tag{3}$$

To represent an image, large amount of time and memory space is required for the large amount of data. The difference between malignant and benign tissue may not be easily visible to human eye. By using the feature extraction in frequency domain, the texture and intensity based feature are extracted. Texture analysis differentiates tissues easily for human visual perception and machine learning. In texture method, Gray level co-occurrence matrix (GLCM) in four possible directions 0°, 45°, 90°, 135° & gray level different matrix (GLDM) are applied to extract the features from the brain MRI image [7]. By choosing the effective features, accuracy for early diagnosis can be improved. Textural and intensity features are extracted from ridgelet coefficients obtained by level 1 ridgelet decomposition. Extracted features include contrast, correlation, energy, homogeneity, entropy, mean, standard deviation, root mean square value, variance, smoothness, kurtosis, skewness. PCA is applied to the extracted features and principal components are used further for classification purpose.

The SVM algorithm is based on the study of a supervised learning technique and is applied to N number of class classification problem from one class classification problem. The error matrix establishing the terms TP, TN, FP, and FN from the anticipated outcome and ground truthing outputs for the assessment of accuracy, sensitivity, and specificity. A non-linear SVM is employed for classification.

3 Experimental Results

In this study, 80 T2 weighted MRI brain images were retrieved along the transaxial plane. Each images is of size 256 × 256. The dataset covers seven different illnesses of brain images, each disease from different subject. The sample test images were obtained from medical school of Harvard University (www.med.harvard.edu/aanlib/home). Performance of proposed method was evaluated using sensitivity, specificity, precision and accuracy. The metrics can be obtained as follow.

$$Sensitivity = \frac{TP}{TP + FN} \tag{4}$$

$$Specificity = \frac{TN}{TN + FP} \tag{5}$$

$$Precision = \frac{TP}{TP + FP} \tag{6}$$

$$Accuracy = \frac{TP + TN}{TP + FN + TN + FP} \tag{7}$$

where,

True Positive (TP): Non-cancerous brain accurately recognized as non-cancerous
True Negative (TN): Cancerous brain accurately recognized as cancerous
False Positive (FP): Cancerous brain inaccurately recognized as non-cancerous
False Negative (FN): Non-cancerous brain inaccurately recognized as cancerous

The proposed method achieved the accuracy of 97%, which is comparable with the recent studies and is better than some of the DWT based existing works as shown in Table 1.

Table 1. Comparison with existing work

Existing methods	Sensitivity (%)	Specificity (%)	Precision (%)	Accuracy (%)
CT + ZM + DNN [5]	51.48	40.19	-	88.8
GLRLM + Linear [8]	83.33	100	-	91.66
GLRLM + Poly [8]	66.66	100	-	83.33
GLCM + Bayesian [9]	91	83	91	88.2
GLCM + Tree [9]	93	100	100	96
DWT + PCA + A-NN [10]	98.3	81.8	-	95.7
FBB + GLCM + RBF [11]	68	40	-	61.8
FBB + GLCM + MLP [11]	93.1	81.33	-	96.63
DWT + PCA + RBF-NN [12]	92.47	72.00	98.25	91.3
WE + KSVM [13]	93.18	68.00	98.02	91.78
Proposed method	98.76	98.67	99.50	97

4 Conclusion

Computer aided detection of brain tumour has become most important research field in medical imaging. This proposed method extracts GLCM based texture features and intensity features from ridgelet coefficients. To classify brain image into malignant or benign, the extracted features are fed to the SVM classifier. The proposed methodology improves performance accuracy as compared to some of the existing methods. This work can be further extended for images with non-identical pathological condition, types and diseases with the help of overlaid arrow detection method using fuzzy binarization so that to produced several different image layers. This helps to avoid loss of data and make segmentation easier [14].

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Design of Footstep Power Generation System for Green Energy Initiative

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Keywords

Acceleration
Force
Pressure
Piezoelectric Effect

A B S T R A C T

ABSTRACT

The system generates voltage using footstep force. The system serves as a medium to generate electricity using non conventional sources and store or use it. The project is designed to be useful at public places like railway stations where a lot of people keep walking through all day. At such places these systems are to be placed at any entry points where people travel through entrance or exits and they have to foot press on this device to get through. These devices may then generate a voltage on every footstep and when mounted in series they will produce a sizeable amount of electricity. For this purpose we here use piezoelectric sensors that use piezoelectric effect in order to measure acceleration, force, pressure by its conversion into electric signals. We here attach a voltmeter in order to measure its output and small led lights for demonstration. We also use a battery and weight measurement unit for better manifestation of the system.

I. INTRODUCTION

In this project we are generating electrical power as non-conventional method by simply walking or running on the foot step. Non- conventional energy system is very essential at this time to our nation. Nonconventional energy using foot step is converting mechanical energy into the electrical energy.Man has need and used energy at an growing rate for his nourishment and well-being ever since he came on the earth a few million years ago. Due to this a lot of energy resources have been worn out and wasted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India and China where the roads, railway stations, bus stands, temples, etc. are all over crowded and millions of people move around the clock.

This whole human bio-energy being wasted if it can be made possible for utilization it will be great invention and crowd energy farms will be very useful energy sources in crowded countries. This project uses piezoelectric sensor. In this project the conversion of the force energy in to electrical energy. The control mechanism carries the piezo electric sensor, A.C ripples neutralizer, unidirectional current controller and 12V, 1.3Amp lead acid dc rechargeable battery and an inverter is used to drive AC/DC loads.

II. BASIC CONCEPT

The piezoelectric effect was discovered in 1880, by two French physicists brothers Pierre and Paul.They took the name from the Greek word piezo, which× means "to press. Conventional & Non-conventional Energy Sources Energy produced by coal, petroleum, natural¬ gas etc. are called conventional sources. Whereas the sources like biomass, wind,¬ solar etc. are called non conventional energy sources. The confront to convertfootstep energy to electrical energy. Its solution is using piezoelectric material.

III. NEED AND SCOPE

The utilization of waste energy of foot power with human motion is very important for highly populated countries. India and China where the roads, railway stations,¬ temples, etc. are all over crowded and millions of people move around the clock. Our main goal is to harvest as much energy as possible that to without compromising the reliability.

IV. DESIGN METHODOLOGY& DESCRIPTION

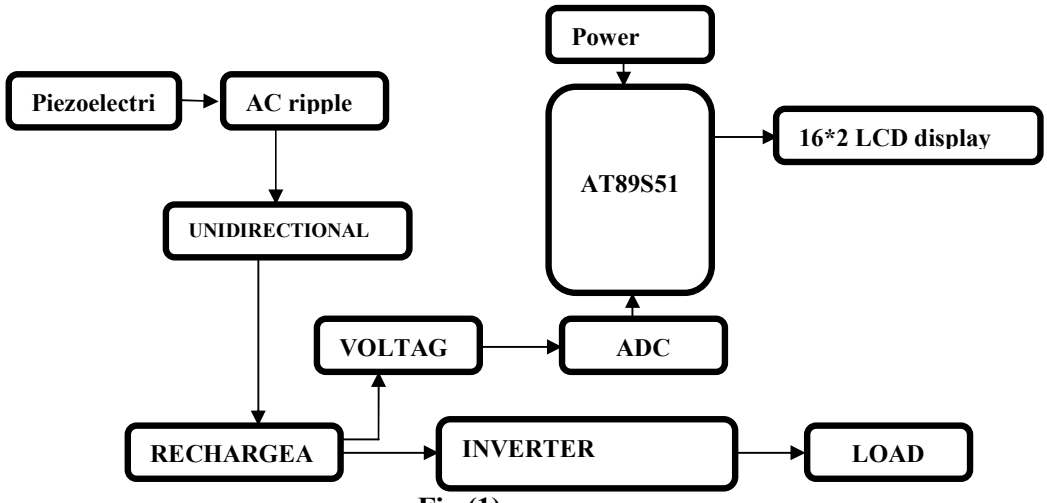
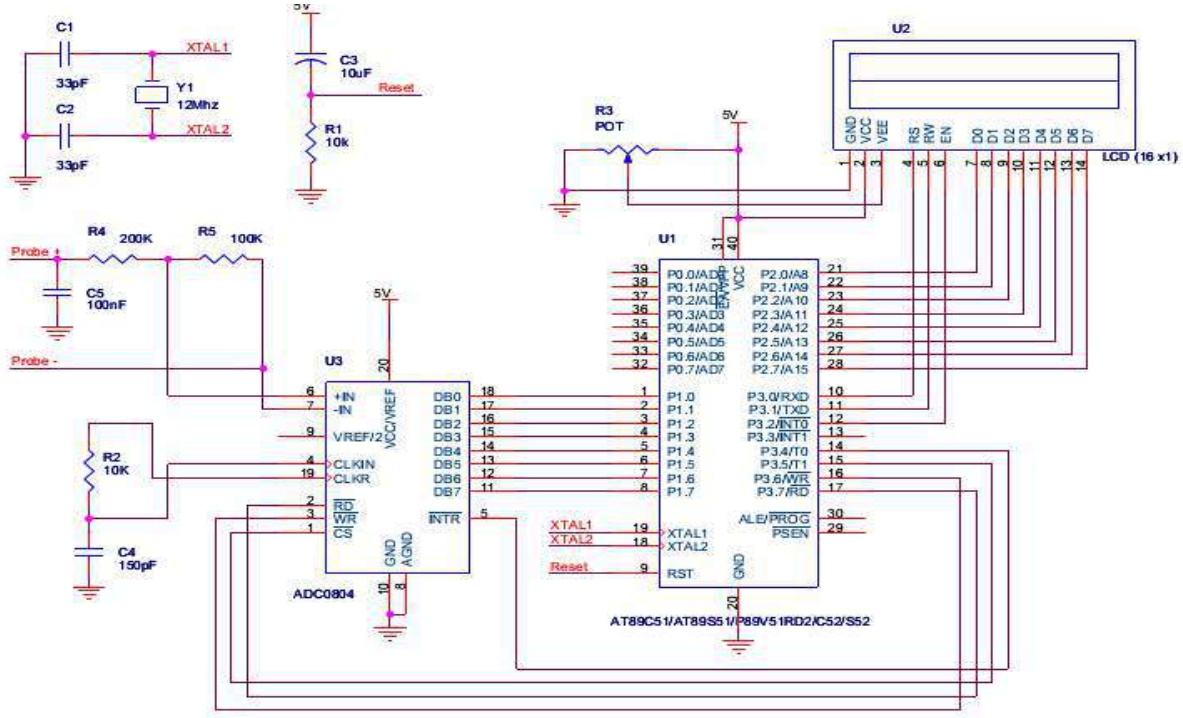


Fig.(1)

The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it. The output of the piezoelectric material is not a steady one. So a bridge circuit is used to convert this variable voltage into a linear one. Again an AC ripple filter is used to filter out any further fluctuations in the output. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, combination of few Piezo films was investigated. Two possible connections were tested - parallel and series connections. The parallel connection did not show significant increase in the voltage output. With series connection, additional piezo-film results in increased of voltage output but not in linear proportion. So here a combination of both parallel and series connection isemployed for producing 40V voltage output with high current density. From battery provisions are provided to connect dc load. An inverter is connected to battery to provide provision to connect AC load. The voltage produced across the tile can be seen in a LCD. For this purpose microcontroller AT89S51 is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage levels.

