Indian Council of Social Science Research

impress
Impactful Policy Research in Social Science

Government of India
Ministry of Human Resource Development

Sponsored

NATIONAL SEMINAR ON

"HIGH LEVEL THINKING USING ARTIFICIAL INTELLIGENCE"

ORGANIZED BY:

SENGUNTHAR ENGINEERING COLLEGE TIRUCHENGODE
EDUCATION EDIFICATION ELEVATION
Estd 2001

BSCIC JAS-ANZ www.jas-anz.com.au/register
ISO 9001 REGISTERED

SENGUNTHAR ENGINEERING COLLEGE

(Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai) Accredited by NAAC with 'A' Grade Recognition of College under Section 2(f) and 12(B) of the UGC Act, 1956

Tiruchengode – 637 205, Namakkal, Tamilnadu, India

SENGUNTHAR
Shrine 2 Success

14TH JUNE 2019

ISBN: 978-93-87793-95-8

NATIONAL SEMINAR ON

"HIGH LEVEL THINKING USING ARTIFICIAL INTELLIGENCE"

Editors

DR. C. VENKATESH,

DR. M. S. R. MARIYAPPAN,

DR. P. RAMESH KUMAR,

DR. P. SUBRAMANIAN

Publish By:

A.R. Research Publication

Preface

ABOUT SEMINAR

National Seminar on "High Level Thinking Using Artificial Intelligence" is a global event organized by Sengunthar Engineering College. This Seminar provides an international forum for researchers, developers, engineers and practitioners who are involved in real time projects that provide solutions to exchange their valuable ideas and showcase the ongoing works which may lead to path breaking foundation of the futuristic engineering. It accentuates indispensability of interdisciplinary and cross – linked thinking with respect of innovation and market opportunities.

ABOUT OUR INSTITUTION

Sengunthar Engineering College was established with the ideal motto of "Education, Edification and Elevation", in the year 2001 underneath of Sengunthar Charitable Trust which always aspires to hone the skills of young minds, maintains better standards and develops scientific temper. Sengunthar has been producing successful professionals, technocrats, entrepreneurs and academicians, since from the inception.

This Co-educational, Self-financing Engineering College, started with the approval of Government of Tamilnadu in 2001 and it is approved by All India Council for Technical Education (AICTE), New Delhi and affiliated to Anna University, Chennai. It has been recognized by UGC, New Delhi under the Section 2(f) and 12(B) of the UGC Act, 1956 and also Accredited with "A" Grade by NAAC. The college is Certified as ISO 9001:2008 Institution by BSCIC. The College started with 3 Under-Graduate Programmes with the Student-Strength of 104 in the year, 2001, now offers 5 Under-Graduate Programmes, 4 Post-Graduate Programmes, and 2 Ph.D. Research Programmes with the support of 147 Teaching Faculty Members and 32 Non-Teaching Staff Members.

The College has had an excellent and consistent academic record right from the beginning. 3 Gold Medalists and 124 University Rank Holders are produced by the eminent faculty members is yet another significant milestone.

PROGRAMMES

UG Programmes
1. B.E. Civil Engineering
2. B.E. Computer Science and Engineering
3. B.E. Electronics and Communication Engineering
4. B.E. Electrical and Electronics Engineering

5. B.E. Mechanical Engineering
PG Programmes
1. M.E. Structural Engineering
2. M.E. Computer Science and Engineering
3. M.E. VLSI Design
4. Master of Business Administration (M.B.A.)
Ph.D. Research Programmes
1. Computer Science and Engineering
2. Electronics and Communication Engineering

AWARDS/ HONOURS

Over the years, the College has grown by leaps and bounds and has made its presence felt in this region because of its unflinching commitment to excellence. The College not only serves as a Center of Academic Excellence but also acts as a platform for students of diverse interests, ranging from Curricular, Co-curricular and Extra-curricular activities. The following awards and recognitions were placed by external agencies:

- The Staffordshire University, UK and Education Matters in Collaboration presented the Award "Teaching Awards in Engineering" to the Department of ECE which has produced University Ranks in the academic year, 2013-2014
- Ranked as "AAA" in India's Best Engineering Colleges by Career360° in the year 2019
- Obtained 124th rank in All Over India Best Engineering College by India Today in the year 2019
- Ranked 9 th place in the lowest fees in India Today in the year 2019
- Retained 6th Position in Ranking of Promising Engineering Colleges in India and obtained 21st Rank at Top Engineering Colleges in Tamilnadu by GHRDC – CSR Survey 2018

HIGHLIGHTS OF SEC

- Permanent Affiliation for ECE, EEE, Mechanical and CSE Programmes
- CSE & ECE Departments are Approved Research Centre by Anna University, Chennai
- 'Mentor of Change' for the Government of India's flagship program of Atal Tinkering Labs (ATLs), established by the Atal Innovation Mission, NITI Aayog.
- Centre of Excellence in ECE Department in Association with M/s. ABE Semi conductors.
- Established Innovation Lab DSP, IoT and Robotics in Collaboration with M/s. Texas Instruments, USA and Knowledge partner STEPS, Coimbatore

- National Cyber safety and Security Nodal Centre for Namakkal Dist.,
- MHRD- IIC Certified Institution
- Obtained GOLD rating at AICTE-CII Survey of Industry linked Technical Institute 2018
- Remote centre of IIT Bombay
- In all Departments Ph.D. holders serve as mentors
- SEPARATE BLOCK for each Department
- Wi-fi Campus
- Well stacked Library with various e-journals
- Start up- Incubation Centre – Sentrix IT Park Inside the Campus
- Online Learning Management System for Students (LMS)
- More than 40 Committees and clubs are functioning for the benefit of students
- Free Transport Facility for Students and Faculty Members
- Pit – stop café
- Good placement record Track
- Personality Development Programmes and Department wise Value Added Courses offered as per the demand of the industry Intensive training to produce a new breed of Entrepreneurs
- 1 Crore Merit and Community Scholarship given by Trust
- Sports clubs are associated with Zonal, District, State and National level Sports Association
- "SECAPPS" Android Mobile Application for stake holders
- Special scholarship for Physically Challenged persons
- A strong network of alumni serves as a forum to share the industrial exposure

Proceeding of the NATIONAL SEMINAR ON "HIGH LEVEL THINKING USING ARTIFICIAL INTELLIGENCE" has been published with **ISBN: 978-93-87793-95-8 at** Sengunthar Engineering College Tiruchengode, Namakkal Dist. Tamilnadu **(India)** the collaboration of MHRD **on 14th June 2019**

FROM OUR CHAIRMAN'S CHAMBER…

I am delighted to state that this one day national seminar which provides an ideal forum for exploring the recent developments and advancement pertaining to all the profession. The national seminar will provide an exceptional platform to the researchers to meet, discuss the Practical Solutions, Scientific Results and Methods in solving intriguing problems with people who are actively involved in these emerging fields.

I admire the efforts of our Secretary and Correspondent, Principal and the Staff members to organize this national seminar successfully. I laud your creditable steps.

With best wishes,

Ever Yours,

Thiru Jansons T.S.Natarajan

Chairman

Sengunthar Charitable Trust

FROM OUR CORRESPONDENT'S DESK...

My Dear Students,

Clear Vision,

Backed by definite plans,

Gives you a tremendous feeling of confidence and personal power.

I am being extolled about the gorgeous march of the visionary achievement through this national seminar**.** The aim of the one day national seminar is to provide a platform to the researchers and practitioners from both academia as well as industry to meet and share cutting-edge development in the field. Besides it will help to learn proven case studies and success stories across industries and the risks and potential. I congratulate the principal, the staffs and the students of our college for organizing national seminar in a majestic manner.

May God bless them with practical wisdom to win all glory.

Ever Yours,

Prof. A. Baladhandapani,M.A.,M.Phil.,

Secretary & Correspondent

Sengunthar Charitable Trust

MESSAGE FROM PRINCIPAL DESK…

My Dears,

The one day national seminar discloses our unity in work to weave a set innovative breed of Engineers. The national seminar will not only take stock of trends and developments at the globally competitive environment. Besides, it will help in sharing of experience and exchange of ideas, which will foster National collaborations. The seminar is a national forum which aims to bring together leading academician, researchers and research scholars to exchange and share their experiences and hard-earned technological advancements about all aspects based on their research.

With an ecstasy, I thank our Management for the freedom and massive support rendered. I am out of words to express my gratitude to my Teaching and Non-Teaching Faculty Members for their immaculate virtue and caliber to conduct this national seminar. I wish good luck to my wards for their successful career.

May God bless with wisdom and fill us with peace now and forever.

With best wishes,

Dr. C. VENKATESH, FIE., FIETE.,

Principal

Sengunthar Engineering College

Tiruchengode

Er. A. B. MADHAN, M.E.,

Chief Executive Officer,
Sengunthar Institutions,
Tiruchengode.

Dears,

Over the past year, there has been a lot of exchange of knowledge and clinical experience in the form of seminars, conferences, and workshops across the country

Our thirsty in voyage of knowledge leads to grab a wide range of ideas and novel concepts. The one day national seminar on “High Level Thinking Using Artificial Intelligence” will wide open a new era. The national seminar would be of immense benefit to Management, Researchers, Academicians, Industry and participants from technical Institutes, R & D Organizations and students

I wish this national seminar on “High Level Thinking Using Artificial Intelligence” plays role in transferring this dynamic teen to a responsible adult.

With best wishes,

Ever Yours,
Er.A.B.Madhan
Chief Executive Officer

Er. ARAVIND TIRUNAVUKKARASU, M.C.A., M.E.,

Director - Corporate Relation & Training,
Sengunthar Institutions,
Tiruchengode.

Dears,

This one day national seminar intends to be the global forum for researchers, educators, academicians and engineers to present and discuss recent innovations and new techniques in Engineering and technology. The conference will be an ideal platform for delegates to exchange their ideas and experiences face to face with many networking opportunities. I hope this The national seminar on “High Level Thinking Using Artificial Intelligence” will provide a great platform for the students to share and exhibit their enthusiastic ideas.

I congratulate all the organizers. I wish this function a phenomenal success.

With best wishes,

Ever Yours,

Er. Aravind Tirunavukkarasu

Director - Corporate Relation & Training

Published by

AR Research Publication,

3/186 Santpura Govindpuri Modinagar- 201201 . Dist: Ghaziabad

This edition can be exported from India only by the publishers, AR Research Publication (India)
ISBN: 978-93-87793-95-8

Managing Director: Gauri Sharma

Senior Researcher—Product Development: Ms. Pratima Singh
Head—Production (Higher Education and Professional): Satinder Kulkarni

Cover Design: Abhishek Sharma

ISBN : 978-93-87793-95-8

INDEX

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Artificial Intelligence in Vehicles – A state of the art study

Dr.C.Venkatesh[1]Dr.P.Ponmurugan[2] Dr.K.Rajangam[3]
[1]Principal, Sengunthar Engineering College, Tiruchengode.
[2]Associate Professor, Dept. of EEE, Sri Krishna College of Technology, Coimbatore.
[3]Professor & Head, Dept. of EEE, Sri Krishna College of Technology, Coimbatore.

Abstract

With the ever-increasing demand in urban mobility and modern logistics sector, the vehicle population has been steadilygrowing over the past several decades. One natural consequence of the vehicle population growth is the increase in trafficcongestion. Almost all (metropolitan) cities in India including the major ones like Mumbai, Delhi, Chennai, etcare sufferingfrom heavy traffic congestion. In the meanwhile, traffic accidents are plaguing the economic development as well. This article is about the use of artificial intelligence in vehicles.

Keywords: Artificial intelligence, Vehicle intelligence, Next-generation vehicles, Electric Vehicles.

1. INTRODUCTION

1.1 Background

With the ever-increasing demand in urban mobility and modern logistics sector, the vehicle population has been steadilygrowing over the past several decades. One natural consequence of the vehicle population growth is the increase intraffic congestion. Almost all (metropolitan) cities including the major ones, like Mumbai, Delhi, Chennai, etcare suffering from heavy traffic congestion. In the meanwhile, traffic accidents are plaguing the economicdevelopment as well. The number of traffic accidentshas been maintaining in a high number during the past fiveyears and people are having more and more vehicles. It isestimated that there is at least one person dying from trafficaccidents worldwide every minute. Besides traffic accidentsand congestions, there are still miscellaneous issues makingpeople uncomfortable. It is more and more difficult to findan available Parking spot during rush hours in urban areas.People usually spend more than 20 min searching for a Parking spot, which is meaningless and quite annoying as thesearching time increases. Environmental pollution is anotherbig issue. With the increasing number of vehicles, vehicleemissions of SO2, NOx, CO, CO2, dust particles, smog andnoise have reached or even exceeded levels comparable tothose from industrial production and are harmful to the environment and human health.

ISBN : 978-93-87793-95-8

With the help of recent development in artificial intelligence (AI), we are able to make vehicles intelligent enoughso that the aforementioned problems can be solved.

1.2 AIV

Artificial intelligence for vehicles (AIV) aims at applyingboth practical and advanced AI techniques to vehicles so thatvehicles can perform human-like or even superhuman behaviors [1,2]. The algorithms such as deep neural networks aredesigned to mimic the working principle of the brain andtrained over large data sets to perform various tasks. Intelligent vehicles combine AI techniques such as environmentalperception, map building and path planning and integratethem with multi-scale auxiliary driving services and otherfunctions [1,2], so that vehicles are able to make intelligentdecisions. It focuses on the applications of artificial intelligence, machine learning and automatic control to vehicles,as depicted in Fig.1.

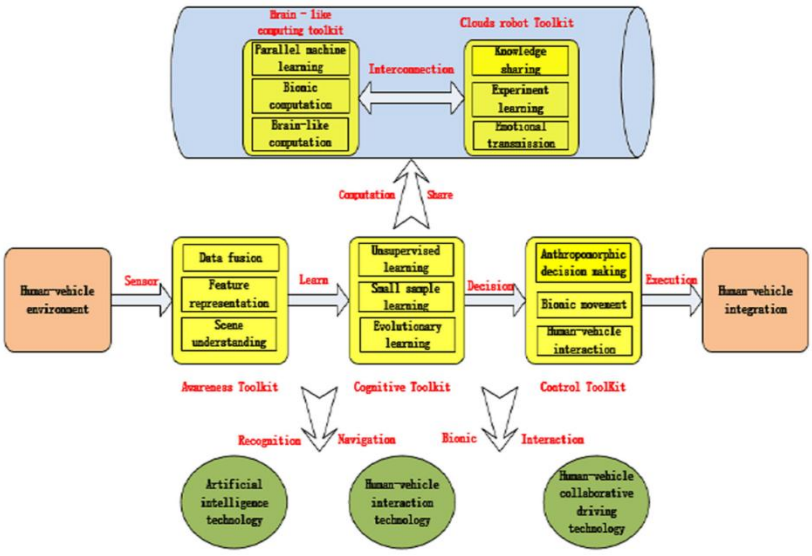


Figure 1: The framework of AIV

1.3 Why do Vehicles Need AI

With rapid economic development, intelligent vehicles are inurgent need. Along with the sustained and rapid growth of carownership, almost every country is facing severe traffic congestion, road safety and environmental pollution problems.In the meanwhile, the number of fatal traffic accidents isincreasing each year and most of them are caused by humanoperating errors. With the continued growth of car ownership, the number of fatal traffic accidents is expected to grow.Relying on advanced AI techniques, we can solve the aforementioned problems.

ISBN : 978-93-87793-95-8

Figure3summarizes four main factorswhich make vehicles in urgent need of AI techniques.

(1) Strategic needs of economy, as the leading developing country, have been late in developing other innovative technologies related to vehicles, such as electric vehicles. However, recent booming of AI techniques grants the country new opportunities to take the lead in developing AI-enabled vehicles.

(2) Artificial Intelligence 2.0 has put the development of new trends of AI technologies such as hybrid intelligence, multi-modal data fusion technologies in a very important strategy point. Developing novel AI techniques for vehicles clearly aligns with such strategies.

(3) Society needs, India has its unique traffic situation. In urban areas, the driving scenarios are too complex and it is very difficult for the drivers to always make the right driving decision. This makes India in the most need of AI-enabled vehicles which can react to complex changing driving environment.

(4) Changes in the business model of automobile, with the development of communication technologies, new modes of business models, such as car sharing, Uber and Ola, of automobile companies are emerging. Almost all of the new business models need AI techniques to support and reach optimized decisions.

2. STATE-OF-THE-ART OF AIV

Currently, enterprises and universities all around the worldhave taken initiative to layout strategic investments in AIVs[3, 4]. National policies and regulations are speeding up torelease restrictions for the expected development. The USA,France, Britain, Germany, Japan, South Korea and othercountries have developed a number of smart car-related policies to promote the integration of intelligent vehicles andexisting transportation systems. Traditional car manufactureand technology companies have invested billions of dollarsto support the development of AIVs.

The leapfrog development of automobile intelligent Internet technology manufacturers and manyindustry giants and emerging companies displayed the latestin the automotive technology products and services such asTesla and Google have launched the automatic driving car tothe road test. At the same time, the traditional car manufactures are gradually advancing the degree of fusion of 'Smart+ connected' technologies.In universities and research institutes, automotive intelligenttechnology is making full use of the latest achievements inartificial intelligence.

The basic AI algorithms roughly include the following four:

i) Artificial neural network (ANN) is one of the most important basic artificial intelligences, namely shallow neural network, consisting of a computational elements (neurons) heavily connected to each other. The number of network inputs

ISBN : 978-93-87793-95-8

can be much greater than the traditional architectures. This makes the network a useful tool for analyzing high-dimensional data.

ii) Compared to ANN, the study of deep learning focuses on deep neural network. It uses a cascade of many layers of nonlinear processing units for feature extraction and transformation and learns multiple levels of representations that correspond to different levels of abstraction.

iii) Support vector machine (SVM) classification methods are the most precise discriminatory methodsused in classification.

iv) Simulated annealing is widely and successfully applied to production scheduling and control engineering.

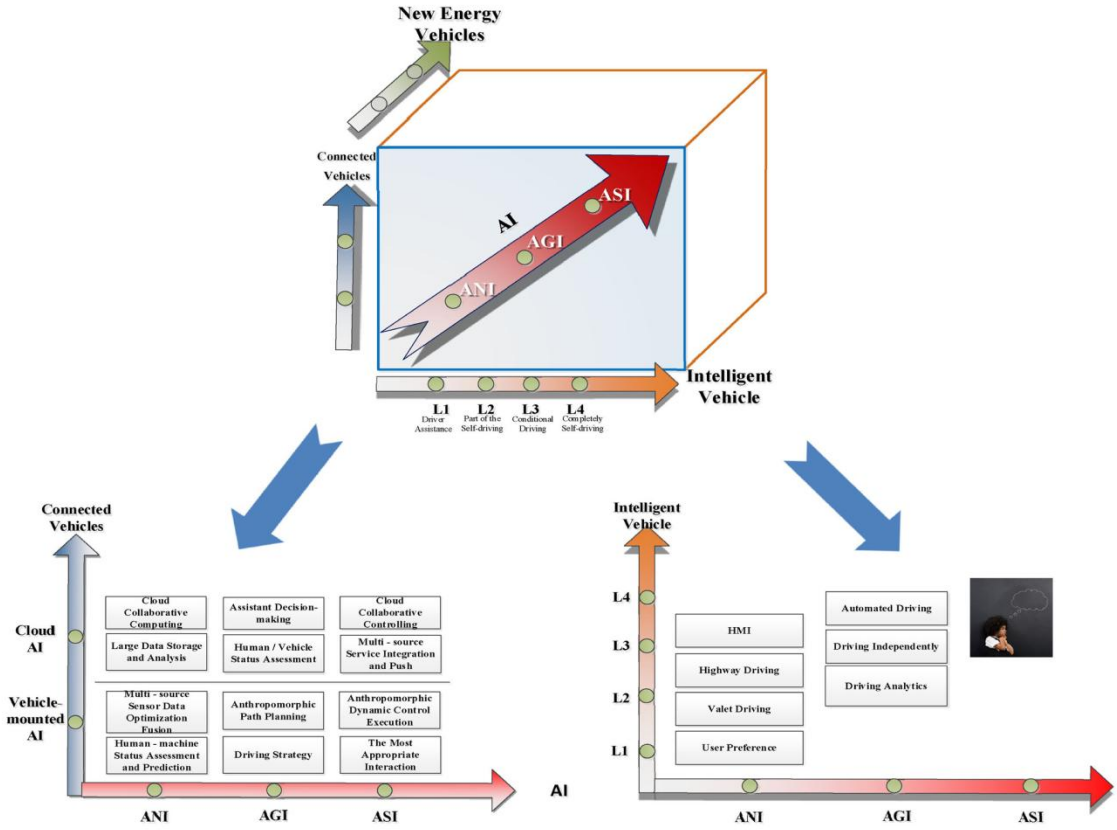
3. NEXT-GENERATION AIV

With the rapid development of AI techniques and vehiclerelated technologies, it can be foreseen that the next generation of AIV will see more standardization and the related AIfunctionalities will be modular. Figure 2 shows the envisionsof the next-generation AIV framework. In the next 10–20years, AIVs will be put into specific application scenariosand have clear definitions over the related AI functionalities. For AI functionalities, it will be divided into three parts,namely world models, planner and decision maker and computing platform.