V. SCEHMATIC DIAGRAM



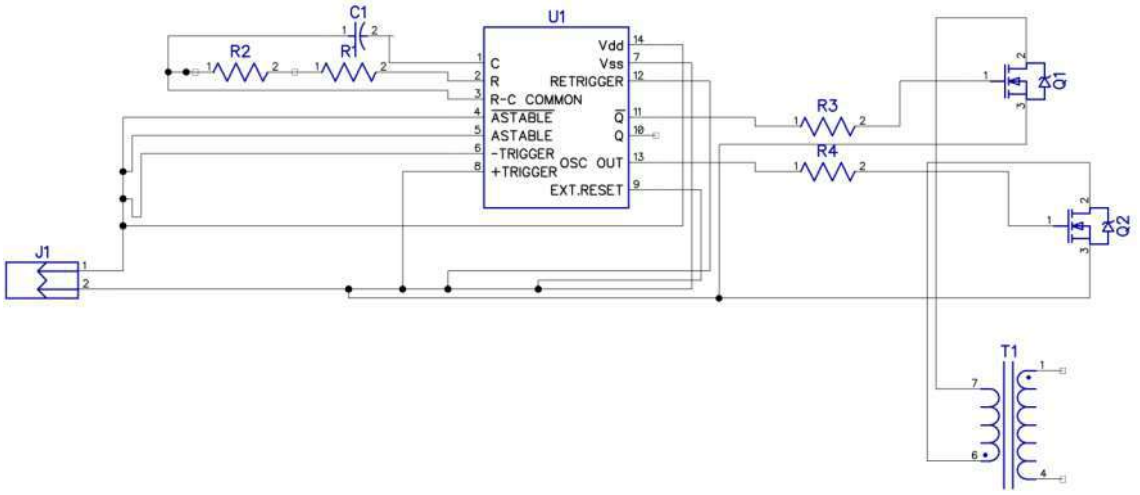


Fig.(2) Schematic Diagram

VI. CONCLUSION

This statement of Albert Einstein is true "Energy can neither be created nor be destroyed it can be transferred from one form to another."

A piezo tile competent of generating 40V has been devised. Comparison between various piezo electric material shows that PZT is superior in characteristics. Also, by comparison it was found that series- parallel combination connection is more suitable. The weight applied on the tile and corresponding voltage generated is studied and they are found to have linear relation. Use of piezo-electric material is eco-friendly causes no pollution. It is an inexpensive way of generating electricity and is easy to install.

This project can be successfully implemented in airports, railway stations and the technology can be incorporated to generate power in the following applications

- In car tyres
- In speed breaker
- Discos
- Staircases
- School / colleges
- Trade mills
- Below railway station
- In boxing panel

Following are the advantages & disadvantages:

- Harvest small, but still significant amounts of energy.
- An innovative approach to a device that people use every day.
- No compromise to safety or reliability.
- There is no pollution with this technology as compared to other power generating technologies, hence it is eco- friendly in nature
- No requirement of fuel for generation
- Marketing and appearance could encourage people to take the stairs instead of energy intensive alternatives such as an elevator or escalator.

VII. FUTURE WORK

In future aspects we can use this principal in the speed breakers at high ways where are rushes

of the vehicles too much thus increase input torque and ultimate output of generator. If we use this project at very busy stairs palace then we produce efficient useful electrical for large purposes.

In future this method will be a promising method for generating eco-friendly electricity. We also contribute this method at common places It is especially suited for implementation in crowded areas. This can be used in street lighting without use of long power lines. It can also be used as charging ports, lighting of pavement side buildings

VIII. ACKNOWLEDGEMENTS

This dissertation report would not have been come into reality without the able guidance, support and wishes of all those who stand by using the development. We wish to give our special thanks to our guide Prof. Jayesh Rane for his timely advice and guidance.We acknowledge all the staff members of the Department of Electronics and Telecommunication Engineering for their help and suggestions during various phases of this project work.

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Design of Railway Track Breakage Detection Using Different Sensors

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Keywords

Driverless Train System
Railway Accidents avoidance
Secure Rail transport
Track Breakage Detection
Ultrasonic Sensor

A B S T R A C T

Railways are the most significant transport in our nation state. Rail accidents are escalating day by day so there is significant to diminish that problem. To eliminate this concern we are working on this. In this project we introduced the driverless railway system with detection of crack. In this project there are two important sections-Track section and Train section. Train section contains ultrasonic sensor which is used for crack detection distance measurement. It also contains motor driver to drive the motor. Track section contains light encoder and decoder which is used to transfer the data through light for communication purpose. The most important part of track section is voltage divider arrangement for breakage detection. It also contains switches which are at ON state for those trains which are required to stop on station and at OFF state for those trains which are not required to stop on station. Signals are also present before and after the station to give indication to train.

I. INTRODUCTION

In our fast developing country, railways are important part of our life style. It becomes lifeline of Indian citizens. There are number of routes all over the country so it is fourth leading railway network in the world. But still it associated with lack of safety transportation. Most of the railway accidents occur due to cracks in the railway track. So to avoid this problem we used the ultrasonic sensor and voltage divider arrangement for detecting the crack. If the crack is obtained at platform the buzzer generates the sound. After detecting the crack, light encoder-decoder are used for transferring the crack information and location. When we provide supply to the device, DC motor starts through driver circuit. At Platform there are two switches that are used to give indication to the train which involves two conditions which are GO and STOP. When crack is detected by voltage divider arrangement in the track between two stations, red signal generated and train stops. On the other side when crack is detected by ultrasonic sensor, again red signal is generated before platform. The main goal of this paper is to detect breakage of track using this arrangement, which can be implemented by each railway station.

II. BACKGROUND

The main problem about the railway investigation is detection of crack in the composition. If these problems are not solved at early stages they might lead to the number of accidents resulting in heavy loss of life and properties. Hence we planned to design the driverless breakage detection model using microcontroller, ultrasonic sensor, voltage divider and light encoder-decoder to find the crack along its route. System is also capable of train halt at defined station.

III. METHODOLOGY

Rail defect detection is a process for many detection techniques have been implemented. For crack detection system following need to be made available: different sensors, light encoder-decoder, signaling system and switches to only make and break connection. Change in the value of resistance indicates more presence of crack on railway track. Hence we use voltage divider arrangement over there. To avoid the human error due to driver or motorman we have designed the driverless setup with switches. The three main components used in the block is IR sensor, Ultrasonic, PIR sensor.IR sensor is used to detect the crack in railway track. Infrared (IR) transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

Passive Infrared Sensors (PIR)

Passive InfraRed sensors (PIR sensors) are electronic devices which calculate infrared light glowing from objects in the field of view. PIRs are often used in the building of PIR
based motion detectors, see below. Apparent motion is detected when an infrared emitting source with one temperature, such as a human body, passes in front of a source with another temperature, such as a wall.

DC Motors

To navigate a distance of 22 Km in 4 hrs, an standard speed of 1.5 meters/sec is needed.

The proposed design uses 3 DC motors. DC motor works according to relay operation. When relay 1 is in the ON state and relay 2 is in the OFF state, the motor is running in the forward direction. When relay 2 is in the ON state and relay 1 is in the OFF state, the motor is running in the turn round direction.

IV. BLOCK DIAGRAM

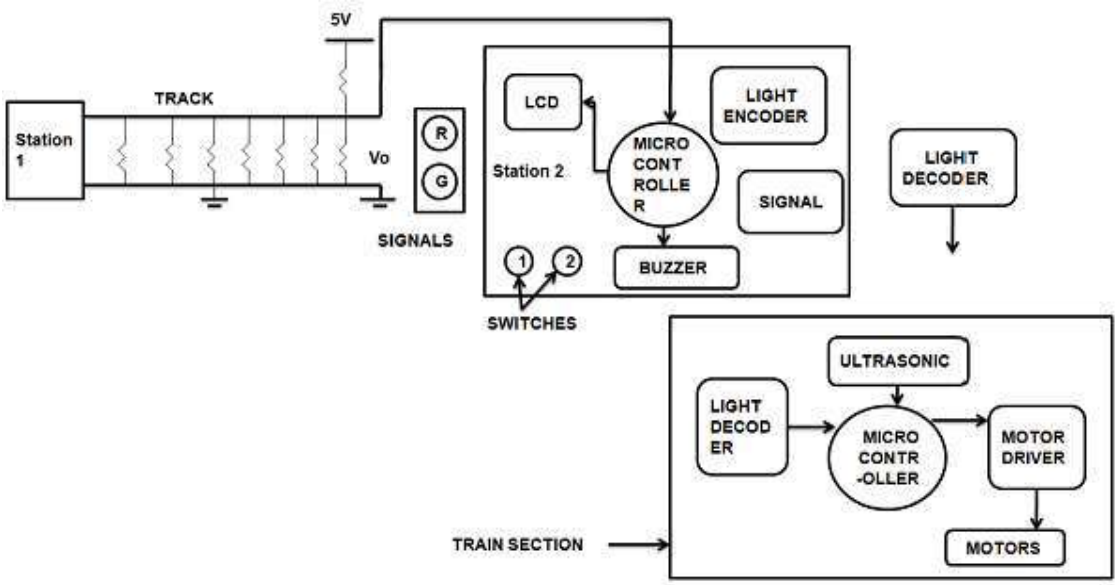

Fig (1): block diagram

V. CONCLUSION

In this project we have represented the voltage divider based as well as ultrasonic sensor based crack detection for railway track and crack can be detected using these two elements. Also we represent driverless model for automatic halt of train on platforms. The main advantage of this system is to reduce railway accidents due to breakage of crack, presence of human on track and due to the signal unnoticed by motorman. But our system needs unbroken power source.

VI. FUTURE WORK

Such system can be used for other execution and also be update for better analysis in following way:
The device can be fitted with a rechargeable battery so that the solar power can be used to charge it and device can run for longer time.We can also design the GSM and GPS based advanced railway crack detection model.

Fig (2): GSM & GPS based advanced railway system

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Smart Apron Using Embroidered Textile Fractal Antenna for E-Health Monitoring System

Authors Authors and affiliations

Shruti Gite, Mansi Subhedar

Conference paper
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Abstract

The rapid advances in the wireless communication field have given a new dimension to antenna design. This paper is envisioned to design a wearable textile antenna for healthcare and medical applications. The proposed antenna is being embroidered on a polyester substrate using conductive stainless steel thread. The antenna is designed at operating frequency of 2.4 GHz (ISM band) used for industrial and medical field. The proposed antenna is embroidered using minkowski fractal design on the pocket of apron. It can be used by doctors and assists in hospitals for data exchange between hospitals, pharmacies, labs, clinicians and even patients. The apron can ensure doctors and healthcare authorities a continuous health monitoring and hence can be rightly termed as "Smart apron." The feasibility of the proposed wearable antenna in our venture has to be tempered with pragmatism. The proposed antenna is being designed using a full-wave electromagnetic simulation tool. Results are obtained in terms of VSWR, bandwidth, current distribution and radiation pattern. The work presented here has profound implications for integrating antennas into smart wearable clothing.

Keywords

Fractal geometry Minkowski fractal Smart apron Embroidered antenna ISM band

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Multimed Tools Appl
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Curvelet transform and cover selection for secure steganography

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Abstract In this paper, we present curvelet transform (CT) based image steganography that embeds scrambled secret image in appropriately selected cover image. Curvelet transform offers optimal nonadaptive sparse representation of objects with edges and possesses high directional sensitivity and anisotropy. Cover image is decomposed using curvelet transform and adaptive block based embedding is carried out only in non-uniform regions of high frequency curvelet coefficients. In addition, this work also demonstrates a new cover selection method to choose suitable cover from image database. Spatial information based image complexity is modelled using fuzzy logic to identify set of images that yields least detectable stego image. From this set of ranked images, best cover can be chosen for carrying secret information depending on amount of information to be embedded. Cover selection offers reduced risk of detectability and ensures security. It is evident from experimental results that proposed method outperforms conventional methods in terms of imperceptibility, robustness and security.

Keywords Image steganography · Image complexity · Curvelet transform · Image quality · Steganalysis

1 Introduction

With the growth of Internet and variety of multimedia technologies, digital images are distributed extensively over the network. Since distribution of digital media is faster and easier nowadays, security issues such as copying, interception and modification of data by the intruder are very often. Motivated by growing concern in securing information transfer

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over insecure channel, lot of work has been done in the field of data hiding and steganography. Steganography, the branch of information hiding is an art of invisible writing. It was often thought that communication of secret information can be secured by encrypting the information before transmitting it over network. However, encryption does not hide the communication, it just helps to make eavesdropper difficult to understand the content of message. Moreover, when intercepted, it is clear that two parties are communicating secretly. Encryption simply improves security by denying access to unauthorized interceptor. On the contrary, image steganography is an art of hiding secret information onto cover image such that its very presence is not revealed. In order to achieve better security, steganography can be employed along with encryption.

In image steganography, original image used to carry secret information is known as cover and modified cover is called as stego. The success of steganography depends mainly on undetectability of embedded secret information. Imperceptibility, robustness and undetectability are the three characteristics of image steganography [18, 32]. It is broadly classified in two types, spatial domain and transform domain steganography. In spatial domain, pixel values are directly altered to hide information bits. The transform domain methods use transform coefficients as carriers of secret bits. Figure 1 shows the conceptual framework for transform domain image steganography. Image is first decomposed using forward image transform. The transform coefficients will act as carriers of covert message. After embedding secret message, inverse transform is applied to obtain stego image. It has been found that transform domain techniques are more robust to JPEG compression and variety of image processing attacks as compared to spatial domain techniques [5]. Steganalysis is the science of detecting hidden information from observed media. In the past years, advanced steganalysis methods are proposed to detect the presence of secret information effectively. For secure communication, steganographer must hide the information bits in cover such a way that statistical features of cover are not perturbed much during the process of embedding and presence of hidden information is not revealed.

In literature, many image steganography techniques are proposed that focus on choice of embedding locations in cover so as to improve stego quality. As proposed work falls in transform domain category, recent transform domain steganography schemes are reviewed and compared. Blind data hiding method using Fresnelet transform is presented in [21]. Coded pattern of information is embedded in particular sub-bands. Embedding capacity is improved over existing methods. For payload of 263,222 bits, PSNR is 32.90 dB and data extraction is blind. Another steganography scheme proposed by Chong Yu employs Arnold transform and morphological component analysis [40]. Authors claim that the scheme overcomes the problem of too narrow hidden data bandwidth in traditional least significant

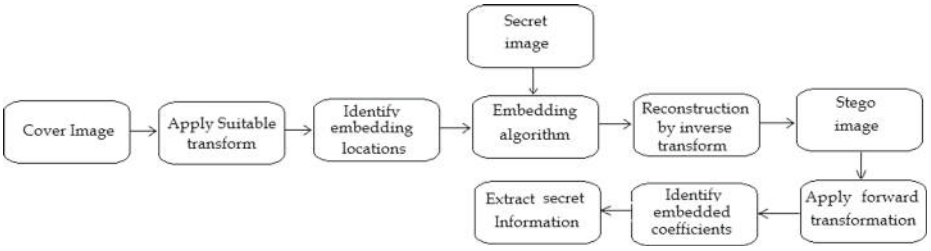


Fig. 1 Conceptual framework of transform domain image steganography

bit (LSB) replacement or LSB matching schemes. Rabie et al. proposed steganography approach based on discrete cosine transform (DCT) [23]. To optimise embedding capacity, a global adaptive region (GAR) embedding scheme is followed. Embedding capacity is found to be improved however there is lot of scope to enhance image quality. Dmour et al. proposed a steganography algorithm based on edge identification and XOR coding [1]. Integer wavelet transform (IWT) is also employed to obtain transform coefficients. Better imperceptibility and security against feature based steganalytic schemes is achieved. A novel joint secret sharing and steganography method is proposed by Khosravi et al. using IWT. A secret image is shared into n shares and the shares and Fletcher-16 checksum of shares are hidden into n cover images [17]. Imperceptibility is verified with quality metrics like PSNR and SSIM and three steganalysis methods are employed to justify security. Sajedi et al. employed contourlet transform to demonstrate transform domain image steganography [25]. Contourlet coefficients with larger magnitude are selected for embedding purpose. Average PSNR of 38.1 dB is obtained for embedding 12000 secret bits in cover of size 512×512. Imperceptibility and embedding capacity has lot of scope for improvement. They found detection accuracy by wavelet and feature based steganalysis as 58.5% and 60.5% for secret data size of 15000 bits. There are many more such schemes in literature; each trying to boost payload capacity while maintaining good stego quality.

Cover selection image steganography is a novel paradigm that finds a set of ranked images that can be used as cover. As compared to other branches of information hiding, only steganography has the freedom to choose cover used to carry secret information. As there is no relation between cover and secret, choice of cover can be made such that it results in least detectable stego. Moreover, as per secret data size, steganographer can choose appropriate cover from this set and embedding can be carried out. Choosing the best image helps to make steganalyzer to misclassify stego as cover.

Kharrazi et al. proposed cover selection when embedder has no knowledge, partial knowledge and full knowledge of steganalysis algorithm [16]. They proposed two types of measures for cover selection. First type considers cover image properties and second rely on cover - stego relationship. Sajedi et al. proposed cover selection approach based on statistical features of image blocks and their neighbourhood [26]. Here, steganalysis results are found to be more effective and justifies undetectability of stego. Sun et al. modelled cover data as Gauss Markov process and proposed correlation as cover selection measure [34]. Cover with smaller correlation improves security and hence can be preferred as host. Sajedi et al. surveyed and categorised cover selection measures in two categories; fast and exact measures. It is very similar to cover based and cover - stego based classification respectively [28].

In this paper, curvelet based image steganography is presented. CT is a multiscale directional transform that offers sparse representation of objects with edges. Cover image is decomposed using CT. High frequency sub - band is divided into blocks of 4×4 and scrambled secret image is embedded in non-homogeneous blocks. Various studies and comparative analysis is performed to evaluate the performance in terms of imperceptibility, robustness and security. This study also presents cover selection scheme based on image complexity modelled with fuzzy logic. To the best of our knowledge, soft computing approach for cover selection is not found in literature.

The remainder of the paper is organized as follows. Section 2 reviews basics of curvelet transform. Section 3 presents proposed curvelet based image steganography algorithm. Section 4 demonstrates a fuzzy based cover selection method. Section 5 presents experimental results for imperceptibility, robustness to stego attacks, detection

accuracy by steganalyzer and cover selection performance. We conclude our work in Section 6.