In order to realize vision automatic positioning systemunder high speed, it is crucial to establish a high-precisionmap. World Models aim at building the high-precision mapfor future AIVs, planner and decision maker will performpath planning and other-related driving decision-makingfunctionalities, and computing platform will provide thein-car computation environment for the execution of mapbuilding as well as decision making.

ISBN : 978-93-87793-95-8

Figure 2: Envisions on how AI can be integrated to help vehicle development



Recently, deep learning (DL)-based perception, conceptionand decision maker are more and more popular in artificialintelligence. LeCun et al. [5] utilize deep learning in imageunderstanding with deep convolutional networks and distributed representations and language processing. Mnih et al. [6] combined deep learning and reinforcement learning,and implemented the human-level control for games, andthen, Silver et al. [7] create computer go based on a combination of deep neural networks and tree search which canplay at the level of the strongest human players. Deep reinforcement learning as the core technology demonstrated theartificial intelligence in finite and full defined domain whichis referred as Artificial Normal Intelligence (ANI). With ANI,AIV is able to achieve assistant driving.

With the breakthrough of human-level conception and thecomputation technology, Lake et al. [8] proposed a computational model which can capture human learning abilitiesfor handwritten form the world's alphabets. Moser et al. [9]realized brain-like localization and navigation and acquiredthe Nobel Prize in Physiology/Medicine in 2014. It followsbrain-like, spiking neural network (SNN), the generation[10] neural net gradually board on the AI stage. Basedon the brain-like conception, the artificial intelligence canbe applied in different

ISBN : 978-93-87793-95-8

generalized domains with humanequal ability which is called Artificial Generalized Intelligence(AGI). With AGI, it makes advanced auxiliary driving andautonomous driving possible in AIV.

The human–machine-based artificial intelligence springsup. Human–machine concept coupling artificial intelligenceperforms playing with young children in school [11].Human–machine semi-physical coupling AI is a foregroundin AIV. Huang [12] utilized human–machine physical coupling AI on interactive learning for human-powered augmentation lower exoskeleton [12,13]. Human–machine-based AIis referred as Artificial Super Intelligence (ASI). With ASI, themachine will hold on the total ability for dealing with transportation and moving services, and even surpass the humanintelligence in every domain.

AI with deep learning and reinforcement learning as thecore technology can be divided into practical artificial intelligence (PAI) and advanced artificial intelligence (advancedAI). We will introduce the PAI and advanced AI in the following sections.

4. KEY TECHNOLOGIES IN AIV

4.1 World Model

World model aims at providing the precise representationof the world. Precision is the key parameter measuring theperformance of a map for intelligent vehicles [13]. [14] Propose to use multiple support regions (MSRs) of differentsizes surrounding an interest point to choose the best scaleof the support region. In [15], the paper proposes a novelmethod to enhance a driver's situation awareness by dynamically providing a global view of surroundings for the driver.

At present, high-precision maps are sorted into two classes,namely ADAS and HAD, respectively. ADAS maps' accuracy is in the scale of meters, while HAD maps can achievethe accuracy of centimeters. HAD maps are more precisethan ADAS maps, with more specific road information, suchas lane and crosswalk lines. This provides the basic recoveryof the real road scene in the data. Therefore, HAD maps canbe used in self-driving cars.Automobile intelligence is the trend of the automobileindustry, which requires high-precision maps with highupdate rate. To reach the state of fully automated driving,high-precision map is the foundation; real-time informationis also required.

Gaode completed the development of ADAS map for freeways and city expressways by the end of 2015 andfor nationalhighways and provincial highways by the end of 2016. Also,Gaode completed the development of HAD map for freewaysin 2016. In 2017, Gaode is going to develop ADAS maps inmore than 30 cities and HAD maps in national highways andprovincial highways. Currently, HAD maps have narrowedthe scale into centimeters. If traditional maps are printed forhumans, the HAD maps are built for vehicles. It allows automobiles driving by themselves in the freeways. The localization functionality is based on

ISBN : 978-93-87793-95-8

image, high-precision cognitivemap is based on deep learning, and vehicle data are fetchedfrom the GIS acquisition module.

4.2 Planner and Decision Maker

The decision module integrates path planning, behavior planning, reference planning and motion planning, makes the final intelligent decision and drives the smart car [16–18]. [19] proposed a development framework and novel algorithms for road situation analysis based on driving actionbehavior, where the safety situation is analyzed by simulating real driving action behaviors. Based on the input of HADmaps and the expectation of the driver, the scheme of pathplanning, behavior planning, reference planning and motionplanning is proposed. (1) Path planning part is to propose themost suitable route for driver according to the maps and theapplication of large data navigation algorithm; (2) behavior planning proposes an anthropomorphic driving schemeaccording to the map and the driver's historical behavior; (3)reference planning predicts the future trajectory of the reference target based on the model input of the moving obstaclesin the map; (4) motion planning combines other vehicle trajectories and proposes the specific short time trajectory.

The decision maker [20–22] is based on the prediction ofthe behavior of other vehicles and makes decisions accordingly. This decision maker must be accepted by passengers(comfortable, reliable, agile, etc.) and also be accepted byother traffic participants (for example, cannot cause panic,ambiguity, strange and other associations).

4.3 Computing Platform for AIV

There are two major directions for the solution in existingcomputing platform. One is the central computation waywhich is represented by NVIDIA PX2. The other is the distributed computation which is represented by Intel, NXP andInfineon, etc. Intel and NVIDIA are competing to promotedriverless cars. Both Intel Go and NVIDIA Drive PX2 havethe same goals—to train the computer to be more intelligent,to help the car to detect pedestrians and identify lanes andstop signals, to make decision based on the data gathered byalgorithm, cameras and sensors.

5. Conclusion and Future Work

This paper surveys the literature of artificial intelligence forvehicles, reviews the history of vehicle development and the future AI for vehicles. In the nearfuture, AIV will be a boosting factor in the vehicle industry; head into the next generation of vehicles which provideshuman-level intelligence.

ISBN : 978-93-87793-95-8

References

1. Faezipour, M., Nourani, M., Saeed, A., et al.: Progress and challenges in intelligent vehicle area networks. Commun. ACM55(2), 90–100 (2012)
2. Oh, S.I., Kang, H.B.: Object detection and classification by decision-level fusion for intelligent vehicle systems. Sensors17(1), 207 (2017)
3. Jadhav AU, Wagdarikar NM (2015) A review: control area network (CAN) based intelligent vehicle system for driver assistance using advanced RISC machines (ARM). In: International Conference on Pervasive Computing. IEEE, pp 1–3
4. Jose, D., Prasad, S., Sridhar, V.G.: Intelligent vehicle monitoring using global positioning system and cloud computing. Proc. Comput. Sci. 50, 440–446 (2015)
5. Le Cun, Y., et al.: Deep learning. Nature 521, 436 (2015)
6. Mnih, V., et al.: Human-level control through deep reinforcement learning. Nature 7540, 529 (2015)
7. Silva, D., et al.: Mastering the game of Go with deep neural networks and tree search. Nature 7587, 484–489 (2016)
8. Lake, B.M., et al.: Human-level concept learning through probabilistic program induction. Science 350(6266), 1332–1338 (2016)
9. Moser, M.-B., Moser. E.I.: The brain's GPS tells you where youare and where you've come from. Scientific American (2016)
10. Service: The Brain Chip. Sci. Mag. 345(6197), 614–616 (2014)
11. Abbott, L.F., et al.: Building functional networks of spiking modelneurons. Nat. Neurosci. 19(3), 350 (2016)
12. Huang, R., et al.: Hierarchical interactive learning for a humanpowered augmentation lower exoskeleton. In: ICRA (2016)
13. Hata, A., Wolf, D.: Road marking detection using LIDAR reflective intensity data and its application to vehicle localization. In: 17th International IEEE Conference on Intelligent Transportation Systems (ITSC), Qingdao, pp. 584–589 (2014)
14. Cheng, H., Liu, Z., Yang, J.: Multi-support-region image descriptors and its application to street landmark localization. Mach. Vis. Appl. 23(4), 805–819 (2012)
15. Cheng, H., Liu, Z., Zheng, N., Yang, J.: Enhancing a driver's situation awareness using a global view map. In: International Conference Multimedia Exploration, pp. 1019–1022 (2017)
16. Hermans, T., Rehg, J.M., Bobick, A.F.: Decoupling behavior, perception, and control for autonomous learning of affordances. In: IEEE International Conference on Robotics and Automation. IEEE, pp. 4989–4996 (2013)
17. Aly, M.: Real time detection of lane markers in urban streets. Comput. Sci. 36(5), 7–12 (2014)
18. Geiger, A., Lauer, M., Wojek, C., et al.: 3D traffic scene understanding from movable platforms. IEEE Trans. Pattern Anal. Mach. Intell. 36(5), 1012–25 (2014)

ISBN : 978-93-87793-95-8

19. Cheng, H., Zheng, N., Zhang, X., Qin, J., van de Wetering, H.: Interactive road situation analysis for driver assistance and safety warning systems: frameworks and algorithms. IEEE Trans. Intell. Transp. Syst. 8(1), 157–167 (2017)
20. Koutník, J., Cuccu, G., Schmidhuber, J., et al.: Evolving large-scale neural networks for vision-based reinforcement learning. Mach. Learn. 25(8), 541–548 (2013)
21. Zhang, J., Cho, K.: Query-efficient imitation learning for end-toend autonomous driving. CoRR 1605.06450 (2010)
22. Ur, E., Ahin, E.: Traversability: a case study for learning and perceiving affordances in robots. Adapt. Behav. 18(18), 258–284 (2010)

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Artificial Intelligence with IoT in Agriculture

Dr.C.Venkatesh[1] P.Sivasankaran[2]

[1]Principal, Sengunthar Engineering College, Tiruchengode.

[2]Assistant Professor, Dept. of ECE, Sengunthar Engineering College, Tiruchengode.

Abstract

In IoT-based good farming, a system is constructed for watching the crop field with the assistance of sensors (light, humidity, temperature, soil wetness, etc.) and automating the irrigation system. The farmers enter the small print of what field to survey, and choose associate in nursing altitude or ground resolution. From the drone information, we are able to draw insights relating to plant health indices, plant investigation and yield prediction, plant height activity, covercowl mapping, field water ponding mapping, exploratory survey reports, stockpile activity, chlorophylactivity, chemical element content in wheat, evacuation mapping, weed pressure mapping, and so on. The drone collects multispectral, thermal, and visual representational processthroughout the flight then lands within the same location it took off. The major edges of victimization drones embrace crop health imaging, integrated GIS mapping, easy use, saves time, and therefore the potential to extend yields. With strategy and coming up withsupportedperiodinformationassortment and process, the drone technology canprovides ahigh-tech makeover to the agriculture business. This paper will use of Artificial Intelligence in Agriculture.

Keywords: Artificial intelligence,chlorophylactivity,geographic information system (**GIS**).

1. Introduction

Agriculture plays a vital role in India's economy. Over fifty eightp.c of the agricultural households depend upon agriculture as their principal suggests that of support, consistent withassociate IBEF report. Agricultural exports representtenp.c of the country's exports and is that the fourth-largest exported principal artefactclass in Asian country.

According to the Department of business Policy and Promotion (DIPP), the Indian agricultural services and agricultural machinery sectors have cumulatively attracted Foreign Direct Investment (FDI) equity flow of regarding $2.45 billion and therefore the food process sector has attracted around $7.81 billion throughoutApr 2000 to Gregorian calendar month 2017. With associate aim to spice up innovation and entrepreneurship in agriculture, the govt. of Asian country is introducing a brand new AGRI-UDAAN programed to mentor startups and alter them to attach with potential investors. On the rear of magnified FDI and tributary government initiatives, the agriculture sector is progressivelyviewingways that to leverage technology for higher crop yield. Many technology corporations and startups have emerged within the past few years with targeted agri-based solutions that profit the farmers.

Based on our research, the most popular applications of AI in Indian agriculture appear to fall into three major categories:

- **Crop and Soil Monitoring** – Companies are leveraging sensors and various IoT-based technologies to monitor crop and soil health.
- **Predictive Agricultural Analytics** – Various AI and machine learning tools are being used to predict the optimal time to sow seeds, get alerts on risks from pest attacks, and more.
- **Supply Chain Efficiencies**– Companies are using real-time data analytics on data-streams coming from multiple sources to build an efficient and smart supply chain.

In the full article below, we'll explore each category of AI applications in the agricultural industry, along with representative companies and use cases.

2. Crop and Soil Monitoring

2.1 CropIn – Using AI to Maximize per-Acre Value

CropIn is a Bengaluru-based startup which claims to be an intuitive, intelligent, and self-evolving system that delivers future-ready farming solutions to the agricultural sector.

ISBN : 978-93-87793-95-8

To explain the benefits of Cropin's technology, the company cites a use case with one of the world's largest producers of potato Specialties Company based in India which leases plots for farming and has 2500+ plots spread across an area of 5200+ acres. Earlier, they used to record farm data manually, thus creating multiple inconsistent entries.

With CropIn's'smartfarm' solution, all the plots were geo-tagged to find the actual plot area. The solution helped in remote sensing and weather advisory, scheduling and monitoring farm activities for complete traceability, educating farmers on adoption of right package of practices and inputs, monitoring crop health and harvest estimation, and alerts on pest, diseases etc.

Essentially, CropIn uses technologies such as AI to help clients analyze and interpret data to derive real-time actionable insights on standing crop and projects spanning geographies. Its agri-business intelligence solution called SmartRisk "leverages agri-alternate data and provides risk mitigation and forecasting for effective credit risk assessment and loan recovery assistance.

Proprietary machine learning algorithm built on satellite and weather data is used to give insights at plot and region level," Krishna Kumar, founder & CEO, Cropinsaid.

2.2 Intello Labs – Using Deep Learning for Image Analysis

Bengaluru-based Intello Labs was started by IIT-Bombay alumnus Milan Sharma in May 2016. The company claims to provide advanced image recognition technology that can recognize objects, faces, flora fauna and tag them in any image.

The company claim to use deep learning algorithms on which a new generation of intelligent applications are being built for applications including agriculture, eCommerce, advertising, manufacturing, and curation.

Small farmers around the world follow traditional farming practices due to lack of access to scientific understanding of crop lifecycle, pests, quality metrics and the latest micro-fertilizers.

"Our Image based solutions provide insights on the crops' health during the growing season and its final harvested quality by click of photograph," the company states on its website.

Intello Labs claims to provide:

- **Agricultural Product Grading:** Automated quality analysis of images of food products is an accurate and reliable method for grading fresh products (fruits, grains, vegetables, cotton etc.) characterized by color, size and shape. Their solution reads the image that a farmer has taken on his phone and determines the product quality in real time, without any manual intervention.
- **Alerts on Crop Infestation:** Farmers can click an image of their crop and use their solution to understand the pests, diseases, and foreign plants (weeds) growing in their farms. The solution uses deep learning and image processing models to identify any crop diseases or pest infestation in the crops. Along with the parameters, it gives recommendations on how that disease can be cured and prevented from increasing further.

The firm has no case studies or visual demos of the technology at this time.

3. Predictive Agricultural Analytics

3.1 Microsoft India – AI-based Sowing App

Determining the right time to sow crops is often one of the biggest challenges for Indian farmers where drought and excess rainfall can be equally serious challenges. Microsoft in collaboration with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), developed an AI Sowing App that uses machine learning and business intelligence from the Microsoft Cortana Intelligence Suite.

The app sends sowing advisories to participating farmers on the optimal date to sow. "The best part – the farmers don't need to install any sensors in their fields or incur any capital

expenditure. All they need is a feature phone capable of receiving text messages," a Microsoft India report stated.

To calculate the crop-sowing period, historic climate data (spanning over 30 years from 1986 to 2015) for the specific area in Andhra Pradesh was analyzed using AI. To determine the optimal sowing period, the Moisture Adequacy Index (MAI) was calculated. MAI is the standardized measure used for assessing the degree of adequacy of rainfall and soil moisture to meet the potential water requirement of crops.

Microsoft has also partnered with United Phosphorous (UPL), India's largest producer of agrochemicals, to create the Pest Risk Prediction App that again leverages AI and machine learning to indicate in advance the risk of pest attack.

Today, these farmers across the Indian states of Andhra Pradesh and Karnataka wait to get a text message before sowing the seeds. As per the report cited above, in a few dozen villages in Telangana, Maharashtra, and Madhya Pradesh, farmers receive automated voice calls alerting them whether their crops are at risk of a pest attack based on weather conditions and stage of the crop. No specific numbers on the results were reported.

3.2 Agri Supply Chain

Gobasco — The Intelligent Agri Supply Chain

Based in the North Indian state of Uttar Pradesh, Gobasco has the advantage of a high-tech team. VedantKatyar, co-founder & CEO of the company is an engineering graduate from premier Indian technology institute BITS Pilani while CTO Abhishek Sharma is a PhD in Artificial Intelligence from the University of Maryland in the US.

Gobasco claims to employ real-time data analytics on data-streams coming from multiple sources across the country aided with AI-optimized automated pipelines to dramatically

ISBN : 978-93-87793-95-8

increase the efficiency of the current agri supply chain. "Our data-driven online agri-marketplace affords the best prices for both the producers and buyers at their fingertips.

Through our carefully engineered tech-driven pipeline, designed for the Indian agri supply-chain, we operate at a higher profit margin than the traditional companies," the company stated in its website.

Gobasco uses AI and related technologies in the various stages of the agri supply chain to ensure it is efficient and fast. Some of them are listed below:

- **Transition Discovery:** Real-time data analysis on multiple data-streams along with crowd-sourced data from producer/buyer marketplaces and transporters feeds their automatic transaction discovery algorithm to obtain high-margin transactions.
- **Quality Maintenance:** Computer vision and AI-based automatic grading and sorting is done for vegetables and fruits for creating an international agri-commodity standard for reliable trading across country boundaries.
- **Credit Risk Management:** Crowd-sourced data, algorithms and analytics overcome the credit default problem, the most challenging problem of current supply-chain, to ensure a very low risk operation.
- **Agri-Mapping:** Deep-learning based satellite image analysis and crowd-sourced information fusion obtains a real-time agri map of commodities at a resolution of 1 sq-km.

4. Real Life Applications of AI Research Areas

There is a large array of applications where AI is serving common people in their day-to-day lives −

Sr.No.	Research Areas
1	**Expert Systems** Examples − Flight-tracking systems, Clinical systems.

ISBN : 978-93-87793-95-8

2	**Natural Language Processing** Examples: Google Now feature, speech recognition, Automatic voice output.
3	**Neural Networks** Examples − Pattern recognition systems such as face recognition, character recognition, handwriting recognition.
4	**Robotics** Examples − Industrial robots for moving, spraying, painting, precision checking, drilling, cleaning, coating, carving, etc.
5	**Fuzzy Logic Systems** Examples − Consumer electronics, automobiles, etc.

5. AI - Popular Search Algorithms

Searching is the universal technique of problem solving in AI. There are some single-player games such as tile games, Sudoku, crossword, etc. The search algorithms help you to search for a particular position in such games.

5.1 Single Agent Path finding Problems

The games such as 3X3 eight-tile, 4X4 fifteen-tile, and 5X5 twenty four tile puzzles are single-agent-path-finding challenges. They consist of a matrix of tiles with a blank tile. The player is required to arrange the tiles by sliding a tile either vertically or horizontally into a blank space with the aim of accomplishing some objective.

The other examples of single agent pathfinding problems are Travelling Salesman Problem, Rubik's Cube, and Theorem Proving.

Search Terminology

- **Problem Space** − It is the environment in which the search takes place. (A set of states and set of operators to change those states)
- **Problem Instance** − It is Initial state + Goal state.

ISBN : 978-93-87793-95-8

- **Problem Space Graph** − It represents problem state. States are shown by nodes and operators are shown by edges.
- **Depth of a problem** − Length of a shortest path or shortest sequence of operators from Initial State to goal state.
- **Space Complexity** − The maximum number of nodes that are stored in memory.
- **Time Complexity** − The maximum number of nodes that are created.
- **Admissibility** − A property of an algorithm to always find an optimal solution.
- **Branching Factor** − The average number of child nodes in the problem space graph.
- **Depth** − Length of the shortest path from initial state to goal state.