2 Curvelet transform

Owing to popularity of JPEG file format on Internet, transform domain steganography came up with embedding in DCT coefficients. In basic JPEG based image steganography, cover image is divided into blocks of 8×8. 2D-DCT is computed for each of this 8×8 block and covert message is embedded in quantized DCT coefficients. Many variations to basic DCT based steganography scheme have been proposed in literature. But all these schemes rely on unrealistic assumption of independence of the blocks. To overcome this issue, use of discrete wavelet transform (DWT) was suggested. DWT offers better energy compaction than DCT without causing any blocking artefact. However, wavelets possess limited ability in capturing directional information. Since wavelets ignore geometric properties of structures, they represent just point singularities and ignores regularity of edges. To overcome this, solutions that can be thought of include multiscale and directional representations like steerable pyramid, curvelet transform, brushlets, complex wavelets etc. They can be explored to capture geometrical structures such as smooth contours in natural images. These shortcomings of wavelets are also resolved by ridgelet transform as it gives sparse directional analysis and represents objects with line singularities.

The curvelet transform is a multiscale directional transform that allows an almost optimal non-adaptive sparse representation of objects with edges. As CT, has a sparse representation and offers improved compression possibilities, it also has better denoising performance [7]. The curvelet transform possess very high directional sensitivity and anisotropy. There exist two separate CT algorithms, unequispaced FFT transform (USFFT) and wrapping transform (WT). USFFT uses a decimated rectangular grid tilted along the main direction of each curvelet. There is one such grid per scale and angle. WT uses instead a decimated rectangular grid aligned with the image axes. For a given scale, there are essentially two such grids (decimated mostly horizontally or mostly vertically). Both implementations need $O(n^2 logn)$ flops for n by n Cartesian arrays [8, 31]. Also, CT requires fewer coefficients for representation and edge produced by curvelet is smoother than the wavelet edge [3]. A curvelet coefficient $c(j, l, k)$ can be expressed as:

$$c(j, l, k) = \langle f, \varphi_{j,l,k} \rangle \tag{1}$$

where $j = 0, 1, 2, \ldots$.is a scale parameter, $l = 0, 1, 2, \ldots$.is an orientation parameter and $k = (k_1, k_2), k_1, k_2 \in \Im$ is a translation parameter. The waveform $\varphi_j(x)$ is defined by its Fourier transform $\varphi_\wedge = U_j(\omega)$. Let the frequency window U_j is defined in the Fourier domain by,

$$U_j(r, \theta) = 2^{-3j/4} W(2^{-j} r) V \left\{ \frac{2\lfloor j/2 \rfloor)\theta}{2\pi} \right\} \tag{2}$$

where W is the radial window, V is the angular window and $\lfloor j/2 \rfloor$ is the truncated integer of $j/2$. Figure 2a exhibits basic digital tiling. The windows U_j smoothly localize the Fourier transform near the sheared wedges obeying the parabolic scaling. The shaded region represents one such typical wedge. Figure 2b illustrates sharp localization in spatial and

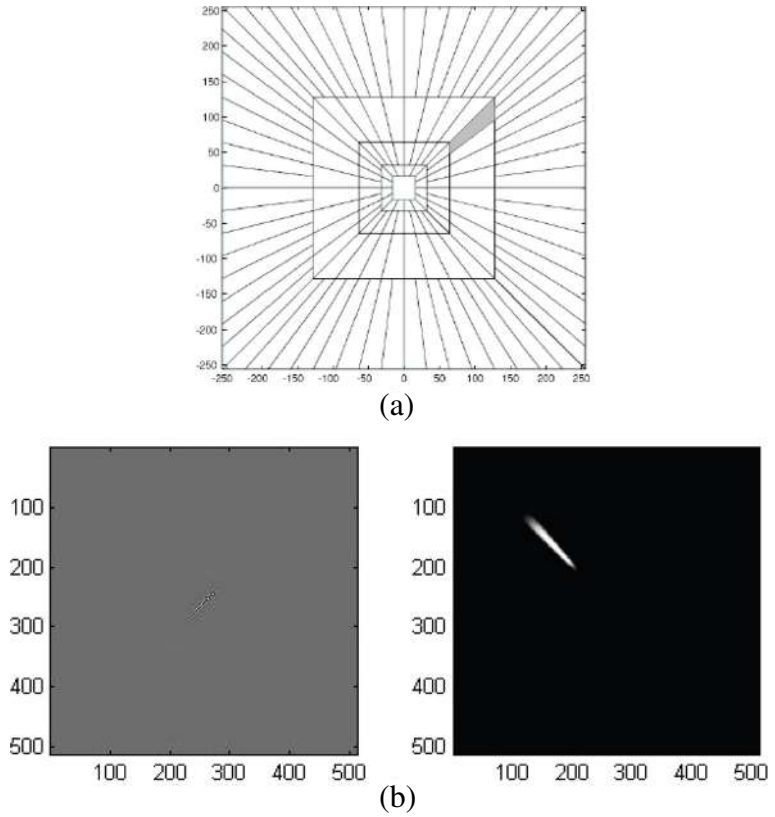


Fig. 2 **a** Digital corona of the frequency domain (**b**) Spatial and frequency domain

frequency domain. This is achieved by setting all coefficients in curvelet domain to zero except that at required location [4]. We employed fast discrete curvelet transform via unequispaced FFT's. Figure 3a and b depict input image Peppers of size 512×512 and its CT coefficients. CT decomposition of image results in cell array of curvelet coefficients from coarse to finest scale. Since human visual system (HVS) does not recognize the modifications in high frequency coefficients, they can be preferred as secret carriers.

3 Proposed image steganography method

In this section, a new curvelet based image steganography technique is proposed that achieves a trade off between imperceptibility and payload capacity. The main objective is to maximize the embedding capacity while offering best security to stego image. A adaptive block based embedding approach is proposed. Variation of pixel values plays vital role in deciding uniformity of image region. Adaptive embedding helps to achieve better security and good visual quality. Let $C = f(x, y), 0 \leq x \leq M, 0 \leq y \leq N$ denotes original cover image where $f(x, y)$ is intensity of image at point (x, y). Similarly, let

Fig. 3 **a** Test image Peppers (**b**) Level 7 curvelet decomposition

$S = f(z, w), 0 \leq z \leq M, 0 \leq w \leq N$ be secret image to be embedded in cover. Embedding and extraction procedure can be summarized as follows and depicted in Fig. 4a and b.

1. Preprocessing: RGB cover image of size 512×512 is converted to grayscale image. A grayscale Cameraman image of size 256×256 is used as secret image and is embedded in cover. As first layer of security, Arnold transformation is used. A two dimensional Arnold transform is given by,

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (mod N) \tag{3}$$

   where x and y are pixel coordinates and N is height or width of image. Level of scrambling is known as period of Arnold transformation. The best degree of scrambling refers to number of iterations when scrambling is optimized and is used as secret key here. Without knowledge of secret key, exact retrieval of secret information can not be guaranteed.
2. Apply level 6 curvelet transform to cover image and obtain curvelet coefficients. It gives coarse, detail and fine layer sub-bands. Choose high frequency curvelet coefficients as HVS can not reliably distinguish changes made to these coefficients.

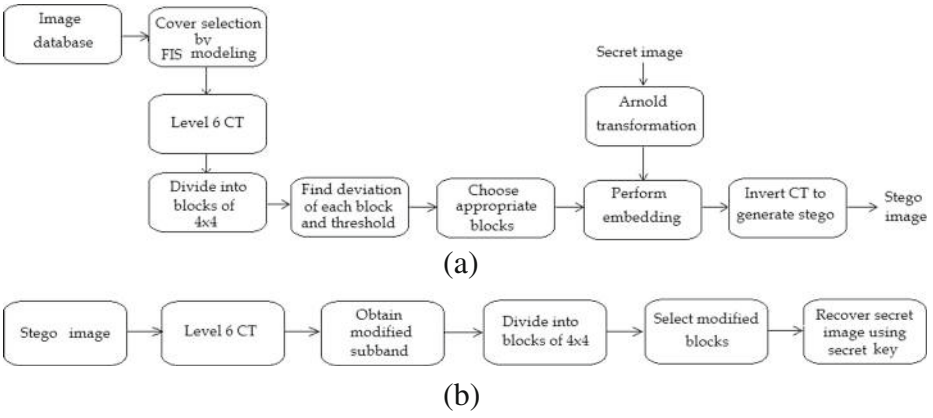


Fig. 4 Framework of proposed system (**a**) Embedding algorithm (**b**) Extraction algorithm

3. Divide this sub-band into blocks of 4×4. Non uniformity of local regions helps to obtain better places to hide data in. Stego image is said to be secure when embedded data is undetectable by steganalyzer. So data hiding locations and amount of changes made contribute significantly to visual quality and security of stego image.

   By choosing standard deviation as a feature to judge the suitability of block to be considered for embedding, adaptive embedding is achieved in non-uniform or non-homogeneous regions. Calculate threshold as mean of standard deviation of all blocks.
4. Choose the blocks having deviation higher than threshold and use for embedding.
5. Perform embedding by replacing each chosen 4×4 block of cover by the corresponding block of secret image using spread spectrum method. Value of embedding factor or scaling factor should be chosen experimentally to achieve better imperceptibility.
6. Apply inverse curvelet transform (ICT) to obtain stego image.
7. Verify stego quality using well accepted image quality metrics such as PSNR (peak signal to noise ratio), MSSIM (mean structural similarity index), UQI (universal image quality measure) and IF (information fidelity).
8. Extraction procedure involves similar steps to be performed with stego image. Decompose stego image using level 6 forward curvelet transform.
9. Extract the modified curvelet sub-band coefficients.
10. Recover embedded information using same scaling factor employed for embedding.
11. Using secret key as period of Arnold transformation, retrieve the secret image and compare with original secret image.