5.2 Brute-Force Search Strategies

They are most simple, as they do not need any domain-specific knowledge. They work fine with small number of possible states.

Requirements −

- State description
- A set of valid operators
- Initial state
- Goal state description

5.3 Breadth-First Search

It starts from the root node, explores the neighboring nodes first and moves towards the next level neighbors. It generates one tree at a time until the solution is found. It can be implemented using FIFO queue data structure. This method provides shortest path to the solution.

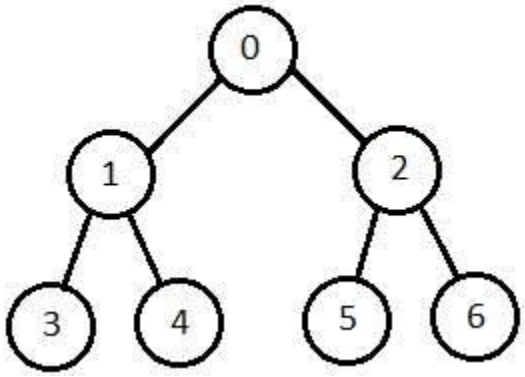
If **branching factor** (average number of child nodes for a given node) = b and depth = d, then number of nodes at level d = b^d.

The total no of nodes created in worst case is $b + b^2 + b^3 + \ldots + b^d$.

Disadvantage − Since each level of nodes is saved for creating next one, it consumes a lot of memory space. Space requirement to store nodes is exponential.

ISBN : 978-93-87793-95-8

Its complexity depends on the number of nodes. It can check duplicate nodes.



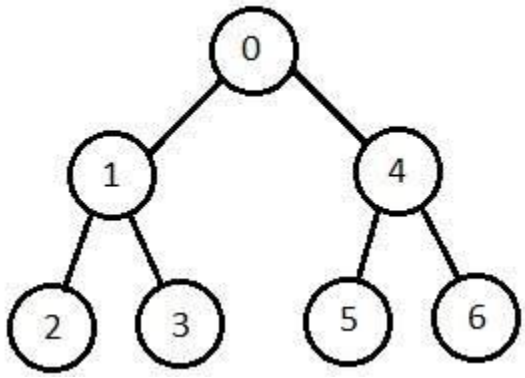
5.4 Depth-First Search

It is implemented in recursion with LIFO stack data structure. It creates the same set of nodes as Breadth-First method, only in the different order.

As the nodes on the single path are stored in each iteration from root to leaf node, the space requirement to store nodes is linear. With branching factor b and depth as m, the storage space is bm.

Disadvantage − This algorithm may not terminate and go on infinitely on one path. The solution to this issue is to choose a cut-off depth. If the ideal cut-off is d, and if chosen cut-off is lesser than d, then this algorithm may fail. If chosen cut-off is more than d, then execution time increases.

Its complexity depends on the number of paths. It cannot check duplicate nodes.



ISBN : 978-93-87793-95-8

5.5 Bidirectional Search

It searches forward from initial state and backward from goal state till both meet to identify a common state.

The path from initial state is concatenated with the inverse path from the goal state. Each search is done only up to half of the total path.

Uniform Cost Search

Sorting is done in increasing cost of the path to a node. It always expands the least cost node. It is identical to Breadth First search if each transition has the same cost.

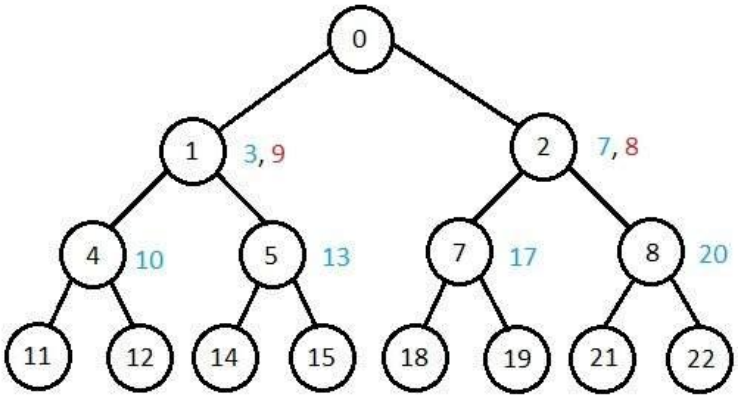
It explores paths in the increasing order of cost.

Disadvantage − There can be multiple long paths with the cost ≤ C*. Uniform Cost search must explore them all.

Iterative Deepening Depth-First Search

It performs depth-first search to level 1, starts over, executes a complete depth-first search to level 2, and continues in such way till the solution is found.

It never creates a node until all lower nodes are generated. It only saves a stack of nodes. The algorithm ends when it finds a solution at depth *d*. The number of nodes created at depth *d* is b^d and at depth *d-1* is $b^{d-1.}$



5.6 Comparison of Various Algorithms Complexities

Let us see the performance of algorithms based on various criteria –

ISBN : 978-93-87793-95-8

Criterion	Breadth First	Depth First	Bidirectional	Uniform Cost	Interactive Deepening
Time	b^d	b^m	$b^{d/2}$	b^d	b^d
Space	b^d	b^m	$b^{d/2}$	b^d	b^d
Optimality	Yes	No	Yes	Yes	Yes
Completeness	Yes	No	Yes	Yes	Yes

6. AI in Agriculture – Present Applications and Impact

Factors such as climate change, population growth and food security concerns have propelled the industry into seeking more innovative approaches to protecting and improving crop yield. As a result, AI is steadily emerging as part of the industry's technological evolution.

In this article we explore applications of artificial intelligence to provide business leaders with an understanding of current and emerging trends, and present representative examples of popular applications.

6.1 Artificial Intelligence in the Agricultural Industry – Insights Up Front

Based on our research, the most popular applications of AI in agriculture appear to fall into three major categories:

- **Agricultural Robots** – Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers.
- **Crop and Soil Monitoring** – Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.
- **Predictive Analytics** – Machine learning models are being developed to track and predict various environmental impacts on crop yield such as weather changes.

In the full article below, we'll explore each category of AI applications in the agricultural industry, along with representative companies, use-cases, and videos.

ISBN : 978-93-87793-95-8

6.2 Agricultural Robotics

Blue River Technology – Weed Control

The ability to control weeds is a top priority for farmers and an ongoing challenge as herbicide resistance becomes more commonplace. Today, an estimated 250 species of weeds have become resistance to herbicides. In a research study conducted by the Weed Science Society of America on the impact of uncontrolled weeds on corn and soybean crops, annual losses to farmers are estimated at $43 billion.

Companies are using automation and robotics to help farmers find more efficient ways to protect their crops from weeds. Blue River Technology has developed a robot called *See & Spray* which reportedly leverages computer vision to monitor and precisely spray weeds on cotton plants. Precision spraying can help prevent herbicide resistance. The short video below demonstrates how the robot works in action:

According to its website, the company claims that its precision technology eliminates 80 percent of the volume of chemicals normally sprayed on crops and can reduce herbicide expenditures by 90 percent. It has been estimated that over 1 billion pounds of pesticides are used in the US annually.

In September 2017, major manufacturing company John Deere announced its acquisition of Blue River Technology. John Deere is reportedly investing $305 million to complete the transition. The company claims that the original Blue Technology firm and current staff will remain in Sunnyvale where John Deere hopes to continuing growing the firm.

(Blue River Technology is one of many vendors listed in our robotics / vehicle vendor section here at Emerj.)

Harvest CROO Robotics – Crop Harvesting

Automation is also emerging in an effort to help address challenges in the labor force. The industry is projected to experience a 6 percent decline in agricultural workers from 2014 to 2024. Harvest CROO Robotics has developed a robot to help strawberry farmers pick and pack their crops. Lack of laborers has reportedly led to millions of dollars of revenue losses in key farming

ISBN : 978-93-87793-95-8

regions such as California and Arizona. In the Hillsborough County, Florida region which has been described as the "nation's winter strawberry capital," between 10,000 and 11,000 acres of strawberries are typically harvested in a season.

Harvest CROO Robotics claims that its robot can harvest 8 acres in a single day and replace 30 human laborers. In the short video below, the Harvest CROO team provides a demonstration of the robot:

An estimated 40 percent of annual farm costs are funneled into "wages, salaries and contract labor expenses" for crops such as fruits and vegetables where labor needs tend to be the highest.

In June 2017, Florida-based Wish Farms announced its implementation of Harvest CROO Robotics' strawberry harvester in the summer of 2017. The farm claims that the robot spans "over six beds of plants" and carries "16 individual picking robots." To date, Harvest CROO Robotics has reportedly raised $2.8 million from investors and farms representing 20 percent of all U.S. strawberry production.

6.3 Crop and Soil Health Monitoring

PEAT – Machine Vision for Diagnosing Pests / Soil Defects

Deforestation and degradation of soil quality remain significant threats to food security and have a negative impact on the the economy. Domestically, the USDA has estimated that the annual cost of soil erosion is approximately $44 billion dollars.

Berlin-based agricultural tech startup PEAT, has developed a deep learning application called Plantix that reportedly identifies potential defects and nutrient deficiencies in soil. Analysis is conducted by software algorithms which correlate particular foliage patterns with certain soil defects, plant pests and diseases.

The image recognition app identifies possible defects through images captured by the user's smartphone camera. Users are then provided with soil restoration techniques, tips and other possible solutions as explained in the short video below:

The company claims that its software can rapidly achieve pattern detection with an estimated accuracy of up to 95 percent. PEAT recently published that its international clientele base had

ISBN : 978-93-87793-95-8

reached over 500,000. The company does acknowledge its partners, and client quotes on its website but specific case studies do not appear to be available.

Without specifics regarding the size of client farms, we are unable to confirm if the Plantix app poses any significant limitations for larger farms. Competitor CropDiagnosis appears to follow a similar model for its app.

Trace Genomics – Machine Learning for Diagnosing Soil Defects

Similar to the Plantix app, California-based Trace Genomics, provides soil analysis services to farmers. Lead investor Illumina helped develop the system which uses machine learning to provide clients with a sense of their soil's strengths and weaknesses. The emphasis is on preventing defective crops and optimizing the potential for healthy crop production.

According to the company's website, after submitting a sample of their soil to Trace Genomics, users reportedly receive an in-depth summary of their soils contents. Services are provided in packages which include a pathogen screening focused on bacteria and fungi as well as a comprehensive microbial evaluation. As described in the video below, an analysis of soil DNA is also central to Trace's system:

Video: <iframe src='//players.brightcove.net/2097119709001/4kXWOFbfYx_default/index.html?videoId=5502727538001' allowfullscreenframeborder=0></iframe>

As of February 2017, the company has raised $8 million in total equity funding from six firms including the Illumina Accelerator. Product packages begin at $199 for the Pathogen Screen. Favorable quotes from two farms are featured on the Trace Genomics website. However, data indicating how Trace Genomics specifically improved outcomes is not included

Sky Squirrel Technologies Inc. – Drones and Computer Vision for Crop Analysis

The presence of drones in agriculture reportedly dates back to the 1980s for crop dusting in Japan. The market for drones in agriculture is projected to reach $480 million by 2027. Today, companies are leveraging AI and aerial technology to monitor crop health.

SkySquirrel Technologies Inc. is one of the companies bringing drone technology to vineyards. The company aims to help users improve their crop yield and to reduce costs. Users pre-

program the drone's route and once deployed the device will leverage computer vision to record images which will be used for analysis.

Once the drone completes its route, users can transfer a USB drive from the drone to a computer and upload the captured data to a cloud drive. SkySquirrel uses algorithms to integrate and analyze the captured images and data to provide a detailed report on the health of the vineyard, specifically the condition of grapevine leaves. Since grapevine leaves are often telltales for grapevine diseases (such as molds and bacteria), reading the "health" of the leaves is often a good proxy for understanding the health of the plants and their fruit as a whole.

The SkySquirrel Technologies team provides an overview of how the drone functions in the short video demonstration below:

The company claims that its technology can scan a 50 acres in 24 minutes and provides data analysis with 95 percent accuracy. Specific use cases do not appear to be available on the company's website.

(Readers with a specific interest in drones may be interested in our full article called "5 Industrial Drone Applications".)

Predictive Analytics

a. Where – Satellites for Weather Prediction and Crop Sustainability

a Where, a Colorado based company uses machine learning algorithms in connection with satellites to predict weather, analyze crop sustainability and evaluate farms for the presence of diseases and pests.

For example, daily weather predictions, are customized based on the needs of each client and and range from hyper local to global. Types of clients mentioned on the company's website include farmers, crop consultants and researchers. We've covered AI for weather prediction earlier this year, but the video below gives a good idea of some of the fundamental technologies at play.

As shown in the 3 minute video below, the company claims to specialize in providing a high quality of data that is continuously updated at a rapid rate:

The company also claims that it provides its users with access to over a billion points of agronomic data on a daily basis. Data sources include temperature, precipitation, wind speed,

ISBN : 978-93-87793-95-8

and solar radiation, "along with comparisons to historic values for anywhere on the agricultural earth."

The company does not appear to provide any case studies on its website. Software application examples are featured in the company's blog but it is unclear how much clients have invested in aWhere's services and how those investments have impacted outcomes.

Farm Shots – Satellites for Monitoring Crop Health and Sustainability

Based in Raleigh, North Carolina, Farm Shots is another startup focused on analyzing agricultural data derived from images captured by satellites and drones. Specifically, the company aims to "detect diseases, pests, and poor plant nutrition on farms."

For example, the company claims that its software can inform users exactly where fertilizer is needed and can reduce the amount of fertilizer used by nearly 40 percent. The software is marketed for use across mobile devices. In April 2017, Farm Shots along with its associate partner, Planet, announced limited free access to its products for John Deere clients through June 2017. This collaboration offers another glimpse into John Deere's interests in expanding into the agricultural tech space. FarmShots does not appear to feature examples of specific clients or case studies on its website.

7. Conclusion and Future work

Artificial intelligence driven innovations are rising to help improve proficiency and to address difficulties confronting the business including, crop yield, soil wellbeing and herbicide-opposition. Farming robots are ready to end up a much esteemed use of AI in this part.

It is doable that agrarian robots will be created to finish an expanding various cluster of assignments in the following three to five years. Yield and soil checking advances will likewise be critical applications going ahead as environmental change keeps on being inquired about and assessed. The measure of information that can possibly be caught by advancements, for example, automatons, and satellites every day will give rural business another capacity to anticipate changes and distinguish openings. We anticipate that satellite machine vision applications (for climate, crop wellbeing, foreseeing crop yield, and so forth) will turn out to be increasingly more typical for expansive modern homesteads in the coming 5-10 years.

References

[1] Ji-chun Zhao, Jun-feng Zhang, Yu Feng "The study and application of the IOT technology in agriculture", Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference on 9-11 July 2010

[2] SumithaThankachan and Dr.S. Kirubakaran A Survey Conducted on E-Agriculture with Indian Farmers A monthly Journal of Computer Science and Information Technolog, IJCSMC, Vol. 3, Issue. 2, February 2014,

[3] S MahendraDev "Small Farmers in India: Challenges and Opportunities, Institute of Development Research, Mumbai", http://www.igidr.ac.in/pdf/publication/WP June 2012

[4] Sukhvir Kaur, Gian Singh "Analysis of Income Distribution among Marginal and Small Farmers in Rural Punjab" International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

[5] **Deshpande,R.S.(2002),"**Suicide by Farmers in Agrarian Distress and Possible Alleviatory **Steps", Economic and Political Weekly, Vol. 37, No. 26,** pp. 2610 2610

[6] Dev,Mahendra and A. Ranade (1998), **"Raising** Food ‗ Prices and Rural Poverty: Going Beyond **Correlations",** Economic and Political Weekly, Vol. 33, No. 39, pp. 252 36.

[7] A. Paventhan "Internet of Things based approach to Agriculture Monitoring" ERNET India Regional Centre, Bangalore, Asia-Pacific Advanced Network (APAN) 36th Meeting, 20th August 2013

[8] Rayner Alfred "The rise of machine learning for big data analytics" IEEE Conference Publications, 2016 2nd International Conference on Science in Information Technology (ICSITech) 10.1109/ICSITech.2016.7852593, 2016

[9] https://emerj.com/ai-sector-overviews/artificial-intelligence-in-indian-agriculture-an-Industry-and-startup-overview/

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Comparative Study Of Conventional Machine Learning And Deep Learning Algorithms Using Transfer Learning To Perform Detection Of Glaucoma Using Fundus Retinal Images

S R Shruthi Vidya[1], Deepti Ravishyam[1], S Chaitanya[1],

N M S Chaitanya[1], Dhanalakshmi Samiappan*

Department of Electronics and Communication Engineering, SRM Institute of Science and Technology, Kattankulathur-603203
*dhanalakshmi.s@ktr.srmuniv.ac.in

ABSTRACT

Glaucoma detection from fundus retinal images is a difficult task which demands years of practice and expertise in the domain. In this paper, we present a detailed view on glaucoma diagnosis using conventional machine learning algorithms such as k nearest neighbours, SVM, logistic regression and random forest. We combine these base model results by applying ensemble learning to create one optimum predicted output. We then compare the results obtained from the conventional classifiers to transfer learning models. Different inductive transfer learning models are applied and the performance of models are compared. [11] The random forest model and ensemble learning model seem to perform better than all other conventional models. The highest sensitivity and F1 score of 77.61% and 0.77 respectively was seen in ensemble learning. However, the highest specificity and accuracy of 91.22% and 78.45% was observed in the random forest algorithm. The best performance was obtained by applying transfer learning using the VGG19 and GoogLeNet models with AUC of VGG19 being 0.8919 and AUC of GoogLeNet being 0.8872.

INTRODUCTION

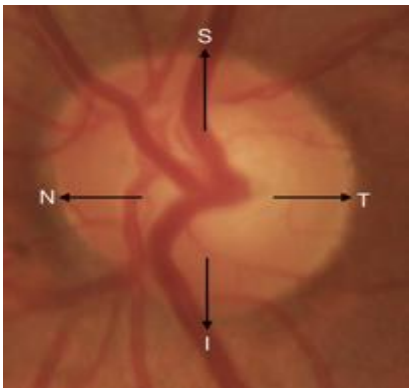
Glaucoma is a complex neuro-retinal disease, which damages the structure of the optic nerve head.[2] It is an asymptomatic disease and shows symptoms only in the later stages.[9] It is the second foremost cause for loss of vision, after cataract [1]. Glaucoma is not completely curable and causes irreversible loss of vision [16] i.e., the Visual Field (VF) lost, can't be regained [2,9], which makes it all the more important to detect the disease in its early stage, to reduce its progression and hence prevent from complete blindness.

ISBN : 978-93-87793-95-8

Detection of glaucoma by ophthalmologists is a very arduous process as it needs experienced physicians with expertise in this specific area. [9] Thus, automation of Glaucoma diagnosis is very essential and pertinent. Glaucoma is usually identified by checking family's medical history, ophthalmologists perform dilated ophthalmoscopy or slit beam biomicroscopy [10] and Retinal stereoscopic Fundus images of the eye are captured.[8] There are 4 Diopter lens used to examine the eye to get a 3 Dimensional view of the Optic Nerve Head, which aids in the diagnosis of glaucoma [10]. There are several optic nerve head screening polarimetry and tomography tests such as scanning laser polarimeter[9,14], optical coherence tomography (OCT) [9, 12],confocal scanning laser tomography [9,13] of which OCT is widely used for detection of glaucoma [15].

A routine and periodic eye examination every 2-3 years is necessary to confirm the diagnosis of glaucoma[16]. One more important factor which helps in the detection of glaucoma is increased intraocular pressure(IOP)[17]. Treatment of glaucoma is primarily focused on reducing IOP, as it is the most effective way to prolong the progression of Glaucoma [18]. Frequent follow-up eye screening is required to access the progress of Glaucoma, by finding disk hemorrhage, IOP, Visual field changes, neuroretinal rim widening[19,31]in the eye.
Optic Nerve Head is the region in which the optic nerve enters the back of the eye. Here, ganglion axons leave the eye and the Photoreceptors i.e. Rods and Cones are absent, hence creating a blind spot in the eye.[27-28,31]

In a healthy eye, the neuro-retinal rim follows a configuration known as the ISNT Rule. It states that rim thickness follows the order Inferior > Superior > Nasal > Temporal. When this criterion fails, it is a suspect of glaucoma. This is one of the widely used methods by ophthalmologist to diagnose Glaucoma. [27-30]



ISBN : 978-93-87793-95-8

Fig 1. ISNT Rule[31] is one of the methods to identify glaucoma. The Inferior region must be broader than superior region border than Nasal blade than Temporal in a healthy eye. Any discrepancy in this condition is a suspect of glaucoma.

We have applied machine learning and deep learning algorithms to perform diagnosis of glaucoma in retinal Fundus images.

Many researchers have been delving into Machine Learning and deep learning since 1950s. In the year 1942. A model is created using electric circuit, bringing neural networks into existence[46]. Around the same time in the year 1959, Arthur Samuel created a code which could learned the game checkers without it being explicitly coded[47]. These researchers marked the origination of deep learning and machine learning. But, it has taken several decades, for machine learning and deep learning to become commercially viable and an active area of research. It is because of rapid advancements in software and hardware in today's era, which enables computers to handle high computational cost. There exponential increase in training data[48], which surged the use of machine learning algorithms.

In our project, we have a total of 766 images obtained from all 3 releases of RIM-ONE(r1, r2, r3) dataset, of which 311 are identified to be glaucomatous and 455 are healthy.

Glaucoma diagnosis is usually performed by combining image preprocessing with various feature extraction algorithms like Principal Component Analysis (PCA) to segment optic disc from Retinal Fundus images.[20] Some have used techniques like Fischer score, spearman ranking, mutual information , chi squared with conventional machine learning algorithms such as Logistic Regression, SVM,Linear Regression, KNN or deep learning algorithms for classification[21,22]

In our project, we aim to automate the diagnosis of Glaucoma by first identifying the Region of Interest(ROI) and then extract features to apply conventional machine learning algorithms and to perform a comparative study between conventional machine learning algorithms and deep learning using transfer learning.

IMAGE ACQUISITION

We have used RIM-ONE open-source dataset [3] which has 766 colored Fundus images of Retina. It has 311 glaucomatous and 455 healthy Retinal fundus images. RIM - ONE image

ISBN : 978-93-87793-95-8

database for glaucoma [7] is created from data collected in collaboration with three Spanish hospitals [4][5][6]. RIM-ONE is a color open-source fundus retinal image dataset which has accurate gold standard in section of optic nerve head(ONH). In out project we have included the 3 releases by authors of RIM-ONE dataset.

RIM-ONE Data Set	Format of images	Number of glaucomatous images	Number of healthy images	Size of images
Release 1	BMP	40	118	316 x 342 to 831 x 869
Release 2	JPG	200	255	290 x 290 to 1375 x 1654
Release 3	JPG	71	82	2144 x 1424

Table. 1 Description of datasets used as inputs to the classifiers to predict, if the given image is Glaucomatous or healthy.[3,7]

IMAGE PROCESSING

There are 766 images obtained from all 3 releases of RIM-ONE(r1, r2, r3) dataset, of which 311 are identified to be glaucomatous and 455 are healthy.[3,7] In the preprocessing step, we have resized all the image to have a common aspect ratio to train all the algorithms homogeneously. No illumination correction was applied, filtering and enhancement techniques were applied.

Location of Region of Interest:

The region of Interest in the retinal fundus image of human eye is the Optic Nerve Head. If there is any neuro-retinal rim widening, it is indicative of Glaucoma[19]. There are two major ways to locate the region of interest feature-based and object-based identification. Feature-based identification involves, detection of pixels which share certain optical or stereoscopic similarities, while object-based identification is by identifying the target shape by analyzing multiple pixels simultaneously.[23]

In our project, we have used Template Matching technique to locate the Region of Interest. We have manually create the template by cropping it from one of the retinal Fundus image, which is used as a reference. [24] This reference is compared with all patches of the input image to find

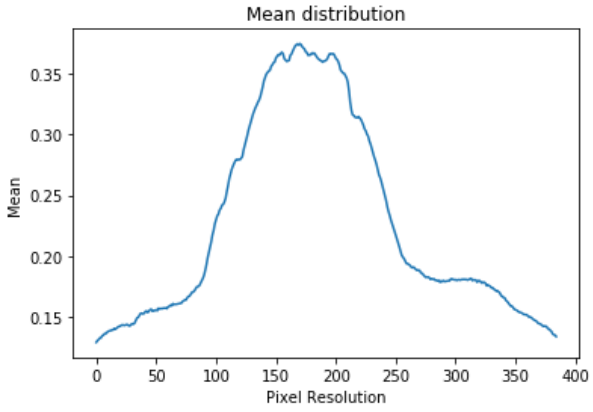
ISBN : 978-93-87793-95-8

the best correlation between the patch and the template [25,26]. Template matching was performed in python using implementation in OpenCV, which was very effective since we were able to obtain the cropped images with optic Nerve Head as its center for all the input images.

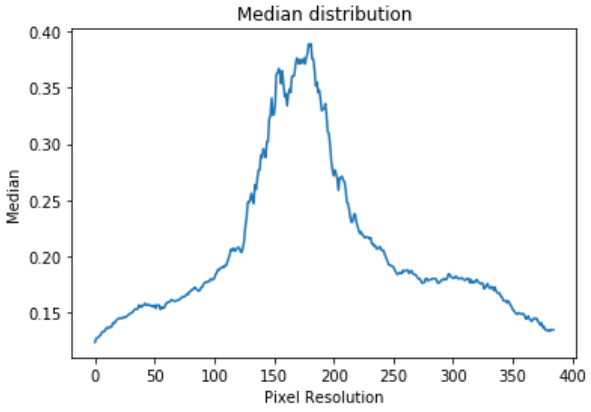
These cropped images were resized to 385x385 for the conventional Machine Learning algorithms and scaled to the input size of the Deep Convolutional Neural Network (DCNN) using Transfer Learning.

Feature Extraction for Conventional Machine Learning algorithms:

Feature extraction plays a vital role in conventional machine learning algorithms. [49] It requires extensive domain knowledge to decide the best features. In our project, we have obtained features to emulate the ISNT Rule, by obtaining row wise and column wise features separately. We have used 6 pairs of features mean, median, standard deviation, kurtosis, skewness and G-Mean. The aspect ratio of the images, is fixed at 385x385. This data extracted from images is around 4M, which is used as dataset to the various machine learning algorithms.

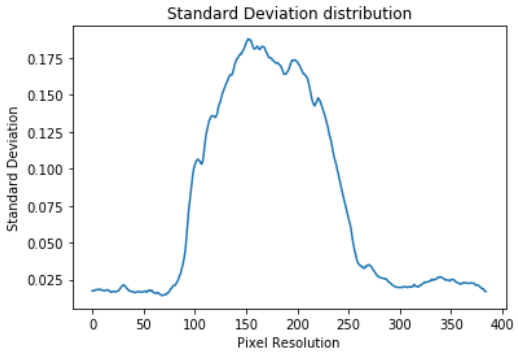


(a) Mean of the Pixels in ROI

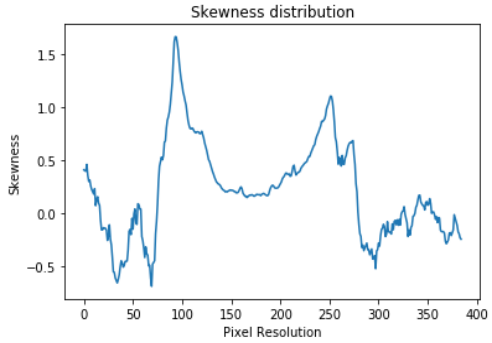


(b) Median of Pixels in ROI

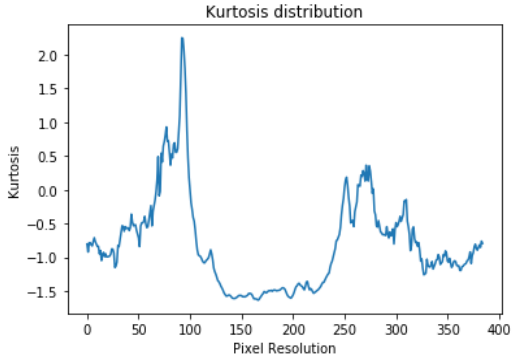
ISBN : 978-93-87793-95-8



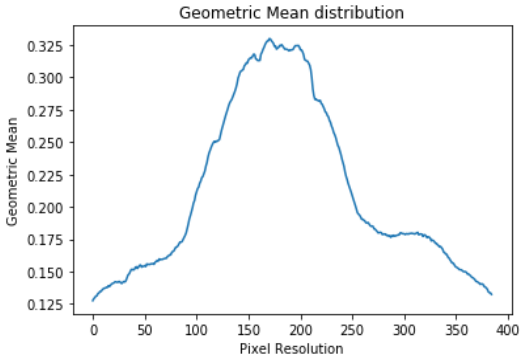
(c) SD of the Pixels in ROI



(d) Skewness of the pixels in ROI



(d) Kurtosis of the Pixels in ROI



(e) G-Mean of the Pixels in ROI

Fig 2. Visualizing the distribution and the extracted features from the pixel intensity values in the dataset. (a) Distribution of Mean of the pixels in the ROI (b) Distribution of Median of the pixels in the ROI (c) Distribution of Standard Distribution of the pixels in the ROI (d) Distribution of Skewness of the pixels in the ROI (d) Distribution of Kurtosis of the pixels in the ROI (e) Distribution of G-Mean of the pixels in the ROI.

Machine Learning techniques:

Machine learning and deep learning act like pillars in this modern society: from making everyday weather forecast, recommendation systems on e-commerce websites, machine translation, object detection, Stock market prediction, the applications of deep learning is endless. This is possible because of new class of techniques known as deep learning.

ISBN : 978-93-87793-95-8

Generally machine learning can be broadly divided into 3 stages :

Data processing : It is one of the crucial stages obtain reliable data. Here, we clean and format the data to suit our requirement for the development of the model. Data processing greatly reduces the complexity of the model. [35] Raw and unstructured data can not serve as input to most of the classifiers. It makes the process of training hard for the algorithm and hence deteriorates the performance of the system. It is used to make data computer understandable, by cleaning, sorting, structuring and summarizing to maximize the models performance.[36,38]

Building the model : Supervised Learning requires labeled input for the model to predict, where as unsupervised learning recognizes patterns in the data, without any explicit labels learns on its own. Reinforcement learning is an interactive algorithm which learns by trial and error method by obtaining feedback on its actions. [37-40]

Tuning and Optimization : After building the base model, the metrics of the model can be improved by tuning parameters in the model. Some of the tuning algorithms are batch normalization, regularization, stochastic gradient descent etc. There are several tuning and optimization algorithms which can be used in both conventional machine learning and deep learning algorithms. [41-45]

CONVENTIONAL MACHINE LEARNING ALGORITHMS

The below conventional machine learning algorithms were applied on the extracted features of the images - mean, median, standard deviation, kurtosis, skewness and K statistics to determine if the eye is glaucomatous.

Support Vector Machine (SVM)

Support Vector Machine is an algorithm that builds a hyperplane in an N dimensional space. Each feature constitutes a dimension in which data points are plotted against its features. The aim of the algo is to build a hyperplane such that it best draws a boundary between the n classes of data points, where n is the number of classes contained in the dataset. [62] SVM has been used here as a supervised learning algorithm as it is a classifier between the 2 classes- namely, glaucomatous eye and normal eye. We applied a radial basis function kernel to the SVM classifier and obtained an accuracy of 79.00%.

ISBN : 978-93-87793-95-8

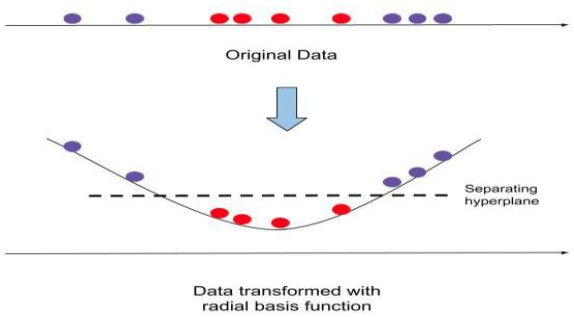


Fig 3. Radial Basis Function Kernel for SVM classification

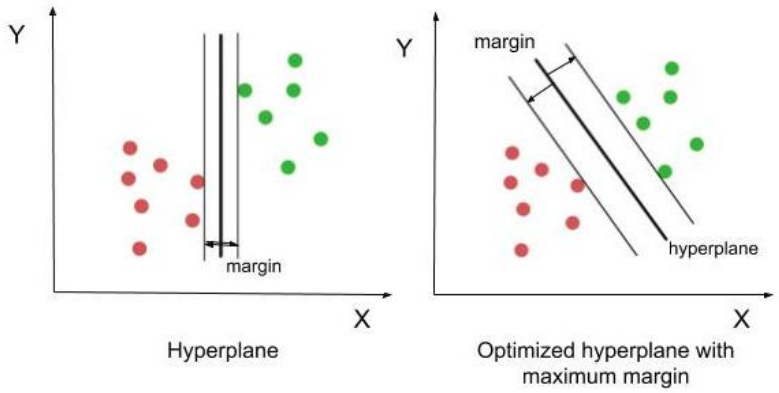


Fig 4. Working of SVM model

$$(w^T x_i) + b > 0 \; if \; y_i = 1$$

$$(w^T x_i) + b < 0 \; if \; y_i = -1$$

Random Forest

Random forest consists of several decision trees that decide if a particular feature in a specific image is glaucomatous or normal. [61] Intuitively, the first feature that one would check must be the one which best tells the classes apart in order to save time and computational cost. The gini index [67-68] in random forest decides which feature is tested at a level.

$$Gini(t) = 1 - \Sigma[P(j|t)]^2$$

ISBN : 978-93-87793-95-8

A data to be predicted is fed into the decision trees at the root and the output is obtained at the leaf. A majority vote is taken from several trees to obtain the predicted output. A random forest model of 400 decision trees with a minimum sample split of 2 was applied to obtain an accuracy of 79.55% which is highest among all conventional algorithms used.

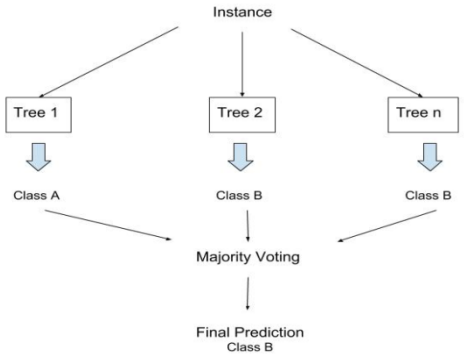
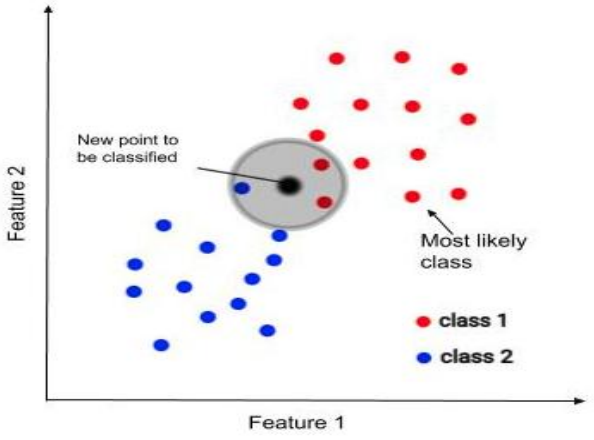


Fig 5. Working of random forest model

K Nearest Neighbour (KNN)

KNN is a supervised machine learning algorithm used for classification between the two classes- glaucomatous and normal. N-features are plotted with each feature being a dimension. The data points are plotted against each feature in the N-dimensional space. During training, the aim of the algorithm is to determine a boundary between both the classes, by finding the closest k data points. Once the region of the two classes is established in the n-dimensional space, any test point falling within the region would be classified as the class of that region.



ISBN : 978-93-87793-95-8

Fig 6. Working of K-NN model

General Minkowski Distance Metric: $D(x_i, x_j) = \left(\sum_{l=1}^{d} |x_{il} - x_{jl}|^{1/p}\right)^{p}$

We use a KNN classifier with a minkowski metric of 2 (euclidean distance) and k being 3 with a leaf size of 30. The model was then tested on the test images and an accuracy of 76.24% was obtained.

Logistic Regression

Logistic regression is a binary probabilistic classifier algorithm that calculates the probability of a data being in class 0 or class 1. It is similar to a simple linear regression model, except for the sigmoid function in the end which translates the predicted real values into their predicted class [63]. A penalty of l2 was applied and an intercept was fit with a scaling of 1. The sigmoid function sets the threshold for the classes on the real values. The model was run on the test images and an accuracy of 75.13% was obtained.

Logistic Regression: $p = \frac{1}{1 + e^{-(b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_p x_p)}}$

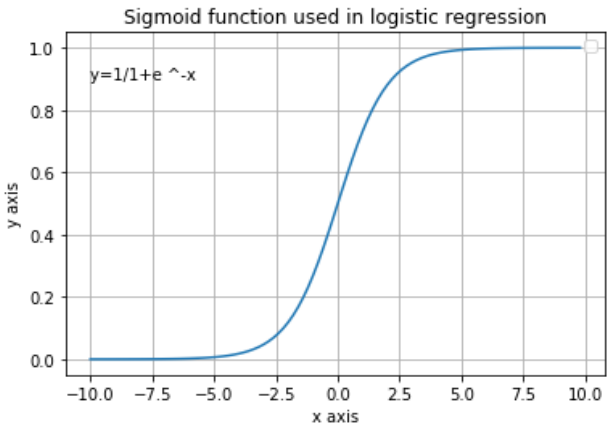


Fig 7. Sigmoid function used in logistic regression

ISBN : 978-93-87793-95-8

Ensemble Learning

Ensemble learning is a method of combining individual model predictions together to improve the prediction probability and reduce variance and bias in the predictions. Ensemble Learning uses multiple algorithms to obtain better predictions than constituent stand-alone algorithms. Ensembles combine multiple hypotheses while using the same base hypothesis. [66] The majority voting technique of ensemble learning was used. [64]

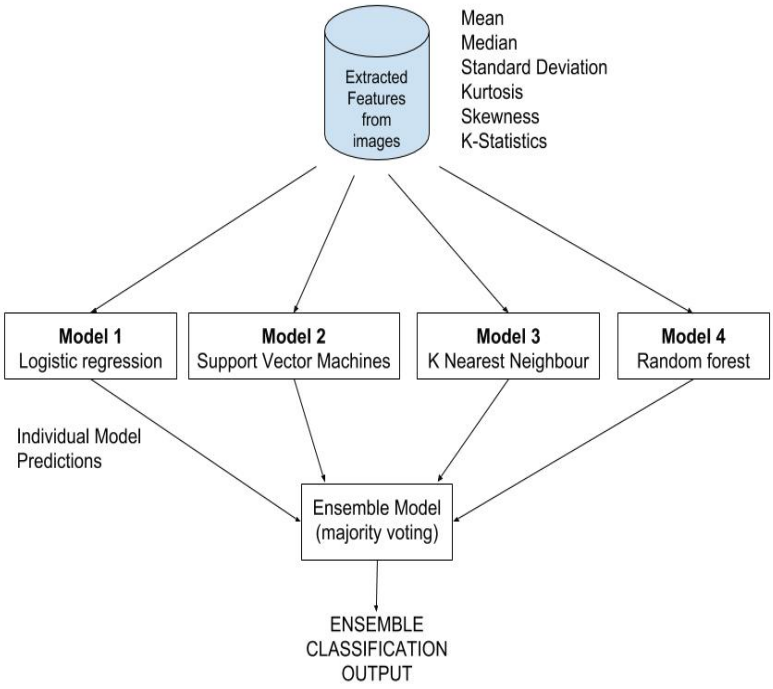


Fig 8. Block diagram of ensemble model

The majority voting technique takes the majority of all the model outputs to produce a final output. Each of the 4 models namely, logistic regression, KNN, SVM and Random Forest were trained on the entire dataset and the majority of the final outputs was obtained as the ensemble output. The accuracy was found to be 83.42% with the highest F1 score of 0.82 and sensitivity of 74.62%.

ISBN : 978-93-87793-95-8

TRANSFER LEARNING ALGORITHMS

Neural Networks :

Conventional machine learning relies on raw data, which requires extensive knowledge and research of the dataset to perform feature extraction and selection. Whereas, deep learning has complex non-linear functions and variations which enables it to learn data without performing much of data processing. it can form complex and abstract patterns from a given data without the need for data to be engineered explicitly. Deep learning techniques form general purpose algorithms, which is very good at identifying complex and intricate patterns from high dimensional data.

Deep Convolutional Neural Networks :

Convolutional Neural network is popularly used for image classification. The evolution of neural networks started around 1960s. Convolutional networks perform both feature extraction and classification simultaneously and thus doesn't require any prior expertise of data, which is necessary for conventional algorithms.