4 Proposed cover selection method

A lot of work is carried out on image steganography; images being the most popular digital media used over internet. Design of image steganography is influenced by three important parameters visual quality, payload capacity and security. In past years, research on image steganography exploited embedding locations as the only way to optimise the performance of steganography. However, in steganography unlike the branches of information hiding like watermarking, steganographer is free to choose cover designated to carry secret. Cover selection steganography aims at finding the best cover from image database. We strongly feel that use of advanced image transforms can offer better visual quality for stego images and robustness too to several image processing operations inspite of embedding large payload. However, with the advancement of steganalysis techniques, it is difficult to maintain security and make stego least detectable. It has been felt that appropriate choice of cover will lead to secure stego. Proposed cover selection technique can be considered as a fast measure of cover selection as it is based on cover image properties.

Yu et al. proposed relation between image complexity and spatial information (SI) [13]. SI measures are robust to image compression and estimate image complexity. It is known that embedding capacity not only depend on type of steganography algorithm but also on image contents. This paper implements fuzzy architecture for cover selection. Fuzzy logic term was coined by Lotfi Zadeh and is now applied in variety of fields [41]. SI is a indicator of edge energy. It helps to analyse local properties of an image. Let s_h and s_v denote gray scale images filtered with horizontal and vertical Sobel kernels. The magnitude of spatial information at every pixel is given by,

$$SI_r = \sqrt{s_h^2 + s_v^2} \tag{4}$$

SI measures used to estimate image complexity are mean, root mean square and standard deviation of SI values across all the pixels in the image [2]. Let 'M' denotes total number of pixels in image. SI_{mean}, SI_{rms} and SI_{stdev} can be formulated as,

$$SI_{mean} = \frac{1}{M} \sum SI_r \tag{5}$$

$$SI_{rms} = \frac{1}{M} \sum {SI_r}^2 \tag{6}$$

$$SI_{stdev} = \sqrt{\frac{1}{M} \sum {SI_r}^2 - SI_{mean}^2} \tag{7}$$

A fuzzy set can be defined mathematically by assigning each possible individual in the universe of discourse a value, representing its grade of membership in the fuzzy set. The process of formulating the mapping from a given input to an output using fuzzy logic is called fuzzy inference system (FIS). Fuzzy set theory differs from traditional set theory in that partial membership is allowed i.e. an element can belong to a set only up to a certain degree. This degree of membership is commonly referred to as the membership value and is represented as,

$$\mu_A(x) \in [0, 1] \tag{8}$$

where 0 and 1 corresponds to full non-membership and full membership value respectively and $\mu_A(x)$ is the degree of membership of element x in fuzzy set A. Steps to apply rule based fuzzy logic can be summarized as:

1. Fuzzify the inputs
2. Apply an implication method
3. Apply an aggregation method to fuzzy sets
4. Defuzzify the output fuzzy set

A fuzzifier performs the function of fuzzification which converts the crisp input to fuzzy values through membership function (MF). Here, there are three FIS variables as three SI measures. Figure 5 show input membership functions for three FIS variables and output membership function for output variable, level of complexity.

Figure 6a shows functional block diagram of Mamdani FIS. Gaussian curve membership function is used for input variables. Their linguistic values are defined as Low (L), Medium (M), High (H) and Very high (VH). Information rules are defined in terms of fuzzy IF-THEN rules: e.g.

If (Mean is Low) and (RMS is High) and (Deviation is High) then (Complexity is High)
Output variable complexity is divided among four classes Low(0.13-0.25), Medium (0.26-0.5), High (0.5-0.75) and Very high (0.75 and above). 64 fuzzy rules are defined to model complexity based on SI measures. Figure 6b shows the rule viewer for proposed FIS. All rules are evaluated in parallel, and the order of the rules is unimportant. Last step is to obtain crisp values from fuzzy sets and is known as defuzzification. The weighted average method is the most frequently used technique for defuzzification but usually restricted to symmetrical output membership function and is given by,

$$z^* = \frac{\sum \mu_c(\bar{z})\bar{(z)}}{\sum \mu_c \bar{z}} \tag{9}$$

where $\sum$ denotes the algebraic sum and $\bar{z}$ is the centroid of each symmetric membership function. Here, images are ranked according to their level of complexity and prediction

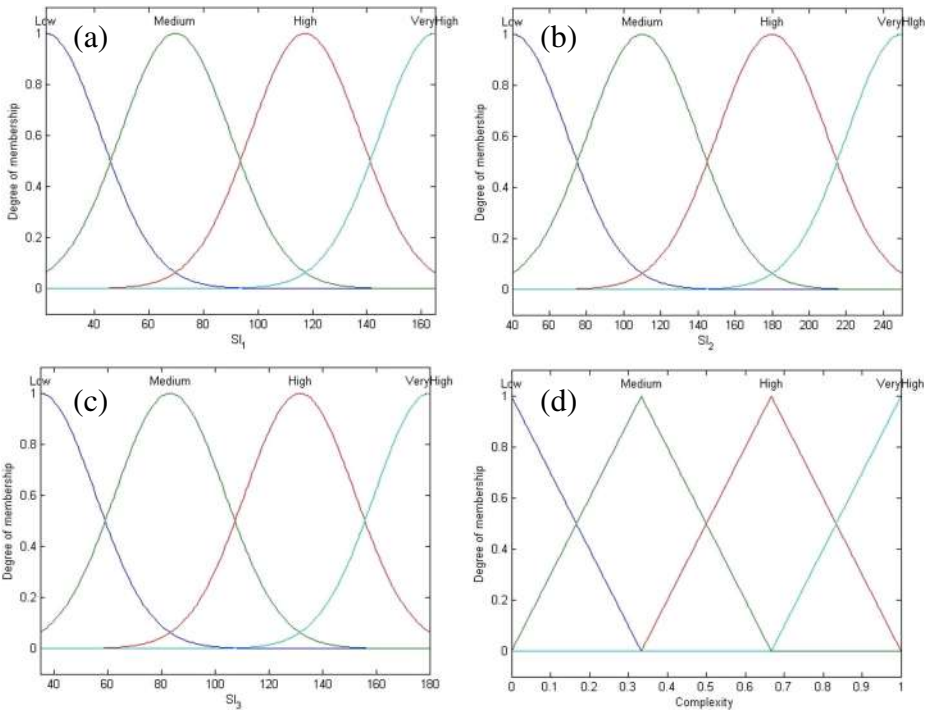


Fig. 5 **a**, **b** and **c** Input membership function for SI_{mean}, SI_{rms}, SI_{dev} (**d**) Output membership function

is made about their candidature as cover. As SI measures analyse local properties of image, image selection based on fuzzy modelled edge energy based complexity will lead to choose cover that offers better imperceptibility. Such complexity metric gives an idea about capability of an image to handle distortions caused by embedding and not to reveal presence of hidden information thereby maintaining good visual quality.

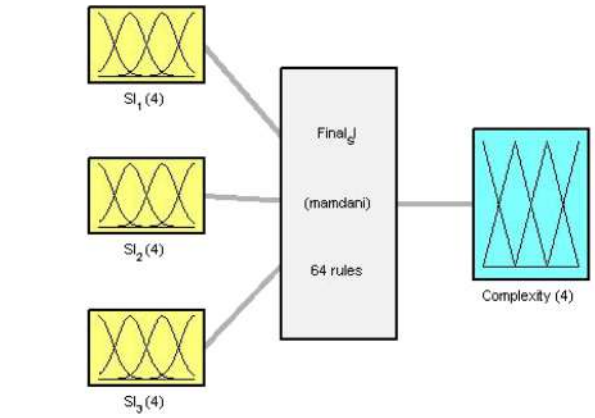
5 Experimental results

A efficient steganography scheme should have high embedding capacity, better imperceptibility and security. Increase in embedding capacity may cause noticeable distortions in stego and degrade visual quality. A trade-off must be obtained in embedding capacity and imperceptibility while maintaining security. In this section, performance of proposed steganography algorithm is verified in terms of imperceptibility, robustness to image processing attacks and undetectability in the presence of steganalyzer. Various image quality metrics used to assess visual quality of stego images are listed below.

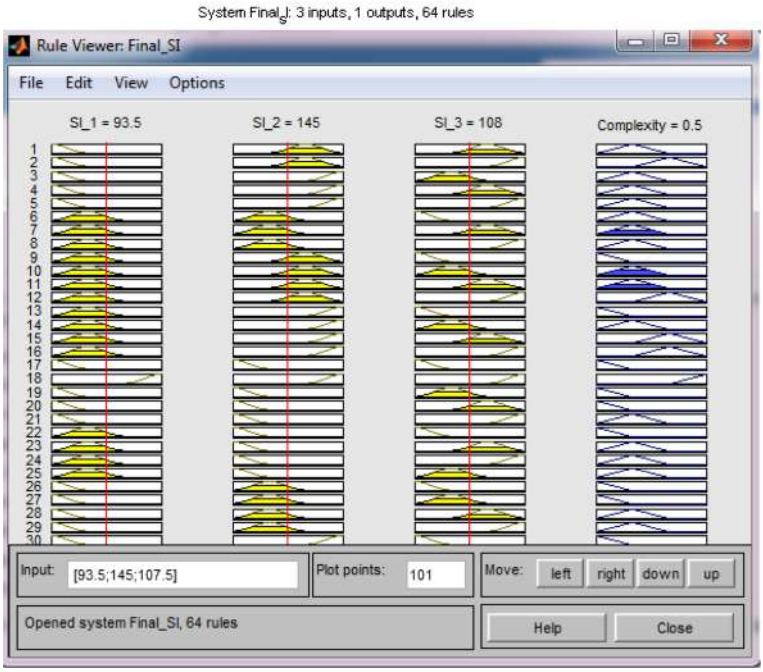
5.1 Quality metrics

1. Peak signal to noise ratio (PSNR): It is the most popular image quality metric used for assessment of stego image quality and is given by,

$$\mathrm{PSNR} = 20 \log_{10} \frac{255}{\mathrm{RMSE}} \tag{10}$$



(a)



(b)

Fig. 6 **a** Mamdani fuzzy inference system (**b**) Rule view for Mamdani FIS

2. Structural similarity index (SSIM): It compares local patterns of pixel intensities that have been normalized for luminance and contrast [38]. The MSSIM metric is calculated on various windows of an image. The measure between two windows x and y of common size $N \times M$ is computed as:

$$\mathrm{MSSIM}(\mathrm{X}, \mathrm{Y}) = \frac{1}{\mathrm{M}} \sum_{\mathrm{j}=1}^{\mathrm{M}} \mathrm{SSIM}(\mathrm{x_j}, \mathrm{y_j}) \tag{11}$$

Where X and Y are cover and stego images respectively, x_j and y_j are image contents at j^{th} local window, and M is number of windows. SSIM is computed as,

$$\mathrm{SSIM(x,\,y)} = \frac{(2\mu_x\mu_y + \mathrm{C_1})(2\sigma_{xy} + \mathrm{C_2})}{(\mu_x^2 + \mu_y^2 + \mathrm{C_1})(\sigma_x^2 + \sigma_y^2 + \mathrm{C_2})} \tag{12}$$

where σ_x is mean intensity of x, σ_y is mean intensity of y, σ_x^2 is variance of x, σ_y^2 is variance of y, σ_{xy} is variance of x and y, $C_1 = (K_1L)^2$, $C_2 = (K_2L)^2$ are two variables to stabilize division with weak denominator, L= dynamic range of pixel values (255 for 8-bit grayscale image), K_1=0.01 and K_2=0.03 by default. As SSIM compares two images based on luminance, contrast and structure, it is worth to validate the algorithm.