In 1959 [50], Wiesel provided a very important insight, that there are 2 types of neurons, simple and complex neurons in the primary visual cortex. Simple neurons are responsible for finding the geometrical lines, edges etc, while complex neurons look at the big picture. This is the core principle behind CNN. The initial layers of the convolutional networks detect intricate pattern, which are convolved to view the bigger picture by the deeper layers. Similar results were proposed by Roberts in 1963 [51], where representations of 2D images are used to build 3D solids. Similar deeper analysis on representational framework and hierarchical modeling was performed by David Marr in the year 1982 [53]. Here, he proposed a 3 strategies, first to identify the primary sketch of the image, then a 2d sketch with information regarding the depth of the object, then to construct the volumetric primitives.

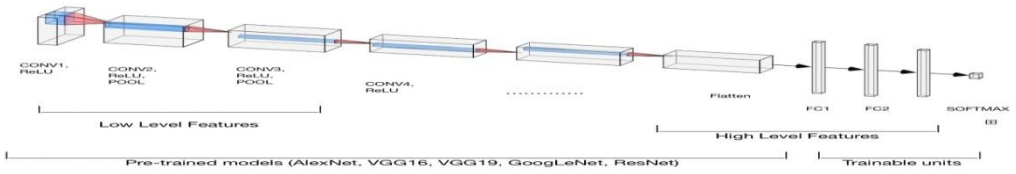


Fig 9. Block diagram of CNN

ISBN : 978-93-87793-95-8

In the year 1980, Fukushima [54] marked the beginning of Convolutional networks, which he referred to as neocognition. It is a self-organized network which trains without any prior knowledge. It was the first unsupervised learning network, which was unaffected by change in position, shape of the object etc. There were several works produced about image analysis. But one of the most important researchers were LeCun et al., [55] who led to modern convolutional Network and started the creation of the popular MNIST data set, for digit recognition. He also introduced and used back propagation to neocognition which is the same technique used even today. This marked the beginning of modern CNN, from the 2006 - 2012 Pascal Visual Object Classification challenge [56] expedited the object detection and annotation for standard dataset with 20 output classes. Then from the year 2012 - Present the Image Net Object Localization Challenge (ILSVRC), has produced several CNN architectures for Image classification, with 1000 output classes.

Architecture	Input size of the image	Number of Convolutional layers	Number of Fully connected layers	Activation function/ special Function used
AlexNet	227 x 227 x 3	5	3	ReLU [57]
VGG16	224 x 224 x 3	13	3	ReLU [58]
VGG19	224 x 224 x 3	16	3	ReLU [58]
GoogLe Net	224 x 224 x 3	22	0	Inception module and Bottleneck layer [59]
ResNet-50	224 x 224 x 3	50	0	Residual block or skip connection[60]

We applied transfer learing on various pre-trained CNN models and the results are recorded.

The 5 different architectures under study are: AlexNet [57], VGG16, VGG19 [58], GooLeNet [59], ResNet-50 (He et al., 2015) [60].

Table 2. Summary and description of the pretrained models used for transfer learning

ISBN : 978-93-87793-95-8

RESULTS AND DISCUSSIONS

The image fig 10 is a fundus image of an eye in RGB color. It's of a resolution of 2144 x 1424 which has two images of fundus image of the same eye. This image alone has 9 million pixels, which will be a few billions of pixels for the whole dataset. This makes this project more computationally expensive. Moreover, only structural changes in the optic nerve head are only needed to detect the disease. So it's important to find the region of interest i.e. Optic Nerve Head from the fundus image and crop the ROI out of the image.

Fig 10. Sample Image from the RIM-ONE dataset

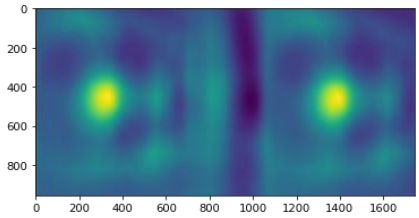


Fig 11. Template Matching Output

To automate the whole process of finding the region of interest and cropping it out of the image Template matching algorithm is used. In template matching, we input a manually cropped ROI as a template for the algorithm and the algorithm uses the template to convolute over a given image. This generates an image with BGR color pixels value varying from 0 to 1, where 0 is the darkest pixel and 1 is the brightest. The more the region in the given image is matching to the template the brighter is the region.

The image fig 11 is the output from the template matching algorithm where the brightest spot corresponds to the region of interest. To obtain ROI coordinates of the brightest spot should be found on the template matching output and the corresponding region in the given image should be cropped to get ROI from the given image

ISBN : 978-93-87793-95-8

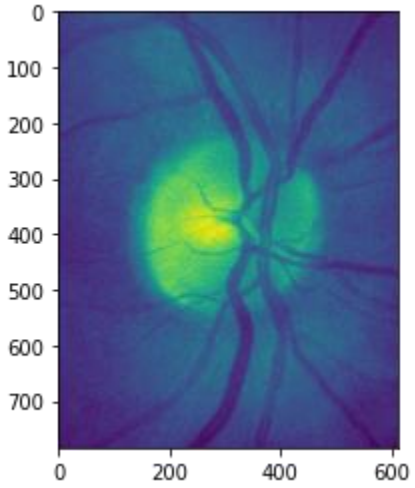


Fig 12. Cropped ROI from Fundus Image

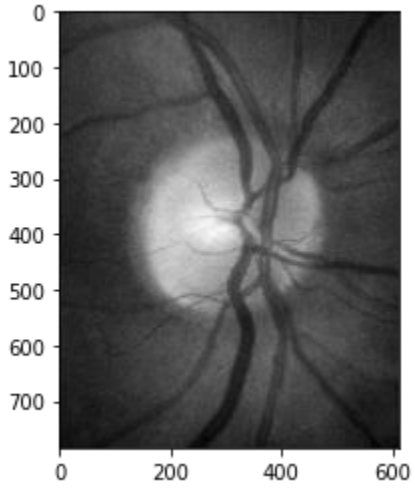


Fig 13. Gray Scale ROI Image

The image is the BGR color image of Region of Interest generated using Template matching algorithm. The above image is of a resolution 700*800 and it's a 3 layered image so it still has 1.6 million pixels for the image. So images are converted to a single layer grayscale image which will reduce the number of pixels about one third.

Due to 3 different sets of databases released periodically images of the first release are of much lower resolution. So all the images are downscaled to a common resolution of 385*385 without compromising on quality.

Conventional machine learning algorithms and convolutional neural networks were implemented on the RIM-ONE data set. The following are the results obtained for the conventional machine learning algorithms.

	Sensitivity(%)	**Specificity(%)**	**Accuracy(%)**	**F1 Score**	**AUC in ROC**
Support Vector Machine	58.20	91.22	79.00	0.76	0.75
Random Forest	53.73	**94.74**	79.55	0.75	0.78
K Nearest Neighbours	53.73	89.47	76.24	0.73	0.66
Logistic Regression	70.14	78.07	75.13	0.74	0.74

ISBN : 978-93-87793-95-8

Ensemble Learning	**74.62**	88.59	**83.42**	**0.82**	**0.82**

Table 3. Results obtained with conventional machine learning algorithms

The random forest model and ensemble learning model seem to perform better than all other conventional models. The highest sensitivity, accuracy and F1 score of 74.62%, 83.42% and 0.82 respectively was seen in ensemble learning. However, the highest specificity of 94.74% was observed in the random forest algorithm. The AUC turns out to be 0.82 in ensemble model which is quite good followed by random forest model with an AUC of 0.78.

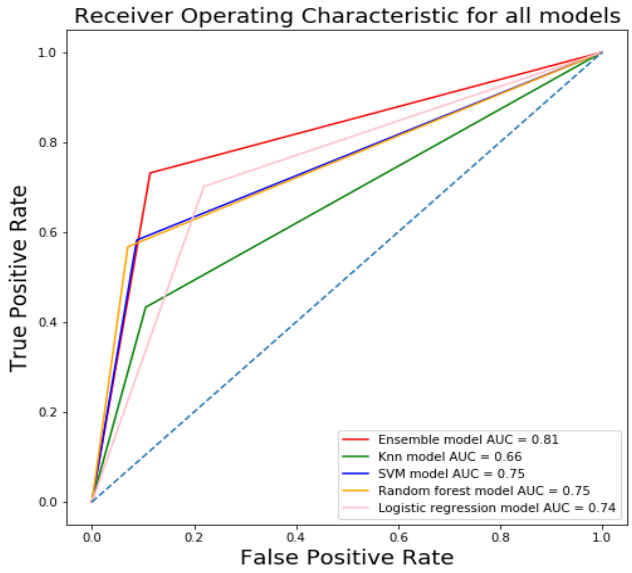


Fig 14. Comparative ROC curve for all conventional machine learning models

The conventional models have a maximum AUC of 0.78 by random forest. However the ensemble model has a higher AUC of 0.82 implying that ensemble learning does improve the accuracy of the models and increases surety of the classification by combining outputs of individual models with a majority vote. It is noted that SVM exactly traces the ensemble model curve to an extent which means that both models classify the true positives equally well but ensemble model performs better than SVM on false positives. It is interesting to note that random forest classifies true positives slightly better than the ensemble model. However, the ensemble model is the best at classifying false positives.

ISBN : 978-93-87793-95-8

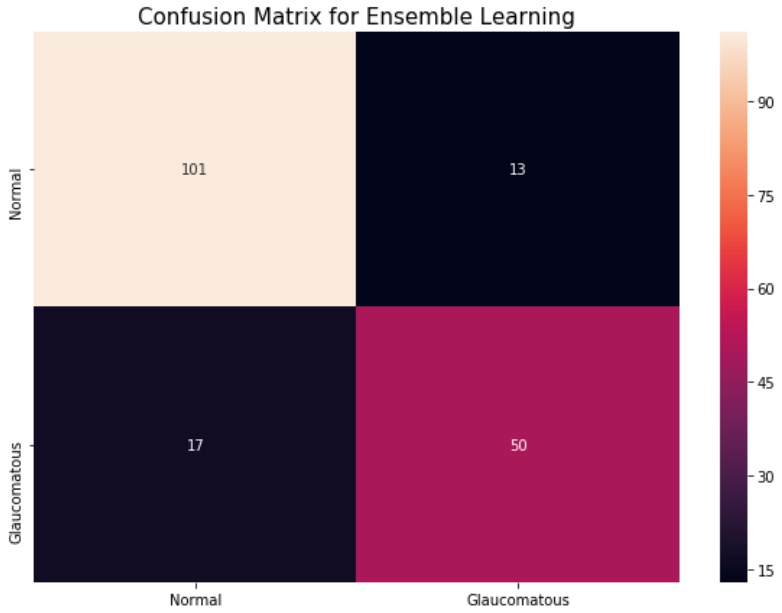


Fig 15. Confusion matrix for ensemble model

The confusion matrix below implies that the ensemble model classified the images with 50 true positives and 101 true negatives. It can be seen that the model misclassified 30 images which is 16.57% of the entire test image set. 101 normal images out of 118 normal images were classified as normal and 50 glaucomatous images out of 63 glaucomatous images were classified as glaucomatous.

Hyper-Parameter Tuning in the pre-trained networks:

For the transfer learning architectures AlexNet, VGG16, VGG19, GoogLeNetnad ResNet-50). We have used Adam Optimization with a learning rate of 0.001, batch size of 32 and the loss function as 'categorical_crossentropy'.

The various pre-trained CNN architectures have been studied, hyper-parameters in the convolutional networks have been fixed. The performance metrics of the different networks are below.

ISBN : 978-93-87793-95-8

Architecture	Sensitivity	Specificity	AUC in ROC	Accuracy(%)
AlexNet	0.7982	0.8023	0.8102	78.82
VGG16	0.8254	0.8133	0.8290	79.26
VGG19	0.8891	0.8572	**0.8919**	84.91
GoogLe Net	0.8631	**0.8723**	0.8872	81.63
ResNet-50	**0.8980**	0.8625	0.8831	**85.92**

Table 4. Description of the performance metrics of the different pre-trained convolutional neural networks. The sensitivity, specificity, AUC and Accuracy of the models are evaluated.

ResNet with 50 layers had the highest sensitivity of 0.898 for the RIM-ONE dataset. VGG19 pre-trained model performed the best and exhibited the highest AUC of 0.8919. The closest was VGG19 with AUC of 0.8891 and then GoogLeNet 0.8631. The best pre-trained CNN models were VGG19 and GoogLe Net for the RIM-ONE dataset. Plotting the confusion matrix of the RIM-ONE dataset for the test images, which contains 85 glaucomatous and 107 healthy images assured that VGG19 and GoogLeNet indeed performed well for our data.

ISBN : 978-93-87793-95-8

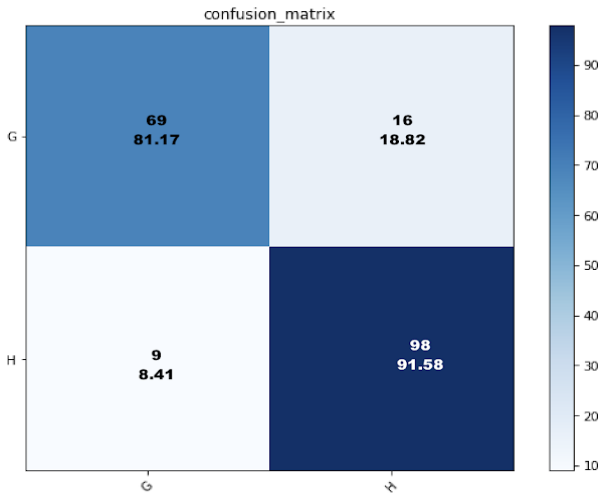


Fig 16. Confusion Matrix for the test dataset with 192 images with VGG19 as the pre-train transfer learning model.

The false positive rate (in %) from the confusion matrix is 8.4%, the precision and recall computed for the VGG19 model was 0.8841 and 0.8117 respectively. The error rate of the VGG19 model is 13.02 %, which turns out to be the best results obtained using transfer learning model.

CONCLUSION

This paper presents a complete overview on machine learning and deep learning models applied to an image dataset. Glaucoma is an irreversible disease caused due to degeneration in retinal ganglion cells [1,2]. This paper automates the process of detection and compares the performance of conventional machine learning algorithms and deep learning using transfer learning. We used an open-source RIM-ONE dataset, and preprocessed the dataset to identify the region of interest and evaluate the performance for different models.

It is seen that the ensemble model gave highest accuracy of 83.42% followed by random forest which yielded 79.55% accuracy. The highest sensitivity, accuracy, F1 score and AUC was obtained by ensemble model. However the highest specificity of 94.74% was obtained in the random forest algorithm compared to 88.59% obtained in ensemble learning.

ISBN : 978-93-87793-95-8

The various pre-trained transfer learning models were Alex Net, VGG16, VGG19, GoogLe Net and ResNet-50, of which VGG19 and GoogLe Net performed better compared to other architectures. This can be due to their high complexity and large number of layers in the CNN.

Feature extraction is a vital part which greatly affects any model's performance. We can see that the feature extraction in the conventional models follow an intuitive approach of computing the 6 features row wise and column wise to capture the essence of the ISNT rule [65] which is used by ophthalmologists. The feature extraction performed by transfer learning however, uses pooling in order to extract features from the image. Deep learning methods include multi layer processing resulting in increased performance. One major difference between conventional models and transfer learning is that the latter learns the feature extraction during training [55] while in the former, the features are manually extracted and given as input to the algorithm, which could contribute to the difference between the performances of the two types of algorithms.

REFERENCES

[1] Cook, C., Foster, P., 2012. "Epidemiology of glaucoma: what's new?", Can J Ophthalmol 47, 223-226.

[2] Lee, S., Sheck, L., Crowston, J.G., van Bergen, N.J., O'Neill, E.C., O'Hare, F., Kong, Y.X.G., Chrysostomou, V., Vincent, A.L., Trounce, I.A., 2012. "Impaired complex-ILinked respiration and ATP synthesis in primary open-angle glaucoma patient lymphoblasts". Investig. Ophthalmol. Vis. Sci. 53, 2431–2437. https://doi.org/10.1167/iovs.12-9596

[3] Fumero, Francisco &Alayón, Silvia & Sanchez, J.L. &Sigut, Jose & Gonzalez-Hernandez, M. (2011). "RIM-ONE: An open retinal image database for optic nerve evaluation". Int. Sym. on CBMS. 1 - 6. 10.1109/CBMS.2011.5999143.

[4] Hospital Universitario de Canarias, Tenerife, Spain, http://www.huc.es

[5] Hospital Clínico San Carlos, Madrid, Spain, http://www.madrid.org/cs/Satellite?pagename= HospitalClinicoSanCarlos/Page/HCLN_home

[6] Hospital Universitario Miguel Servet, Zaragoza, Spain, http://sectorzaragozados.salud.aragon.es/index.php/mod.menus/mem.opcionesMenuNivel4/relmenu.93

ISBN : 978-93-87793-95-8

[7] Samanta, Sourav Ahmed, Sk. Saddam Salem, Mohammed Abdel-MegeedM.Nath, Siddhartha Sankar, Dey, Nilanjan,Chowdhury, Sheli Sinha,"Haralick Features Based Automated Glaucoma Classification Using Back Propagation Neural Network",Proceedings of the 3rd International Conference on Frontiers of Intelligent Computing: Theory and Applications (FICTA) 2014.

[8] James M. Tielsch, Joanne Katz, Kuldev Singh, Harry A. Quigley, John D. Gottsch, Jonathan Javitt, Alfred Sommer, "A Population-based Evaluation of Glaucoma Screening: The Baltimore 63Eye Survey, American Journal of Epidemiology", Volume 134, Issue 10, 15 November 1991, Pages 1102–1110, https://doi.org/10.1093/oxfordjournals.aje.a116013

[9] Moyer VA. US. Preventive Services Task Force (2013) "Screening for Glaucoma: U.S. Preventive Services Task Force Recommendation Statement". Ann Intern Med 159:484–489.

[10] Agarwal P, Saini V, Gupta S, Sharma A. "Evaluation of central macular thickness and retinal nerve fiber layer thickness using spectral domain optical coherence tomography in a tertiary care hospital". J Curr Glaucoma Pract 2014

[11] Pan, S. J., & Yang, Q. (2010). A survey on transfer learning. The IEEE Transactions on Knowledge and Data Engineering, 22(10), 1345–1359.

[12] G.Li,A.K.Fansi,J.F.Boivin,L.Joseph,andP.Harasymowycz,"Screening for Glaucoma High-Risk Populations Using Optical Coherence Tomography," Ophthalmology 117(3), 453–461 (2010).

[13] Adegbehingbe, B.O., Ouertani, A.M. (2009) "Confocal scanning laser tomography of the optic nerve head of glaucoma patients: Inter-correlation of disc parameters". Ghana medical journal, 43(4): 150-6

[14] N. Yamada, P. P. Chen, R. P. Mills, M. M. Leen, R. L. Stamper, M. F. Lieberman, L. Xu, and D. C. Stanford, "Glaucoma screening using the scanning laser polarimeter," J. Glaucoma 9(3), 254–261 (2000).

[15] Hassan Hashemi, Mehdi Khabazkhoob, AbbasAliYekta, Mohammad Hassan Emamian, PayamNabovati& Akbar Fotouhi (2017) "The Distribution of Macular Thickness and Its Determinants in a Healthy Population, Ophthalmic Epidemiology", 24:5, 323-331, DOI: 10.1080/09286586.2017.1290808

ISBN : 978-93-87793-95-8

[16] Thomas SM, Jeyaraman M, Hodge WG, Hutnik C, Costella J, et al. (2014) "The Effectiveness of Teleglaucoma versus In-Patient Examination for Glaucoma Screening: A Systematic Review and Meta-Analysis". PLOS ONE 9(12): e113779. https://doi.org/10.1371/journal.pone.0113779

[17] HeijlALeskeMCBengtsson B et al. " Reduction of intraocular pressure and glaucoma progression: results from the Early Manifest Glaucoma Trial". Arch Ophthalmol.2002;1201268-1279

[18] Leske MC, Heijl A, Hussein M, et al. "Factors for Glaucoma Progression and the Effect of Treatment: The Early Manifest Glaucoma Trial". Arch Ophthalmol. 2003;121(1):48–56. doi:10.1001/archopht.121.1.48

[19] Z. Zhang et al., "Convex hull based neuro-retinal optic cup ellipse optimization in glaucoma diagnosis," 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Minneapolis, MN, 2009, pp.1441-1444.doi:10.1109/IEMBS.2009.5332913

[20] S. Morales, V. Naranjo, J. Angulo and M. Alcañiz, "Automatic Detection of Optic Disc Based on PCA and Mathematical Morphology," in IEEE Transactions on Medical Imaging, vol. 32, no. 4, pp. 786-796, April 2013. doi: 10.1109/TMI.2013.2238244

[21] M. M. R. Krishnan and O. Faust, "Automated glaucoma detection using hybrid feature extraction in retinal fundus images," J. Mech. Med. Biol. 13(01), 1350011 (2013).

[22] M. R. K. Mookiah, U. Rajendra Acharya, C. M. Lim, A. Petznick, and J. S. Suri, "Data mining technique for automated diagnosis of glaucoma using higher order spectra and wavelet energy features," Knowl.- Based Syst. 33, 73–82 (2012)

[23] Jennie Si, Huibao Lin, and Glen Abousleman, "A hierarchical detection algorithm quickly finds and isolates critical regions in low-quality imagery", Electronic Imaging & Signal Processing, 31 November 2006, SPIE Newsroom. DOI: 10.1117/2.1200610.0414.

[24] F. Jurie and M. Dhome, "A simple and efficient template matching algorithm," Proceedings Eighth IEEE International Conference on Computer Vision. ICCV 2001, Vancouver, BC, Canada, 2001, pp. 544-549 vol.2.doi: 10.1109/ICCV.2001.937673

ISBN : 978-93-87793-95-8

[25] Zhong Jin, ZhenLou, Jingyu Yang, Quansen Sun, "Face detection using template matching and skin-color information", Neurocomputing, Volume 70, Issues 4–6, January 2007, Pages 794-800, https://doi.org/10.1016/j.neucom.2006.10.043

[26] Evans, A. C., Beil, C., Marrett, S., Thompson, C. J., & Hakim, A. (1988). "Anatomical-Functional Correlation Using an Adjustable MRI-Based Region of Interest Atlas with Positron Emission Tomography. Journal of Cerebral Blood Flow & Metabolism", 8(4), 513–530. https://doi.org/10.1038/jcbfm.1988.92

[27] J. B. Jonas, W. M. Budde, S. Panda-Jonas, "Ophthalmoscopic evaluation of the optic nerve head, Survey of ophthalmology" 43 (4) (1999) 293–320.

[28]]Hayreh SS, Zimmerman MB, Podhajsky P, Alward WL. "Nocturnal arterial hypotension and its role in optic nerve head and ocular ischemic disorders". Am J Ophthalmol 1994;117:603e24

[29] Y. Chai, H. Liu, J. Xu (2018) "Glaucoma diagnosis based on both hidden features and domain knowledge through deep learning models", Knowledge based systems Journal

[30] Hayreh, S S. "Blood supply of the optic nerve head and its role in optic atrophy, glaucoma, and oedema of the optic disc." The British journal of ophthalmologyvol. 53,11 (1969): 721-48.

[31] Muhammad Salman Haleem, Liangxiu Hana, Jano van Hemert ,Baihua Li ,"Automatic extraction of retinal features from colour retinal images for glaucoma diagnosis: A review", Computerized Medical Imaging and Graphics 37 (2013) 581–596

[32] I. Shamshurin and J. Saltz, "Will Deep Learning Change How Teams Execute Big Data Projects?," 2018 IEEE International Conference on Big Data (Big Data), Seattle, WA, USA, 2018, pp. 2813-2817. doi: 10.1109/BigData.2018.8622337[33] Chawla, Nitesh V. and Davis, Darcy A, "Bringing Big Data to Personalized Healthcare: A Patient-Centered Framework", Journal of General Internal Medicine, September 2013, Volume 28, Supplement 3, pp 660–665. https://doi.org/10.1007/s11606-013-2455-8

[34] By Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, "Data Mining: Practical Machine Learning Tools and Techniques".

[35] Smolinska, A., Hauschild, A.-C., Fijten, R. R. R., Dallinga, J. W., Baumbach, J., & van Schooten, F. J. (2014). "Current breathomics—a review on data pre-processing techniques and

ISBN : 978-93-87793-95-8

machine learning in metabolomics breath analysis". Journal of Breath Research, 8(2), 027105. doi:10.1088/1752-7155/8/2/027105

[36] Chaudhuri, S., &Dayal, U. (1997). "An overview of data warehousing and OLAP technology." ACM SIGMOD Record, 26(1), 65–74.doi:10.1145/248603.248616

[37] Qiu, J., Wu, Q., Ding, G., Xu, Y., Feng, S.: "A survey of machine learning for big data processing". EURASIP J. Adv. Signal Process. 2016(1), 67 (2016)

[38] RoheetBhatnagar, "Machine Learning and Big Data Processing: A Technological Perspective and Review", AMLTA 2018: The International Conference on Advanced Machine Learning Technologies and Applications (AMLTA2018) pp 468-478

[39] Jones, N. "The learning machines". Nature 505(7482), 146 (2014)

[40] Langford, J. "Tutorial on practical prediction theory for classification". J. Mach. Learn. Res. 6(Mar), 273–306 (2005)

[41] Colin Cherry and George Foster, "Batch Tuning Strategies for Statistical Machine Translation", NAACL HLT '12 Proceedings of the 2012 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Pages 427-436.

[42] Sergey Ioffe, Christian Szegedy, "Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift", arXiv:1502.03167v3

[43] Chiyuan Zhang, SamyBengio, Moritz Hardt, Benjamin Recht, OriolVinyals, "Understanding deep learning requires rethinking generalization", arXiv:1611.03530v2

[44] Li Wan, Matthew Zeiler, Sixin Zhang, Yann Le Cun, Rob Fergus,"Regularization of Neural Networks using Drop Connect", Proceedings of the 30th International Conference on Machine Learning, PMLR 28(3):1058-1066, 2013.

[45] Kai Yu, Wei Xu, Yihong Gong, "Deep Learning with Kernel Regularization for Visual Recognition" , Advances in Neural Information Processing Systems 21 (NIPS 2008)

[46] Warren McCulloch and mathematician Walter Pitts, "A logical calculus of the ideas immanent in nervous activity", Bulletin of Bulletin of Mathematical Biology Vol. 52, No. 1/2. pp. 99-115. 1990.

ISBN : 978-93-87793-95-8

[47] Arthur L. Samuel, "Some Studies in Machine Learning Using the Game of Checkers". IBM Journal of Research and Development (Volume:44, Issue:1.2). DOI:10.1147/rd.441.0206

[48] Ian Goodfellow, YoshuaBengio, and Aaron Courville."Deep Learning". 2016. MIT Press.

[49] Yuille, A. L., Cohen, D. S., &Hallinan, P. W. (1989). Feature extraction from faces using deformable templates. Proceedings of CVPR, San Diego, CA, June.

[50] HUBEL, D. H. & WIESEL, T. N. (1959). "Receptive fields of single neurons in the cat's striate cortex", J. Physiol. 148, 574-591.

[51] Roberts, L.G., 1963. *Machine perception of three-dimensional solids* (Doctoral dissertation, Massachusetts Institute of Technology).

[53] Man, D. and Vision, A., 1982. A computational investigation into the human representation and processing of visual information.

[54] Fukushima, K., 1980. Neocognitron: A self-organizing neural network model for a mechanism of pattern recognition unaffected by shift in position. *Biological cybernetics*, *36*(4), pp.193-202.

[55] LeCun, Y., Boser, B., Denker, J.S., Henderson, D., Howard, R.E., Hubbard, W. and Jackel, L.D., 1989. Backpropagation applied to handwritten zip code recognition. *Neural computation*, *1*(4), pp.541-551.

[56] Everingham, M., Van Gool, L., Williams, C.K., Winn, J. and Zisserman, A., 2010. The pascal visual object classes (voc) challenge. *International journal of computer vision*, *88*(2), pp.303-338.

[57] Krizhevsky, A., Sutskever, I. and Hinton, G.E., 2012 Imagenet classification with deep convolutional neural networks. In *Advances in neural information processing systems* (pp. 1097-1105)

[58] Simonyan, K. and Zisserman, A., 2014 Very deep convolutional networks for large-scale image recognition. *arXiv preprint arXiv:1409.1556*.

[59] Szegedy, C., Liu, W., Jia, Y., Sermanet, P., Reed, S., Anguelov, D., Erhan, D., Vanhoucke, V. and Rabinovich, A., 2015 Going deeper with convolutions. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 1-9).

[60] He, K., Zhang, X., Ren, S. and Sun, J., 2016 Deep residual learning for image recognition. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 770-778).

[61] Tin Kam Ho, 1995 Random decision forests. *Proceedings of 3rd International Conference on Document Analysis and Recognition*, Montreal, Quebec, Canada, pp. 278-282 vol.1.

[62] Boser, B.E., Guyon, I.M. and Vapnik, V.N., 1992 A training algorithm for optimal margin classifiers. ACM, In *Proceedings of the fifth annual workshop on Computational learning theory* (pp. 144-152)

[63] Cramer, JS 2002 The origins of logistic regression. Tinbergen Institute Working Paper. 119 (4): 167–178.

[64] Opitz, D.; Maclin, R. 1999 Popular ensemble methods: An empirical study. Journal of Artificial Intelligence Research. 11: 169–198. doi:10.1613/jair.614

[65] Harizman N, Oliveira C, Chiang A, et al. The ISNT Rule and Differentiation of Normal From Glaucomatous Eyes. Arch Ophthalmol. 2006;124(11):1579–1583. doi:10.1001/archopht.124.11.1579

[66] Polikar R. 2006 Ensemble based systems in decision making. *IEEE Circuits and Systems Magazine*, vol. 6, no. 3, pp. 21-45

[67] Gini, C. 1909 Concentration and dependency ratios (in Italian). English translation in Rivista di PoliticaEconomica, 87(1997), 769–789

[68] Strobl, C., Boulesteix, A.L. and Augustin, T., 2007. Unbiased split selection for classification trees based on the Gini index. *Computational Statistics & Data Analysis*, *52*(1), pp.483-501.

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Artificial Intelligence in Deep Learning

Dr.B.Sujatha
Professor, Department of Computer Science and Engineering
Sengunthar Engineering College, Tiruchengode

Abstract:

Artificial Intelligence (AI), which means building the systems that, can do intelligent things like human beings. Machines can perform automated tasks using human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. The one word, "Decision Making", plays a vital role in Industrial revolution and now it has became a necessity after digital revolutions where information are being generated in trillions of bytes. To process this information in splits of a second and to make a decision, we needed that computer machine to think and perform like human brains and so the Artificial intelligence becomes more popular today because of increased data volumes, advanced algorithms and upgrade in computing power and storage. [1]

AI makes it possible for machines to learn from experience, with correct new inputs and perform human-like tasks. The most AI examples starts from chess-playing computers to self-driving cars-rely deeply on deep learning and natural language processing. Using these technologies, computers can be educated to perform specific tasks by processing large amounts of data and recognizing patterns in the data.

Deep learning is a subset of Machine learning that predominantly solving complex problems with high speed and that has applications ranging from natural language processing and image recognition to drug discovery and toxicology, recommended systems etc. It is an enhancement of Artificial Neural Network (ANN) which imitates how the human brain learns and resolves the problems. Applications using deep learning are built on deep neural networks (DNN), with multiple hidden layers of units between the input and output layers. Artificial neurons loosely model an artificial brain, with each neuron connected to many others with an individual neural unit performing a summation function that combines the values of all its

ISBN : 978-93-87793-95-8

inputs together. The effect is that it is possible to train systems to be self-learning and that can perform specific tasks, given enough training data and time.

What exactly deep learning is it actually uses a neural network with several layers of nodes between input and output. It is generally better than other methods on images, speech and certain other types of data, because the series of layers between input & output do feature identification and processing in a series of stages, just as human brains seem to.

Always we have good algorithms for learning weights in neural network with 1 hidden layer. But, we need more advanced algorithms for learning the weights in network with more hidden layers.

The procedure of deep neural networks is that it considers some examples from a sample dataset and calculates error for this network. Adjust weight based on error and repeat this procedure each time by taking a random training instance, and making slight weight adjustments. So, algorithms are well designed for weight adjustments to make changes that will reduce the error.

Deep learning and AI have moved well beyond science fiction into the revolutionary of internet and enterprise computing. The availability of new, rich data sources, access to more computational power in the cloud, advancement of refined algorithms making deep learning real.

References:

1. https://www.sas.com/en_in/insights/analytics/what-is-artificial-intelligence.html

2. https://skymind.ai/wiki/ai-vs-machine-learning-vs-deep-learning

3. https://dzone.com/articles/deep-learning-and-the-artificial-intelligence-revo-4

4.https://www.psirep.com/system/files/From%20Machine%20Intelligence%20to%20Deep%20Learning.pdf?width=900&height=675&iframe=true.

A Review of Deep Learning Methods and Applications for Unmanned Aerial Vehicles

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Despeckling of Carotid Artery Ultrasound Images with a calculus approach

S.Latha[a], Dhanalakshmi Samiappan*[b]
[a,b,1] *ECE Department, SRM Institute of Science and Technology, Kancheepuram, Tamil Nadu, India*

dhanalakshmi.s@ktr.srmuniv.ac.in

Abstract: Carotid artery images indicates any presence of plaque content, which may lead to atherosclerosis and stroke. Early identification of the disease is possible by taking B-mode ultrasound images in the carotid artery. Speckle is the inherent noise content in the ultrasound images, which essentially needs to be minimized. The objective of the proposed method is to convert the multiplicative speckle noise into additive, after which the frequency transformations can be applied. The method uses simple differentiation and integral calculus and is named variable gradient summation. It differs from the conventional homomorphic filter, by preserving the edge features to a great extent and better denoising. The additive image is subjected to wavelet decomposition and further speckle filtering with three different filters Non Local Means (NLM), Vectorial Total Variation (VTV) and Block Matching and 3D filtering (BM3D) algorithms. By this approach, the components dependent on the image are identified and the unwanted noise content existing in the high frequency portion of the image is removed. Experiments conducted on a set of 300 B-mode ultrasound carotid artery images and the simulation results prove that the proposed method of denoising gives enhanced results than the conventional process in terms of the performance evaluation methods like Peak Signal to Noise Ratio, Mean Square Error, Mean Absolute Error, Root Mean Square Error, Structural Similarity, Quality Factor, Correlation and Image Enhancement Factor.

Keywords: speckle; denoising; carotid artery; wavelet decomposition.

1. INTRODUCTION

Imaging modalities like Ultrasound, Magnetic Resonance Imaging, Computer Tomography, Thermal Imaging have noise built in from the acquisition process which has to be processed and removed for further detection of illness by segmentation and classification processes. Medical Ultrasound is non-invasive, cost effective, safe modality for primary and accompanying technique for other imaging techniques. It is highly influenced with multiplicative speckle noise, where the image is in the form of noise component multiplied with the image intensity. Other noises like gaussian and salt & pepper are additive, in the sense that, the noise and the

ISBN : 978-93-87793-95-8

intensity are in added form. Speckle has an undesirable negative impact among radiologists. In addition, diagnosis may become erratic leading to mental pressure among patients.

Denoising the multiplicative noise is a time consuming process and also requires effective post processing. The denoised image is the input to the further processing methods like segmentation, feature extraction, classification or regression. Therefore the first step of denoising must be redundancy free to get the accurate classified results. The algorithms of these image processing tasks must be accurate and robust.

The general procedure to deal with speckle is to convert it to additive, and then perform the necessary frequency domain enhancement transformations in the additive component. Image is retried back by an exponential operation. Several granular speckle reducing filters were proposed in the literature to reduce the noise in the images assuming a multiplicative noise. There is no evident proof yet to justify speckle as a multiplicative noise corrupting image.

Image Performance Metrics available like Peak Signal to Noise Ratio (PSNR), Structural Similarity Index Measure (SSIM), Mean Square Error (MSE) and many others have been used to compare the denoising techniques [1, 2, 3, 4]. De-An Huang et al. proposed self-learning from a single image based on a decomposition approach and dictionary learning applied on denoising [5]. But the method focused only on Gaussian noise and rain removal. The run time was nearly 100s for an image of size 256*256 pixels which is not suitable for real time problems [6].

It is required to analyze the statistical behavior of the estimated image, while selecting the parameters of the filters. Gabriela Ghimpe et al. proposed a decomposition framework for image denoising, in which the components of the moving frame are identified. By this approach the local geometry of the image is preserved, which would have been the drawback of denoising the image directly [7]. The results outperformed in terms of PSNR and SSIM. The model the author proposed is suitable for filters like NLM, BM3D and VTV. But it is not suitable for images whose noise model is unknown [8,9].

Hossein et al. proposed a global way of filtering in patch based methods [10]. This will reduce the time complexity in large images. It is more suitable for the images which have more number of similar patches. The development of such a model with enhanced speckle reduction techniques is the current requirement for the granular ultrasound images. The purpose of this work is to address the speckle noise of the ultrasound images in a better way, so that the fine details and the edges are preserved to a large extent.

Regularization by a combination of total variation and a higher order variation and identifying the fidelity term by Kullback-Leibler divergence was proposed by Xi-Le Zhao et al. [11]. This method reduces the staircase effect along with noise removal in Synthetic and

ISBN : 978-93-87793-95-8

ultrasound images. Combining data misfit and a weighted total variation function, as a product function for cost estimation, despeckling ultrasound images was proposed [12]. Smoothing in preferred orientations is done, to improve the denoising in boundaries of the image, with mean absolute error as the stopping criteria for iterations. Log compressed images can be obtained from the nakagami distribution, using a maximum a-posteriori estimation framework. Optimization of the augmented Lagrange and Chambolle's projection method was applied to solve the maximization problem [13]. A fast speckle reduction by a convex variational model was proposed by JieHuang et al. for ultrasound images. With KL distance metric, a variable splitting method and Bregman iteration was proposed [14]. An automatic selection of the regularization parameter of the Aubert–Aujol (AA) was proposed [15]. Spatial variation was concentrated more to improve the texture preservation.

The speckle is modelled by using a differentiation using calculus approach. The method is proved to be better than the traditional homomorphic filtering by both mathematical and numerical analysis. Further examined with wavelet decomposition and speckle reducing filters to improve the performance so that the filtered image is closer to the original image. The article starts with the carotid artery structure and the significance of using ultrasound imaging for stroke prediction by radiologists.

The mathematical modelling of the homomorphic approach and the proposed method are validated with numerical analysis. Filters are then applied for further denoising and their performance metrics are listed. The coherent speckle noise system has many number of randomly distributed scatterers with noise appearing as dark or bright dots in the image. The brightness of the pixel depends on the phase relationship between the returned waves from the scatterers and the scatterer properties in the resolution cell.

Speckle is present in ultrasound images which is inexpensive and a good diagnosis tool in the area of medical imaging. Carotid atherosclerosis, which is a chronic degenerative disease, which results in the formation of fat deposit called plaque in the inner lining of the carotid artery [16]. B mode ultrasonographic images can be used for identifying the plaque stenosis extent in the carotid artery. The comparison of the traditional homomorphic filter and the proposed Vectorial Gradient Summation (VGS) is done for the B mode ultrasound carotid artery images with and without plaque. The method is tested in 300 carotid artery ultrasound images, with and without plaque, acquired from a scan center. The age group of the people were 50 to 70. In the list, 135 images were images which had abnormalities like plaque formation. The remaining images were normal images which did not have any abnormalities.

ISBN : 978-93-87793-95-8

2. PLAQUE DETECTION USING ULTRASOUND CAROTID ARTERY IMAGES

Carotid artery abnormalities are found using ultrasound imaging [17-19]. The proposed method is applied in those images for speckle reduction.

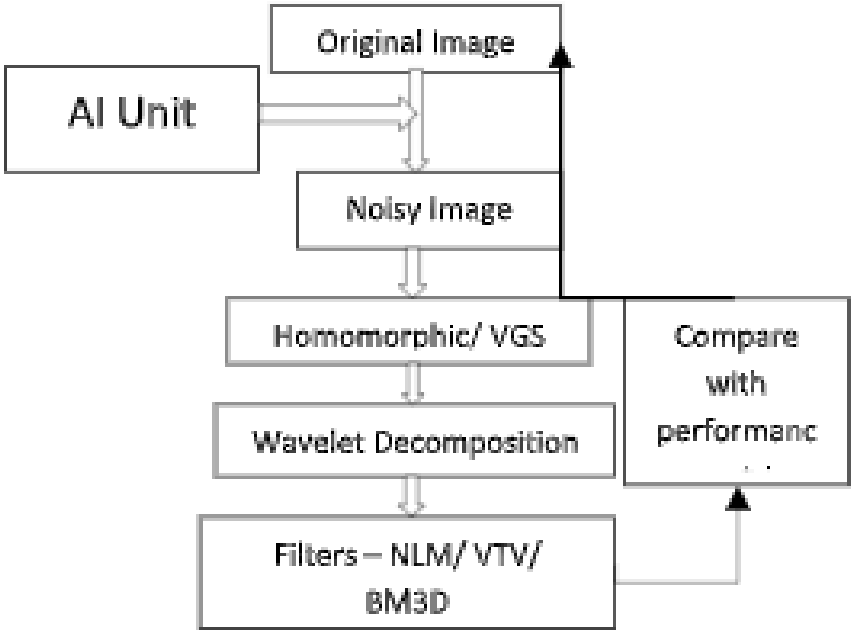


Fig. 1. Basic Model for Denoising of Image.