3. Universal image quality index (UQI): Here, quality measurement is independent of images being tested, viewing conditions and observers. So quality assessment with this metric is more meaningful than traditional metrics. This metric models any distortion as a combination of three different factors; loss of correlation, luminance distortion and contrast distortion [37]. Let $x = x_i | i = 1, 2, \ldots N$ and $y = y_i | i = 1, 2, \ldots N$ be original and test image respectively. It is given by,

$$Q = \frac{\sigma_{xy}}{\sigma_x\sigma_y} \frac{2\bar{x}\bar{y}}{(\bar{x}^2) + (\bar{y}^2)} \frac{2\sigma_x\sigma_y}{\sigma_x^2 + \sigma_y^2} \tag{13}$$

where

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$
$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$$
$$\sigma_x^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$$
$$\sigma_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}(y_i - \bar{y})^2$$
$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})$$

The first component represents correlation coefficient between x and y, second component measures how close mean luminance is between x and y. The third component measures how similar the contrast of images are.

4. Normalised correlation coefficient (NCC): It suggests degree of similarity between cover and stego. It's value lies between -1 and 1. If two images are exactly identical, value will be 1; if they are completely opposite, value will be -1. The value will be 0 if two images are uncorrelated. Let $C(i, j)$ represents cover and $C'(i, j)$ is the stego image. NCC is given by,

$$NCC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[C(i,j) - \mu_c][C'(i,j) - \mu_{c'}]}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[(C(i,j) - \mu_c)^2]}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[(C'(i,j) - \mu_{c'})^2]}} \tag{14}$$

where μ_c & $\mu_{c'}$ is mean of cover and stego respectively.

5. Image fidelity (IF):

$$IF = 1 - \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}(C(i,j) - C'(i,j))^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}(C(i,j))^2} \tag{15}$$

6. Average difference (AD):

$$AD(C, C') = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} \mid C(i, j) - C'(i, j) \mid \tag{16}$$

7. Maximum difference (MD):

$$MD(C, C') = max_{i,j} \mid (C(i, j) - C'(i, j)) \mid \tag{17}$$

8. Bit error rate (BER):

$$BER(C, C') = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} C'(i, j) \oplus C(i, j)}{M \times N} \times 100 \tag{18}$$

9. Correlation quality (CQ):

$$CQ(C, C') = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} C(i, j) \times C'(i, j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} C(i, j)} \tag{19}$$

10. Normalised absolute error (NAE):

$$NAE(C, C') = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} \mid C(i, j) - C'(i, j) \mid}{\sum_{i=1}^{M} \sum_{j=1}^{N} \mid C'(i, j) \mid} \tag{20}$$

5.2 Imperceptibility assessment

Simulations are carried out on 1.7GHz CPU, 4GB RAM, MATLAB R2015a. Test images from USC-SIPI image database [36] are used to verify imperceptibility and robustness to attacks offered by proposed curvelet based steganography method. Cover images used to carry secret image are depicted in Fig. 7. All cover images are grayscale images of size 512×512. It includes Barbara, Lena, Pirate, Boat, Elaine and House. Grayscale Cameraman image of size 65536 bytes (256×256) is used as secret image and is embedded in each cover image using embedding algorithm discussed in Section 3. Figure 8 shows stego images for visual quality assessment. Subjective measurement includes identification of any noticeable distortions in stego images with naked eye. From Fig. 8, it is evident that all stego images are of good visual quality and it is difficult to suspect about the presence of hidden information.

Table 1 shows objective assessment using image quality metrics PSNR, MSSIM, IF and UQI values for stego images shown in Fig. 8. MSE and PSNR are inconsistent with HVS. UQI evaluates loss of correlation, luminance distortion and contrast distortion. SSIM considers image degradation as perceived change in structural information. So, performance of UQI and SSIM is better than MSE and PSNR. Hence, in addition to PSNR, SSIM and UQI are also employed to judge imperceptibility. MSSIM, IF and UQI should be ideally 1 and PSNR should be more than 30 dB. Average values of PSNR, MSSIM, IF,NCC and UQI are 52.23 dB, 0.9997, 0.9999, 0.9999 and 0.9999 respectively and confirms better imperceptibility.

Imperceptibility performance is also verified using test images from two popular image databases; UCID database [29] and Washington image database [14]. 800 test images from UCID database and 500 test images from Washington database are selected randomly. Using proposed steganography algorithm, stego images are obtained for each of these test images and quality evaluation is made. Figure 9 exhibits PSNR and MSSIM values for 500 test images from UCID and Washington image database. Table 2 shows

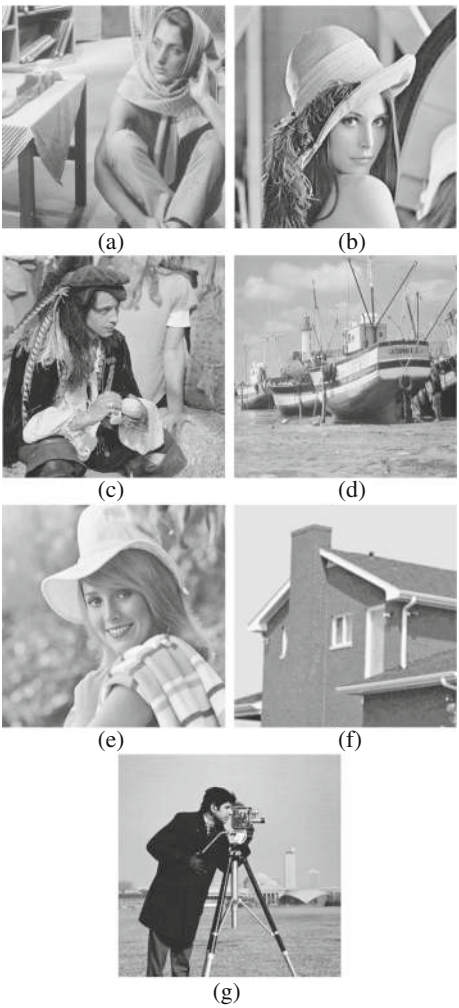


Fig. 7 Cover images: (**a**) Barbara (**b**) Lena (**c**) Pirate (**d**) Boat (**e**) Elaine (**f**) House (**g**) Secret image: Cameraman

average values of PSNR, MSSIM, UQI and IF for these 500 test images. Experimental results confirm that proposed steganography algorithm satisfy imperceptibility characteristic.

5.3 Robustness to attacks

Image steganography is a means of covert communication. It is basically hidden writing where intruder is unaware of secret communication. When stego images are transferred over the network, there are chances of attack made either to detect, retrieve or destroy secret information hidden in stego image. For a steganographer, it is crucial to design steganography scheme robust to all such attacks. Image manipulation is one of the popular ways to attack steganography. A variety of image processing attacks are applied to stego images to check robustness. A list of stego attacks includes rotation by 90°, sharpen, Gaussian blur, addition of different types of noise like Gaussian noise, salt and pepper noise, speckle noise,

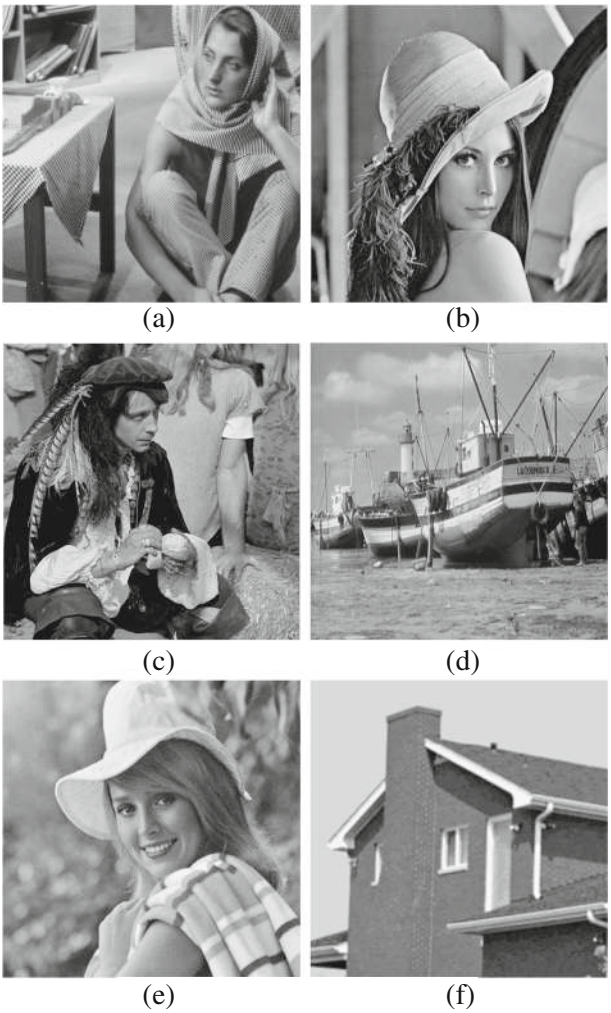


Fig. 8 Stego images (**a**) Barbara (**b**) Lena (**c**) Pirate (**d**) Boat (**e**) Elaine (**f**) House

cropping, histogram equalization and JPEG compression etc. In order to verify imperceptibility of attacked stego, several metrics as PSNR, MSSIM, MD, AD, IF and NAE are employed and values are depicted in Table 3. As can be seen from Table 3, stego quality is acceptable for almost all attacks. NAE, AD should be as low as possible, IF, MSSIM should be close to 1.