Fig.1 gives the process to be followed with the traditional homomorphic and VGS approach. Understanding the biomechanical features of carotid artery is the only option for early detection of stroke and other heart related illnesses, so that preventive measures can be initiated. Fig. 2 gives the internal structure of the carotid artery with and without plaque deposit. C.P. Loizou et al., proposed texture analysis of the ultrasound image of CCA and its correlation with age and gender of the patient [20].

ZhifanGao et al. proposed a non-linear state space approach with a time variant control signal generated by a mathematical model for the common carotid artery wall tracking from a sequence of images [21]. To derive the state of the target tissue, an unscented kalman filter was used to solve the nonlinear state transfer function. By initiating an elasticity based state space approach for motion estimation is proposed [22]. Block matching and parameter training for the parameter initialization problem is done.

ISBN : 978-93-87793-95-8

Intima is a thin layer which grows with age, for a normal person. Media layer is a smooth muscle cell echolucent layer, between the intima and the adventitia layers. It does not change considerably with age. The formation of fat deposit in the interior of the artery, significantly changes the thickness of the intima media layer and the adventitia boundary.

Detecting the changes in the carotid artery layers and accurate measurement of plaque diameter is possible when ultrasound image is taken in the subjected area. B-mode ultrasound imaging technique is cost effective, non-invasive and provides us a reliable source of information regarding carotid artery features.

It provides the geometry, flow rate information and also the composition of the plaque which is a very useful measure for further treatment. But the granular looking multiplicative speckle noise is the area which has to be addressed in ultrasound image. Speckle reduction will considerably show improved image quality.

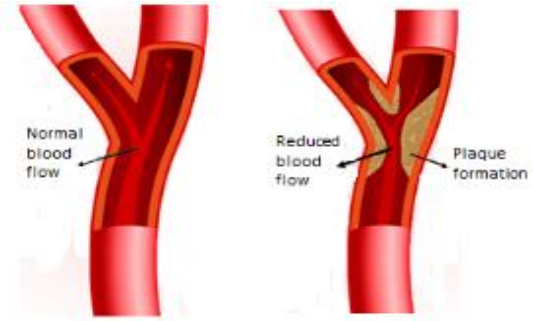


Fig. 2. Internal Structure of Common Carotid Artery.

3. MATHEMATICAL AND NUMERICAL MODELLING OF HOMOMORPHIC FILTERING

3.1. Mathematical Model

The technique used in literature is the homomorphic filtering technique which applies the illumination reflection model. The model is given by

$$I(x,y) = i(x,y) * r(x,y) \quad (1)$$

I(x,y) is the acquired image which is the product of the brightness component from the source i(x,y) and the reflectance component of the object on the scene of interest r(x,y). By this approach, the incidence changes slower than reflectance and thus comprises more of the low frequency proportion.

In homomorphic filtering, the low frequency component is reduced, thus reducing the effect of illuminance and preserving the high frequency reflectance component. For achieving the filtering process, it is necessary to transform the spatial domain image to frequency domain by

ISBN : 978-93-87793-95-8

any frequency domain transformations like fourier transform. Before the transformation, the multiplicative component is converted by taking logarithm [23, 24].

The steps followed in homomorphic filtering is presented in this section.

Log on both sides gives,

$$z(x,y) = \ln(I(x,y)) = \ln(i(x,y)) + \ln(r(x,y)) \quad (2)$$

Applying Fourier transform on both sides,

$$F\{z\} = F\{\ln(i(x,y))\} + F\{\ln(r(x,y))\} \quad (3)$$

$$F\{z\} = F_i(u,v) + F_r(u,v) \quad (4)$$

Fi(u,v) is the fourier transform of ln(i(x,y)) and Fr(u,v) of ln(r(x,y)). On applying H(u,v) on the frequency domain, Z(u,v) which is the filtered resultant image is calculated as

$$R(u,v)=Z(u,v)H(u,v)=Z(u,v)F_i(u,v)+Z(u,v)F_r(u,v) \quad (5)$$

H may be any of the filtering technique which may be selected based on the application. To get back the image in spatial domain, inverse fourier transform is performed.

$$r(x,y)=F^{-1}(u,v)=F^{-1}\{Z(u,v)F_i(u,v)+Z(u,v)F_r(u,v)\} \quad (6)$$

To remove the logarithm and get the denoised enhanced image exponential is applied on r(x,y).

$$g(x,y) = \exp\{r(x,y)\} \quad (7)$$

By this method, the granular multiplicative speckle is converted to additive and thus frequency domain processing are performed for enhancement. Speckle has the property of minimizing the contrast and signal to noise ratio of the tissues and the homomorphic filtering has done its first step in minimizing the speckle content.

It has the ability to increase the brightness and contrast by locating and separating the illuminance and reflectance components along with dynamic controlling. Homomorphic filtering is a very old technique, which is also applied in majority of the other applications like speech and signal processing.

3.2. Numerical Analysis

Assuming the image to be linearly distributed and modelled as i(x) = x + 4 and the linearly varying speckle, assume r(x)=x + 5.

$$\log(g) = \log(i * r) = \log(i) + \log(r) \quad (8)$$

$$\log(g) = \log(x+4) + \log(x+5)$$

ISBN : 978-93-87793-95-8

Assuming the image to be linearly distributed as i(x) = x+4 and the speckle noise to be exponentially distributed as r(x) = ex

$$\log(g) = \log(x+4) + \log(ex) \quad (9)$$

Applying different values for x, the logarithm of the resultant image characteristics are obtained. The resultant Fig. 3 shows both linear speckle and the exponential speckle gives linear curve.

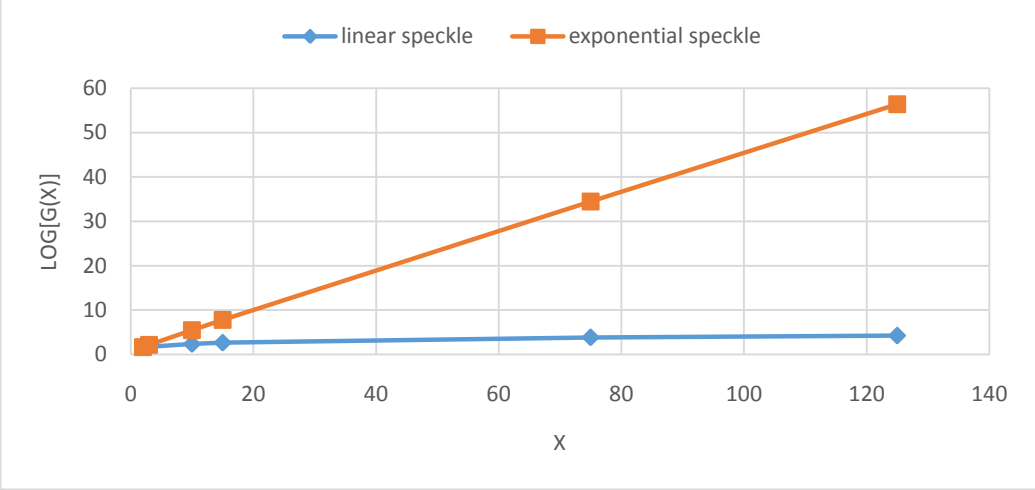


Fig. 3. Homomorphic filtering applied on linear and exponential speckle model.

4. MATHEMATICAL AND NUMERICAL MODELLING OF THE PROPOSED VARIABLE GRADIENT SUMMATION APPROACH

4.1. Mathematical Model

To convert the multiplicative speckle noise into additive, a differentiation integration calculus method is proposed, which preserves more details and gives much better performance evaluation metrics than the homomorphic filtering. Excessive speckle reduction may lead to loss of fine necessary details of image which may contain lesions. But the proposed VGS approach visually preserves the fine details of the carotid artery ultrasound image, thus does not affect the further segmentation and classification results.

Thus far, for converting the multiplicative to additive noise, homomorphic filtering is only applied in most of the literature. Consider S(x) as the speckle noise spread over the entire image and as a function of pixel value x. The original image intensity is represented as a(x). Since speckle is multiplicative,

ISBN : 978-93-87793-95-8

$n(x) = S(x)\, a(x)$ (10)

n is the corrupted noisy image. On differentiating,

$$\frac{d}{dx}\big(n(x)\big) = \frac{d}{dx}[S(x)a(x)] \quad (11)$$

$$= S(x)\frac{d}{dx}\big(a(x)\big) + a(x)\frac{d}{dx}(S(x)) \quad (12)$$

Speckle content in the image has very less intensity compared to the image intensity. So the differentiation of the speckle will have even more smaller value. Hence neglecting the term $\frac{d}{dx}(s(x))$ term and assuming exponential speckle, the equation 12 becomes

$$\frac{d}{dx}\big(n(x)\big) = S(x)\frac{d}{dx}\big(a(x)\big) + a(x) \quad (13)$$

For linearly distributed images of intensity values a(x) may be assumed as x. Linear distribution is similar to a ramp signal.

$$\frac{d}{dx}\big(n(x)\big) = S(x) + a(x) \quad (14)$$

Thus the multiplicative speckle is made additive by differentiation. This differentiation is for the point spread and to integrate the differentiation for the whole image, integration is performed on both sides. Further, the frequency domain processing are performed for enhancement of the image suitable for segmentation and classification.

$$\int \frac{d}{dx}\big(n(x)\big)dx = \int s(x)dx + \int a(x)dx \quad (15)$$

The above equation represents that on integrating each speckle gradient of the speckle content over the entire image, resultant is the summation of the speckle noise content over the entire image and the intensity of the original image without added speckle content.

Hence it can be concluded that: n'(x) = S'(x) + a'(x)

Where S'(x) represents the speckle noise over the entire image and a'(x) represents the intensity of the whole image without any added speckle. Hence, this speckle property start from each speckle point and gradually spread over the entire image. Hence the speckle noise can be termed as 'Point Spread Noise' [25].

4.2. Numerical Analysis

Considering linear image intensity distribution over the original image, a(x) = x+4. Since speckle noise is exponentially distributed, S(x) = e^x. By eqn 10,

$$n(x) = e^x x^4 \quad (16)$$

ISBN : 978-93-87793-95-8

Differentiating with respect to x,

$$\frac{d}{dx}[n(x)] = \frac{d}{dx}[e^x x^4] \quad (17)$$

$$= e^x \frac{d}{dx}(x+4) + (x+4)\frac{d}{dx}(e^x) \quad (18)$$

$$= e^x + (x+4)e^x \quad (19)$$

Integrating on both sides,

$$n(x) = \int e^x + \int (x+4)e^x \quad (20)$$

Where $\int e^x$ the summation of all speckle points is over the image and the second term represents intensity of the whole image. The equation reduces to

$$n(x) = e^x + \frac{x^2}{2} + 4x \quad (21)$$

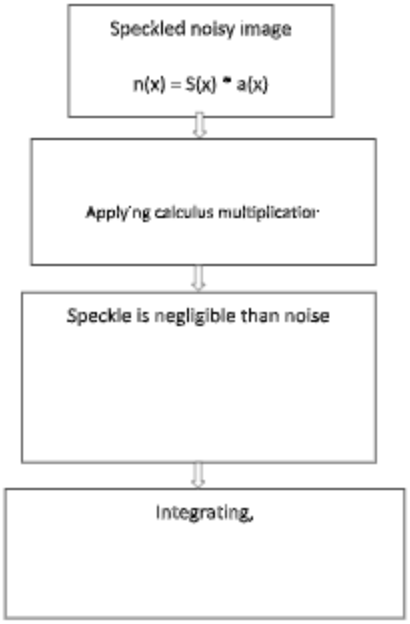


Fig. 4. VGS Approach

Considering speckle noise follows linear distribution, S(x)=x+c. Let the constant c be 5, S(x) = x+5. Hence linearly distributed image, a(x) = x + 4.

$$n(x) = (x + 5)(x + 4) \quad (22)$$

$$\frac{d}{dx}\big(n(x)\big) = 2x + 9 \quad (23)$$

ISBN : 978-93-87793-95-8

By addition of speckle and image intensity,

$n(x) = S(x) + a(x) = (x + 5) + (x + 4)$ (24)

$= 2x + 9$ (25)

Thus proved that differentiation of the noisy image is equal to the sum of image intensity and speckle content. On integrating the above expression over the whole image,

$n(x) = \int(x + 5)dx + \int(x + 4)dx = x^2 + 9x$ (26)

Our assumptions and conclusions to convert speckle noise from multiplicative to additive holds true only if the intensity of the original image is linearly distributed, known that speckle follows linear distribution over the image. Exponential speckle could result in an increased differentiated output over sum of speckle and image intensity.

$e^x(x + 4) > e^x + (x + 4)$ (27)

But it could result in lowering down the speckle content spread over the entire image by a known factor $e^x(x + 4) - e^x + (x + 4)$ which is a considerable amount of noise content. Hence this method could be helpful in speckle reduction over the images. Therefore, considering linear distribution of speckle noise content over a linearly distributed intensity of original image the multiplicative speckle could be converted to an additive speckle.

The following are the observations after implementation of proposed algorithm: For exponential varying speckle the image in the integrated expression provides better results than the image intensity taken directly. For linearly varying speckle the image in the added expression of $S(x) + a(x)$ provides better results than image intensity in the integrated expression.

Table 1

Difference between product and summation for exponentially varying speckle compared with traditional homomorphic filtering

Image intensity x	$e^x(x + 4)$	$e^x + (x + 4)$	Reduced speckle content $e^x(x + 4) - e^x + (x + 4)$	Reduced speckle content - homomorphic filtering
2	44.33	13.38	30.95	1.646
3	140.59	27.08	113.51	2.147
10	308370.52	22040.46	286330.06	5.4891

ISBN : 978-93-87793-95-8

15	6.211×10^7	3.269×10^6	5.88×10^7	7.793
75	2.949×10^{34}	3.733×10^{32}	2.911×10^{34}	34.469

Table 1 indicates that the reduced speckle content for the proposed approach is better than that of the homomorphic filter.

5. VGS APPLIED TO WAVELET DECOMPOSITION AND OTHER DENOISING METHODS

5.1. Wavelet Decomposition

Most of the speckle reducing approaches apply locally adaptive recovery methodologies, like partial differentiation methods, adaptive methods and wavelet based methods. Wavelet thresholding methods are applied along with speckle reducing filters, considering the noise is converted to additive Gaussian

from multiplicative speckle. After automatic threshold selection, the wavelet coefficients are shrinked selectively to zero and decomposed till the majority of the low coefficients are processed [26-27].

The desired information is represented by fewer number of coefficients, and the energy of the noise is spread across the wavelet coefficients. For the compact representation, the other wavelet should be similar to the ultrasound pulse. The Bayesian map estimator applied for the wavelet transform is given by

$$y(g) = \arg\max_x [-\frac{(g-x)^2}{2\sigma_\eta^2} + p(x)] \quad (28)$$

Where η is the noise in the image with mean zero and variance σ_η^2.

Homomorphic filter and the proposed method are compared by applying on wavelet threshold decomposition and then filters like non-local means (NLM), Block Matching and 3D filtering (BM3D) and Vectorial Total Variation (VTV) were applied for further denoising. Then the inverse wavelet thresholding is applied along with inverse of either homomorphic or proposed method based on which method was applied initially.

ISBN : 978-93-87793-95-8

5.2. Non-Local Means (NLM) Filter

Yi Zhan et al. proposed iterative weight refining for non-local means denoising applied on ultrasound images using the mean of absolute error [28,29]. NLM uses the correspondence innate in the images where the similarity is reserved patch wise, which is combined with wavelet shrinkage which uses the sparsity in the image.

For the acquired speckled image I, at pixel (x,y), the refurbished intensity, K(x,y) by the traditional non-local means filter is given by the following equation.

$$K(x,y) = \sum_{(r,t)\in\Omega(x,y)} I(r,t)\phi(x,y,r,t) \quad (29)$$

Where Ω(x,y) is a search window centered at image pixel location (x,y) and ϕ is the weight indicating the similarity in structure between (r,t) and (x,y) coordinates, given by

$$\omega(x,y,r,t) = \frac{1}{Z(x,y)}\exp\left(-\frac{Dis(x,y,r,t)}{x^2}\right) \quad (30)$$

Z is the normalization constant and h is the decay parameter which controls the degree of filtering. Eucledian distance D is, is the difference between square of $I_p^n(x,y)$ and$I_p^n(r,t)$.

The algorithm is realistic after the necessary applying the image enhancements and selecting neighborhood adaptively. Applying Bayesian framework, a similarity weight is introduced in the traditional NLM, to significantly suppress the speckle content. Results obtained indicates that the proposed method along with NLM and wavelet decomposition performs better than homomorphic filtering in terms of evaluation metrics like Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Mean Structural Similarity (MSSIM) and Quality Index (QI).

5.3. Block Matching and 3D (BM3D) Filter

BM3D filtering is applied in the sparse representation of the wavelet domain thus effectively separating the noise in the image. It is done by grouping of similar 2 dimensional blocks into groups called 3D arrays, collaborative filtering and shrinkage of the generated groups. Thus BM3D uses the advantage of more number of similar patches and the highly correlated local data, thus uses both the both local and global features of the image. The image intensity can be preserved and separated from the noise content effectively when filtering is executed in 3D.

This denoising method exploits the possible likeness like correlation, affinity, etc. among clustered blocks to evaluate the exact signal in all of them by producing a highly sparse representation in 3D transform domain, so that the noise can be removed by wavelet shrinkage. This approach of exploiting similarity and estimating the original signal is called as collaborative filtering. This progression reveals the finest details shared by grouped blocks by preserving the unique features of each individual block.

ISBN : 978-93-87793-95-8

Igor Djurovic proposes that the method improves the decision based median filter with adaptive characteristics [30]. For each reference patch, similar patches are identified from the input image by classifying them according to some similarity criteria and transformed into a 3D data array by grouping the matched 2D blocks with automatic threshold selection, the 3D matrix is filtered in the transform domain. The noise intensity is much reduced when different patches are processed instead of local neighbourhood [31].

By identifying the repeating details, BM3D performs better filtering in edges and boundaries of the image, thus preserving the necessary details. Initially, similar regions are generated in the wavelet transform domain. The transform coefficients whose values are less than the threshold value is made zero. With the formation of the 3D matrix, 3D patches are formed. The coefficients below the threshold are removed and the others are preserved. The operation is done for all pixels and then aggregated to the similar blocks. Inverse 3D filtering is performed and gathering of the patches is done to get the filtered image.

For linear and exponential speckle, BM3D with the proposed method gives enhanced results with respect to MSE, Signal to Noise Ratio (SNR), Root Mean Square Error (RMSE) and Image Enhancement Factor (IEF) than the traditional logarithmic conversion method.

5.4. Vectorial Total Variation (VTV) Filter

VTV is a type of regularization denoising algorithm, which penalizes the gradient magnitude of the channel by taking L2 differences, thus combines the available channels with regularizing vectorial total variation to preserve the edge details. It is based on the principle that if the image has more number of total variations, then integration of the absolute gradient value will be high.

Instead of using a regularization norm, the VTV norm is minimized to reduce the number of iterations and thus the execution time is minimized. Thus by minimizing the total variations, the noise component can be removed, preserving the image intensity. In the generated vectorial image, the direction of the maximum and the minimum variations are acquired using eigenvectors. The information regarding the rate of change happened is collected using the corresponding eigenvalues. To prevent the staircasing effect, higher order VTV is performed [7,32].

5.5. Quality Metrics

The goal of the image denoising algorithm is to remove the noise content without making changes in the fine details of the image. To prove the proposed filters performance, the original

ISBN : 978-93-87793-95-8

image is corrupted with speckle noise of different variance and mean zero. Homomorphic filtering and the proposed calculus method are simulated with the wavelet decomposition and other speckle reducing algorithms [19]. The denoised image is compared with the original image with the following performance evaluation quality metrics.