To verify robustness against image processing attacks, NCC, BER and CQ metrics are employed and their values are presented in Table 4. It can be seen that for all images value of BER is almost 0 and NCC is 1 or very close to 1.

5.4 Steganalysis results

Steganalysis refers to detection of hidden message from stego image and is used to check security of image steganography algorithm. For any given steganography scheme, not only

Table 1 Stego quality evaluation

Image	PSNR	MSSIM	UQI	IF	NCC
Barbara	51.70	0.9999	1	0.9999	1
Lena	52.09	0.9998	1	0.9999	0.9999
Pirate	53.60	0.9997	1	0.9999	1
Boat	54.35	0.9997	0.9996	1	1
Elaine	51.22	0.9998	1	0.9999	0.9999
House	50.43	0.9994	1	0.9999	1

perceptual transparency but also undetectability is crucial to validate the algorithm. Here, security is modelled in terms of detection accuracy. With wide variety of image transforms available, usually there will be no visual evidence of tamper and stego image seems to be

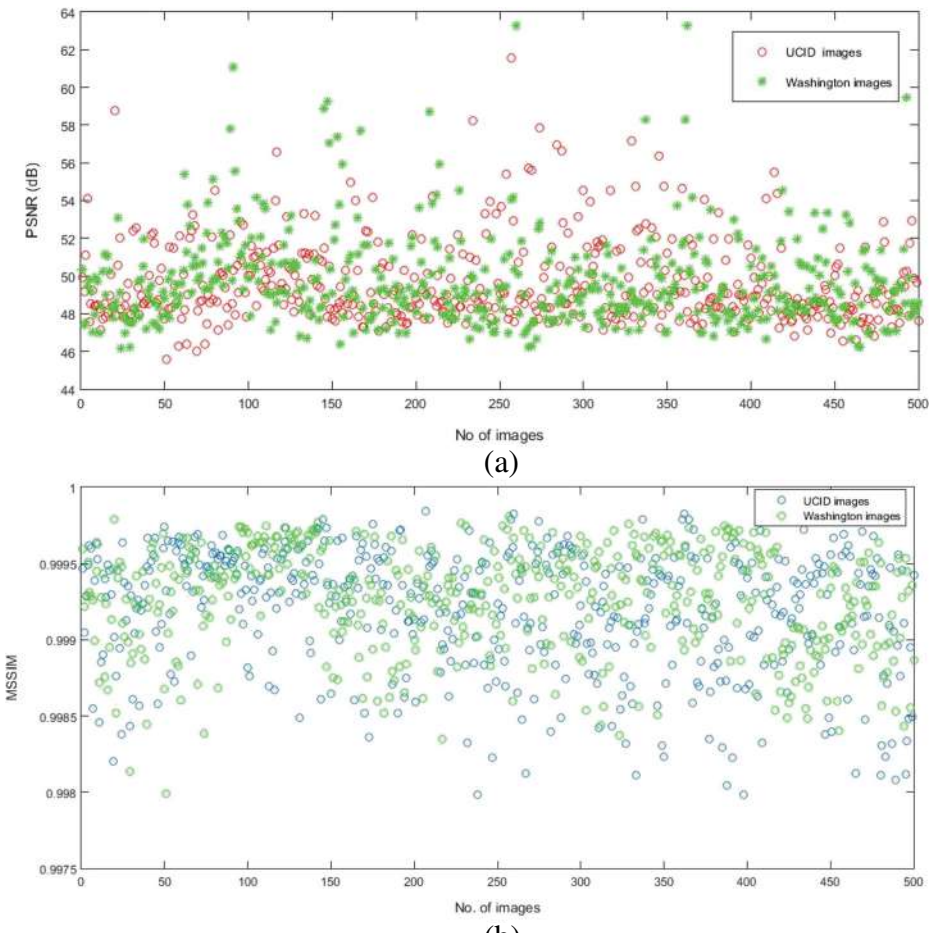


Fig. 9 Imperceptibility via image quality for UCID and Washington database images (**a**) PSNR vs. No. of images (**b**) MSSIM vs No. of images

Table 2 Imperceptibility assessment of images in UCID and Washington image database

Image Database	PSNR (dB)	MSSIM	UQI	IF
UCID Database (800 images)	51.02	0.99	0.99	0.99
Washington Database (500 images)	50.63	0.99	0.99	0.99

of best visual quality inspite of embedding large payload. However, steganalysis tries to break steganography by analysing statistical features of stego image. Steganalysis is a two class classification problem that classifies input image as either clean or stego. As proposed scheme works in transform domain, wavelet based and contourlet based steganalysis algorithms proposed in [19] and [27] are employed to measure detection accuracy.

In wavelet based steganalysis scheme (WBS), stego image is decomposed using separable quadrature mirror filters (QMFs). It divides frequency space into multiple scales and orientations using separable lowpass and highpass filters applied along image axes. It results in vertical, horizontal, diagonal and lowpass sub-band. Subsequent scales are created by recursively filtering lowpass sub-band. The statistical model consists of two sets of statistical features. First set of statistics consists of mean, variance, skewness and kurtosis of sub-band coefficients at each orientation and scale. The second set of statistics is based on errors in an optimal linear predictor of coefficient magnitude. It results in 24-dim feature vector. Classifier is trained for statistics of cover and stego images. Support vector machine (SVM) is used as classifier and classifies sample image in either clean or stego category.

Contourlet transform based steganalysis scheme (CBS) is also employed to obtain steganalysis results. Contourlets offer high degree of directionality. They perform better in capturing geometrical features like smooth contours in images where wavelets fail. So performance evaluation with CBS will be more effective. In CBS, Level 3 contourlet decomposition is obtained. For each of eight sub-bands in third level, first four moments i.e. mean, variance, skewness and kurtosis of eight sub-bands and difference between actual and linear predicted coefficients result in 64 dimension feature vector. Non-linear SVM is used for classification.

Table 3 Evaluation of image quality for different attacks, stego of Lena 512 × 512, secret cameraman 256 × 256

Nature of attack	PSNR	MSSIM	MD	AD	IF	NAE
Rotation (90°)	29.1144	0.4332	187	26.3471	0.9131	0.1235
Sharpen	32.2129	0.7725	118	4.1522	0.9857	0.0004
Gaussian Blur (sigma=1.5)	33.1687	0.8121	112	3.3680	0.9911	0.0135
Gaussian noise (mean=0, var 0.001)	35.1370	0.8132	36	3.0112	0.9976	0.0146
Salt and Pepper (density=0.01)	47.1490	0.8469	219	0.5863	0.9984	0.0034
Speckle noise (0.002)	37.3518	0.7997	38	1.9315	0.9962	0.0106
Median filtering	39.7481	0.9264	156	1.1001	0.9989	0.0101
Wiener filtering	39.1724	0.8892	44	1.3110	0.9989	0.0015
Crop (25%)	29.7610	0.5924	137	23.2351	0.8824	0.1132
Histogram Equalization	30.1213	0.9147	52	7.1403	0.9840	0.0523
JPEG compression (QF=50)	40.1093	0.9382	39	1.0127	0.9963	0.0013

Table 4 Security evaluation of attacked stego

Nature of attack	Lena			Barbara			Elaine		
	CQ	NCC	BER	CQ	NCC	BER	CQ	NCC	BER
Rotation (90°)	125.35	0.999	0	117.89	1	0	132.53	1	0.00003
Sharpen	150.32	0.9932	0.0074	146.42	0.9611	0.0468	153.25	0.9943	0.0070
Gaussian blur (sigma=1.5)	142.11	1	0	137.55	1	0	149.69	1	0.0000038
Gaussian noise (mean=0, var 0.001)	144.16	1	0.000038	142.77	0.9998	0.0000015	151.90	1	0.0000038
Salt and Pepper noise (density=0.01)	144.37	0.9963	0.0049	142.63	0.9963	0.0049	151.65	0.9964	0.0050
Speckle noise (0.002)	143.37	1	0	142.82	1	0	151.91	1	0.0000038
Median filtering	143.36	1	0.0000015	141.05	1	0.000015	151.66	1	0.000014
Wiener filtering	144.05	1	0	141.33	1	0	151.42	1	0.0000038
Crop (25%)	121.12	1	0	84.12	1	0	158.07	1	0.0000038
Histogram equalization	158.12	1	0.0163	162.24	1	0.0151	152.56	1	0.0155
JPEG compression (QF=50)	143.23	1	0	142.65	1	0.0000152	151.76	1	0.0000037

Table 5 Detection accuracy in percentage

Algorithm	Secret data	Steganalysis	Feature Dim	Group A	Group B
Proposed method	256 × 256	WBS	24	52.52%	53.2%
		CBS	64	52.10%	56.38%

5.4.1 Cover selection performance by detectability

To test proposed cover selection method against steganalysis, following experiment is arranged. Randomly collect 500 test images from Washington image database. Compute SI measures for all these images and obtain their level of complexity by fuzzy modelling

Fig. 10 Cover images with different levels of fuzzy based complexity and corresponding PSNR values (**a–d**) Low and medium complexity (**e–i**) High and very high complexity

as explained in Section 4. According to their level of complexity, categorize these images into two groups; Group A and Group B. Group A consists of images with low and medium complexity and Group B contains images with high and very high complexity. A grayscale Cameraman image of size 256 × 256 is used as secret image and is embedded in each image from Group A and Group B using proposed embedding algorithm discussed in Section 3. Steganalysis results are obtained separately for two groups using both WBS and CBS methods. Performance measure for steganalysis results is detection accuracy of stego images. TP is true detection of stego images and FP is false detection of clean images. The detection accuracy is average of true detection of both stego and cover images. It has been observed that steganalyzer is not able to distinguish between cover and stego image and most of the times stego is misclassified as cover. To increase the reliability of results, the same experiment is repeated number of times and average detection accuracy is computed. Table 5 shows detection accuracy for Group A is 52.52% and 52.10% for WBS and CBS respectively. For Group B, detection accuracy is 53.2% and 56.38%. It can be seen that Group A images have less detectability and can be preferred over Group B images for covert communication.

5.5 Cover selection based on visual quality of images

Cover selection module helps to reduce the risk of detectability of stego images. If steganalyzer is able to suspect the presence of hidden information, purpose of steganography is broken. Following experiment is arranged to verify imperceptibility of stego images when cover selected using proposed cover selection method is used to carry secret image. Collect 500 test images randomly from Washington image database. Obtain SI measures and compute the level of complexity for each test image as explained in Section 4. Choose a grayscale Cameraman image of size 256 × 256 as secret image. Using embedding steps, obtain stego images for each of the test image by embedding secret as explained in Section 3. Using exact measure of cover selection as PSNR, imperceptibility of stego is verified for covers with various complexities. Figure 10 show some of the images from Washington image database that are modelled with fuzzy complexity. It include low, medium, high and very high complexity images and PSNR values obtained with proposed steganography approach. It has been observed that low and medium complexity images

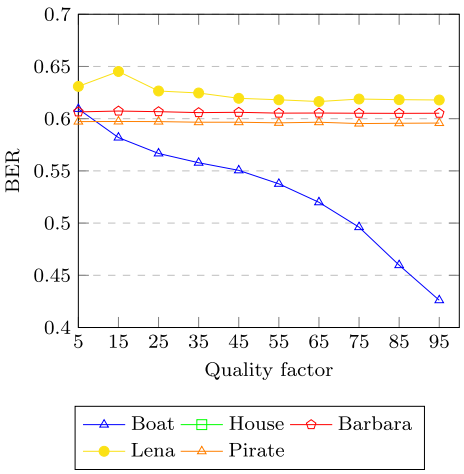


Fig. 11 Effect of JPEG Compression on BER

have high and very high PSNR values respectively. However, high and very high complexity images have medium but acceptable (in the range 45-48 dB) PSNR values. When the steganographer want to choose cover, he can refer to look up table where SI features and a

Table 6 Comparison of proposed scheme with existing methods

Algorithm	Secret size	Cover image	PSNR	SSIM	NCC	UQI
Thabit et al. [35]	49152 bits	Lena	43.29	-	-	-
		Airplane	40.27	-	-	-
		Baboon	34.33	-	-	-
		Peppers	41.71	-	-	-
Sajasi et al. [24]	256 × 256	Lena	47.78	-	-	-
		Baboon	49.98	-	-	-
Kanan et al. [15]	256 × 256	Lena	45.12	-	-	-
		Airplane	45.18	-	-	-
		Peppers	45.13	-	-	-
		Baboon	45.12	-	-	-
Xiao et al. [39]	256 × 256	Framelet + SVD Lena (1)	41.23	-	1	
		Framelet +SVD + CS Lena (0.9)	41.30	-	0.9981	-
		Framelet +SVD + CS Lena (0.8)	42.17	-	0.9971	-
		Framelet +SVD + CS Lena (0.6)	43.12	-	0.9927	-
Subhedar et al. [33]	256 × 256	Lena	49.0369	0.9963	0.9996	
		Airplane	49.2608	0.9971	0.9997	-
		Peppers	50.1480	0.9966	0.9997	-
		Baboon	37.7031	0.9917	0.9966	-
		Splash	54.8019	0.9975	0.9996	-
Gulave et al. [12]	78.7Kb	Lena	39.84	0.953	-	0.806
		Peppers	40.29	0.932	-	0.8
		Barbara	39.70	0.964	-	0.857
		Elaine	40.01	0.956	-	0.890
		Baboon	39.62	0.979	-	0.961
Mohammad et al.[30]	12288 bits	Lena	53.78	0.9959	-	-
		Barbara	51.61	0.9961	-	-
		Airplane	54.17	0.9963	-	-
Reba et al. [20]	255 × 255	Lena(255 × 255)	40.26			
		Baboon(255 × 255)	40.09			
Rabie et al. [23]	479 × 479	Lena	27.21			
Proposed method	256 × 256	Lena	52.09	0.9998	0.9999	1
		Peppers	48.3429	0.9992	0.9999	0.9999
		Barbara	51.70	0.9999	0.9999	1
		Elaine	51.22	0.9998	0.9999	1
		Baboon	49.04	0.9998	1	1
		Airplane	49.2652	0.9988	1	1
		Spalsh	48.9181	0.9993	0.9998	0.9952

class of complexity is stored and choose the cover appropriately. Due to varying image content, they may have different embedding capacities and detectability. Hence as per secret size to be communicated, choice of cover may vary.

5.6 Resistance to JPEG compression

Image steganography is a means of covert communication. As secret hidden in cover is of prime importance in steganography, in addition to verifying error rates between original cover and attacked stego, secret image retrieval from JPEG compressed stego is also verified. Results are obtained using quality factor (QF) ranging from 5 to 95. Stego image is first compressed and further employed for extraction of embedded secret information. BER values between original and extracted secret are calculated. Figure 11 depicts results for five stego images. Error rates are too low and confirm robustness to JPEG compression.

6 Comparison with existing work

To show efficacy of proposed method, comparison is made with existing image steganography schemes in terms of imperceptibility and steganalysis results. As proposed method demonstrates transform domain steganography, it has been compared with transform domain methods only. Table 6 presents imperceptibility comparison with existing schemes using quality metrics PSNR, SSIM, NCC and UQI. As can be observed from Table 6, all quality metrics possess better values as compared existing steganography schemes and proves that proposed method outperforms in terms of imperceptibility.

Another important parameter to validate the steganography scheme is steganalysis performance. Table 7 shows the comparison of detection accuracy with existing schemes to judge the validity of proposed cover selection method. For comparison of steganalysis results, transform domain steganography and steganalysis schemes are employed. Sajedi et al. presented cover selection steganography based on similarity of image blocks. In this scheme, blocks of secret image are compared with blocks of a set of cover images and the image with most similar blocks to those of secret image is selected as the best candidate to carry secret image. Wavelet based [9] and feature based [11] steganalysis methods are employed. Nazari et al. proposed another way to choose cover from image database based

Table 7 Comparison of detection accuracy with existing methods

Algorithm	Secret size	Cover size	Steganalysis scheme	Classifier	Detection accuracy(%)
Kharrazi et al. [16]	4.3kb	63.5kb	WBS	FLD	58.33
			FBS	Non linear SVM	46.3
Nazari et al. [22]	10,000 bits	512 × 512	WBS	FLD	60
			BBS	CDC	62
Sajedi et al. [25]	15000 bits	512 × 512	Wavelet	FLD	58.5
			Feature based	(Non linear SVM)	60.5
Sajedi et al. [28]	5000 bits	512 × 512	FBS	Non linear SVM	53
			Wavelet	FLD	53
Proposed method	65536 bytes	512 × 512	Wavelet	Non linear SVM	52.52
			Contourlet	Non linear SVM	52.10

on run length matrix and HVS [22]. WBS and BBS [6] schemes are employed for verifying steganalyzers ability to detect stego image. Cho et al applied content dependent classifiers (CDC) to classify given image in either cover or stego category. Adaptive steganography scheme using contourlet transform is proposed by Sajedi et al. Each bit of secret data is embedded by exchanging the value of two coefficients in a 4×4 block of a contourlet sub-band. Resistance to steganalysis is verified using wavelet based steganalysis [9] and feature based steganalysis [10]. Another contourlet based scheme proposed by Sajedi et al. considered effect of cover selection on steganalysis results. Embedding of every bit of secret data is achieved by increasing or decreasing the value of one coefficient in a block of a contourlet sub-band. Variety of fast and exact measures were proposed for cover selection and using exact cover selection measure, steganalysis results were obtained. In proposed method, steganalysis results are better inspite of embedding large volume of secret data; secret image of size 256×256. Though, a large size JPEG image is embedded in cover image of size 512×512, detection accuracy is poor indicating better security against steganalyzer. This proves that our scheme has better imperceptibility, robustness and undetectability as compared to existing transform domain image steganography schemes.

7 Conclusion

This paper presents curvelet transform based cover selection image steganography. Adaptive block based embedding in non homogeneous regions of curvelet coefficients helps to achieve better imperceptibility. Stego quality is assessed using PSNR, MSSIM, IF and UQI. Another contribution of this paper includes a new cover selection method based on image complexity and spatial information. With the help of fuzzy logic, complexity of each image is observed and accordingly cover image is selected such that it results in better stego quality and poor detectability. Robustness to all popular attacks is verified with PSNR, AD, MD, MSSIM, IF and NAE. Also, security of attacked stego is evaluated with CQ, BER and NCC. Results show that proposed scheme is robust to all image processing operations and JPEG compression. Cover selection performance is demonstrated both in terms of visual quality and in the presence of steganalyzer. The scheme is also examined with wavelet based and contourlet based steganalysis algorithms. Average detection accuracy is found to be 52.52% and 52.10% that proves that steganalyzer is not able to distinguish between clean and stego images and scheme is undetectable.

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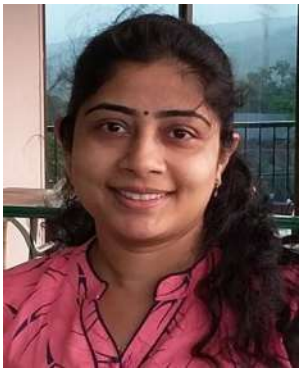

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