Table 2
Denoising Performance Evaluation Measures

Sl.No.	Quality Metrics	Formula	Remarks
1	Signal to Noise Ratio (SNR)	μ/σ	Level of the background noise of image can be compared μ - signal mean; σ - standard deviation of the noise
2	Peak Signal to Noise Ratio (PSNR)	$10\log_{10}(255^2/\text{MSE})$	Approximation to human perception of reconstruction quality. M,N – dimensions of the image
3	Mean Square Error (MSE)	$\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(X(i,j)-Y(i,j))^2$	Collective squared error between the denoised and the original image
4	Mean Absolute Error (MAE)	$\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\lvert X(i,j)-Y(i,j)\rvert$	Average of the absolute errors
5	Root Mean Square Error (RMSE)	$\sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[X(i,j)-Y(i,j)]^2}$	Square root of the squared error averaged in the window
6	Mean Structural Similarity Index Metrics (MSSIM)	$\frac{(2\mu_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)}$ $C_1=(K_1L)^2; C_2=(K_2L)^2$ Dynamic range of pixel $L=2^{bits\ per\ pixel}-1$ $K_1=0.01;\ \ K_2=0.03$ by	Measures similarity between two images consistent with visual perception

ISBN : 978-93-87793-95-8

		default	
7	Image Quality Index (IMGQ)	$\frac{\sigma_{xy}}{\sigma_x \sigma_y} \frac{2\mu_y \mu_x}{{\mu_y}^2 + {\mu_x}^2} \frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2}$	Gives performance based on visual interpretation of the denoised image
8	Correlation (r)	$\sum_{i=-k}^{k} \sum_{j=-k}^{k} X(i,j)\, Y(x-i, y-j)$	Correlation between the images
9	Image Enhancement Factor (IEF)	$\frac{\sum_{i=1}^{m} \sum_{j=1}^{n} \{N(i,j) - X(i,j)\}^2}{\sum_{i=1} \sum_{j=1} (Y(i,j) - X(i,j)^2}$	The factor by which the image is enhanced without distorting the fine details

Table 2 gives the performance evaluation metrics for comparing the proposed approach with the homomorphic filtering. X(i,j) denotes the initial carotid artery ultrasound image; N(i,j) the noisy image and Y(i,j) represents the denoised image. The values of SNR, PSNR, MSSIM, IMGQ, correlation and IEF must be high and MSE, MAE, RMSE values must be low for a good denoising filter.

6. RESULTS AND DISCUSSIONS

Symptomatic and asymptomatic images of the Common Carotid Artery (CCA) were acquired from a local scan center and was subjected to homomorphicdenoising and the proposed VGS approach. Carotid artery ultrasound images were added with speckle noise of different variances and zero mean. The noised image is subjected to homomorphic filter by applying log transformation.

The transformed image is then processed with wavelet decomposition and the resulting coefficients are given to the denoising filters like NLM, BM3D and VTV one after the other. To the processed image inverse wavelet transformation and exponential to remove homomorph are applied. The denoised image is compared with the original image with the performance evaluation metrics. The same procedure is followed with the proposed variable gradient summation cystolithic calculus conversion of multiplicative speckle to additive. The simulations results are compared with the performance valuation metrics specified in the table 2.

ISBN : 978-93-87793-95-8

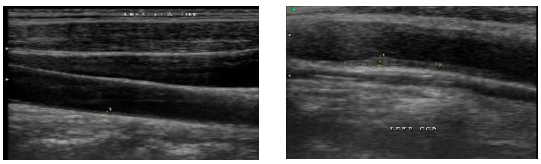
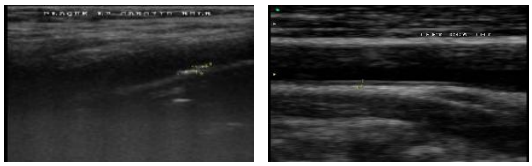


Fig. 5 (a-e). Sample Images. (a)Normal Left CCA. (b)Left CCA with Plaque.

(c)Left CCA with Bulb.



(d)Left CCA plaque bulb. (e)Normal Left CCA.

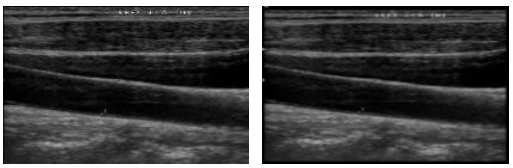
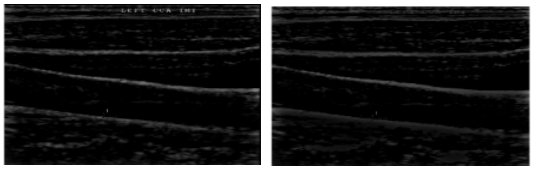


Fig. 6 (a-d). (a)0.004 speckled (b)homomorphic filtered



(c) filtered by proposed VGS considering exponential speckle (d) linear speckle

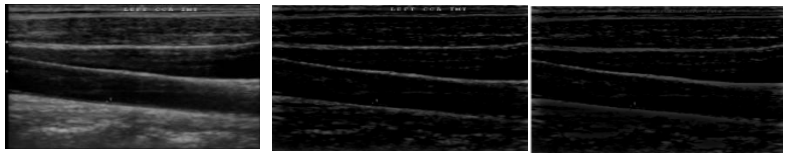


Fig. 7(a-c). (a) DWT with NLM in log transform (b) for exponentially varying speckle (c) linearly varying speckle

ISBN : 978-93-87793-95-8

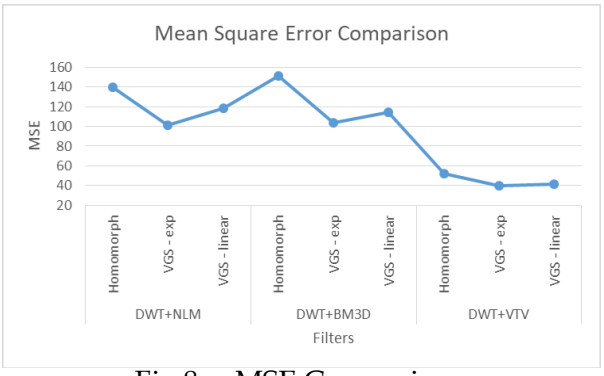


Fig 8.a. MSE Comparison

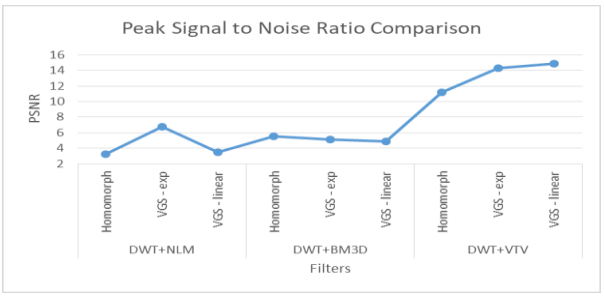


Fig 8.b. PSNR Comparison

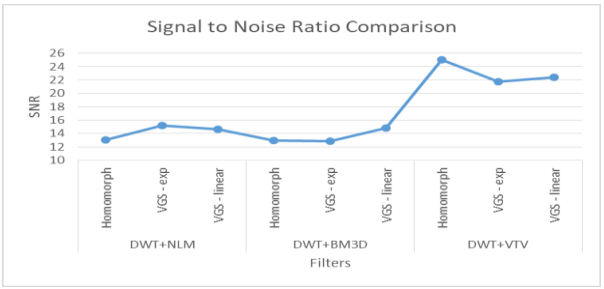


Fig 8.c. SNR Comparison

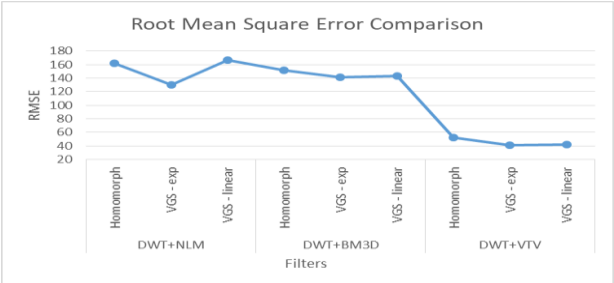


Fig 8.d. RMSE Comparison

ISBN : 978-93-87793-95-8

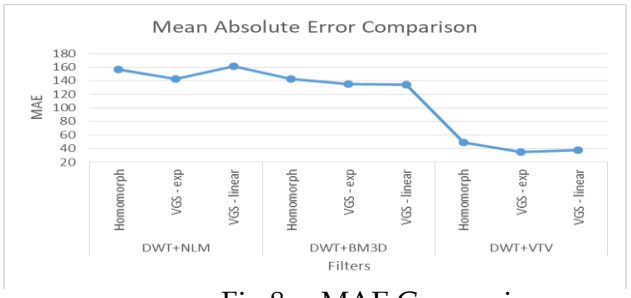


Fig 8.e. MAE Comparison

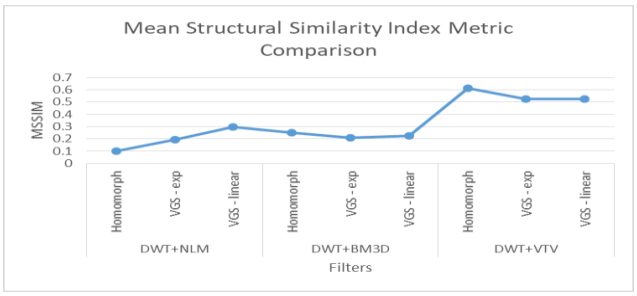


Fig 8.f. MSSIM Comparison

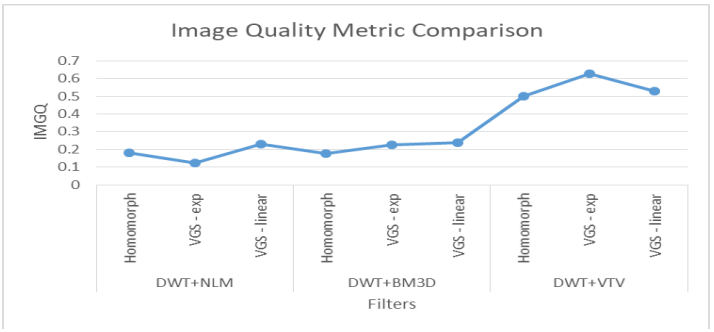
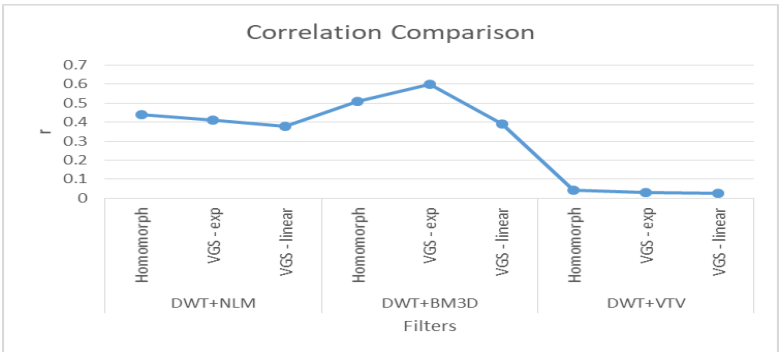


Fig 8.g. IMGQ Comparison



ISBN : 978-93-87793-95-8

Fig 8.h. Correlation Comparison

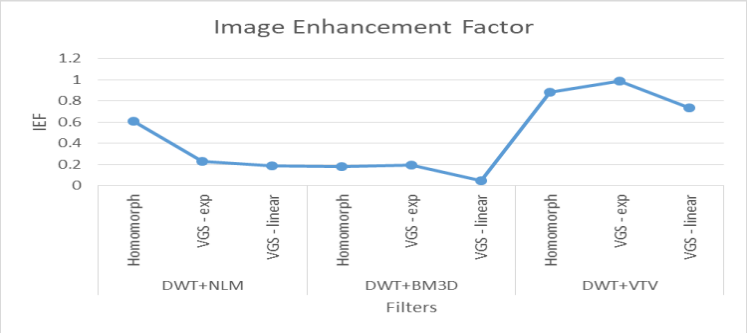


Fig 8.i. IEF Comparison

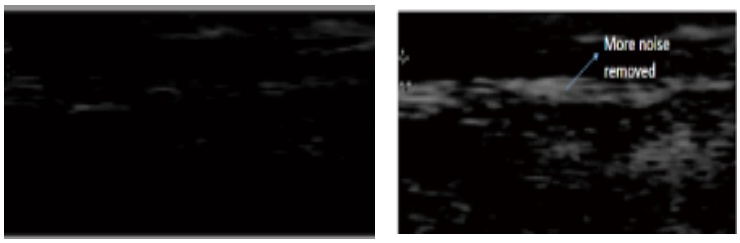


Fig. 9. Residual Analysis: (a)With Homomorphic filtering; (b)With proposed Variable Gradient Summation method

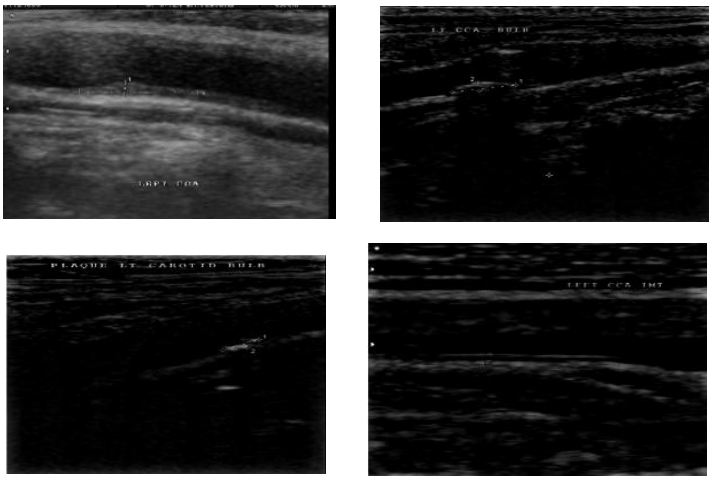


Fig. 10. Results of DWT + VTV applied with the proposed VGS approach for the sample images 5(b-e)

The image undergoes some initial level preprocessing and soft thresholding by automatic threshold selection. The higher order coefficients of the wavelet decomposed image are

ISBN : 978-93-87793-95-8

quantized and edge preserving genetic algorithm refines the parameter optimized threshold value based on the image of interest. Fig.6 a-d gives the sample carotid artery ultrasound images used subjected to homomorphic filtering and variable gradient summation method considering linear and exponential speckle. Results for the first image are shown.

Fig.7 a-c shows the processed image with LNM and wavelet decomposition with the proposed method for the different speckles. Fig.8 a-i plots the performance evaluation metrics comparison for the various applied filters. From the plots, it can be inferred than MSE, RMSE and MAE, the error components gives better results for the proposed methodology of speckle conversion but without wavelet decomposition. PSNR and quality index approaches higher values for applying VTV on wavelet decomposed image and the approaches NLM, BM3D, VTV without wavelet decomposition. SNR is high for VTV with and without wavelet decomposition.

Table 3

Denoising Performance for different filters for five image samples

ISBN : 978-93-87793-95-8

Image	Filter	Method	MSE	PSNR	SNR	RMSE	MAE	MSSIM	IMGQ	corr	IEF
Image 1	DWT+NLM	Homomorph	149.44	3.76	15.49	165.44	160.37	0.1802	0.153	0.435	0.654
		VGS - exp	121.59	4.65	14.49	149.24	142.87	0.1925	0.194	0.476	0.103
		VGS - linear	151.84	3.69	16.52	166.77	161.22	0.2003	0.199	0.337	0.108
	DWT+BM3D	Homomorph	135.27	4.19	14.11	157.41	151.7	0.2108	0.190	0.554	0.163
		VGS - exp	117.69	4.79	13.76	146.82	140.38	0.2055	0.203	**0.572**	0.115
		VGS - linear	119.22	4.74	14.17	147.77	139.27	0.2415	0.242	0.373	0.09
	DWT+VTV	Homomorph	53.668	13.86	21.77	51.70	41.87	**0.556**	0.553	0.032	1.07
		VGS - exp	**42.44**	**14.88**	**22.54**	**45.97**	**37.59**	0.506	**0.577**	0.019	**0.909**
		VGS - linear	45.473	14.58	21.44	47.58	38.8	0.515	0.514	0.028	0.69
Image 2	DWT+NLM	Homomorph	147.40	2.16	12.18	168.55	165.20	0.0991	0.123	0.421	0.635
		VGS - exp	110.72	5.38	15.00	132.21	145.11	0.1925	0.187	0.437	0.211
		VGS - linear	121.42	2.19	16.12	170.01	160.08	0.2234	0.200	0.356	0.111
	DWT+BM3D	Homomorph	162.30	5.76	12.11	151.22	149.76	0.2421	0.170	0.512	0.123
		VGS - exp	109.35	6.12	13.55	145.12	138.22	0.2111	0.205	**0.594**	0.185
		VGS - linear	118.78	4.22	14.77	146.39	136.14	0.2209	0.237	0.384	0.081
	DWT+VTV	Homomorph	55.77	12.80	**23.42**	55.78	49.56	**0.6121**	0.493	0.042	0.879
		VGS - exp	**41.23**	14.56	21.11	**44.32**	**36.25**	0.5423	**0.621**	0.021	**0.999**
		VGS - linear	44.21	**14.78**	22.54	43.18	37.50	0.5224	0.516	0.020	0.701
Image 3	DWT+NLM	Homomorph	152.12	2.88	14.21	170.22	165.78	0.1812	0.161	0.444	0.611
		VGS - exp	120.19	5.12	15.98	151.89	137.26	0.1922	0.181	0.479	0.121
		VGS - linear	154.28	4.87	16.32	164.13	159.87	0.2343	0.211	0.389	0.132

ISBN : 978-93-87793-95-8

	DWT+BM3D	Homomorph	138.11	4.90	13.12	160.11	149.90	0.2231	0.186	0.512	0.101
		VGS - exp	110.12	5.16	14.11	144.92	138.92	0.2121	0.221	**0.600**	0.123
		VGS - linear	118.48	5.87	14.99	145.18	139.11	0.2431	0.231	0.388	0.081
	DWT+VTV	Homomorph	55.38	12.11	20.28	58.23	45.78	**0.6121**	0.555	0.031	0.912
		VGS - exp	**41.55**	**15.18**	**24.54**	**44.12**	**37.00**	0.5232	0.612	0.012	**0.981**
		VGS - linear	44.89	14.56	21.17	46.11	38.10	0.5111	**0.678**	0.002	0.752
Image 4	DWT+NLM	Homomorph	146.12	3.77	15.66	164.32	157.85	0.1888	0.151	0.488	0.11
		VGS - exp	120.34	5.12	14.77	148.57	148.01	0.1956	0.198	0.411	0.561
		VGS - linear	150.87	3.89	17.42	165.11	160.87	0.2223	0.189	0.354	0.411
	DWT+BM3D	Homomorph	137.12	4.99	14.90	155.12	150.12	0.2018	0.191	0.512	0.111
		VGS - exp	114.21	5.43	16.67	140.87	147.89	0.2231	0.211	**0.589**	0.132
		VGS - linear	118.74	5.11	15.12	146.23	140.78	0.2512	0.237	0.311	0.078
	DWT+VTV	Homomorph	55.11	13.88	22.00	50.87	40.87	**0.6321**	0.541	0.012	0.061
		VGS - exp	**40.76**	**15.23**	**22.66**	**44.23**	**36.78**	0.5413	**0.581**	0.018	**0.989**
		VGS - linear	44.23	14.77	21.48	46.91	38.41	0.521	0.511	0.011	0.701
Image 5	DWT+NLM	Homomorph	149.44	3.77	15.61	164.87	161.51	0.1812	0.154	0.540	0.611
		VGS - exp	127.88	4.11	14.54	147.22	144.32	0.1977	0.187	0.411	0.111
		VGS - linear	148.99	3.76	16.01	162.17	160.89	0.2123	0.187	0.300	0.121
	DWT+BM3D	Homomorph	131.23	5.56	14.67	150.12	150.72	0.2111	0.198	0.501	0.181
		VGS - exp	115.11	5.12	13.57	137.89	141.23	0.2123	0.223	**0.600**	0.111
		VGS - linear	110.11	4.99	14.23	140.07	138.76	0.2511	0.277	0.311	0.078
	DWT+VTV	Homomorp	55.67	13.66	21.11	58.92	40.87	0.5651	0.578	0.011	0.900

ISBN : 978-93-87793-95-8

		h									
		VGS - exp	**41.00**	14.92	**23.54**	**44.87**	**36.52**	**0.6121**	**0.612**	0.016	**0.989**
		VGS - linear	44.23	**14.99**	21.44	46.99	38.88	0.5231	0.587	0.030	0.789
Image 6	DWT+NLM	Homomorph	148.77	3.88	15.88	165.29	162.33	0.1889	0.152	0.429	0.655
		VGS - exp	126.99	4.24	13.34	145.89	141.89	0.1999	0.177	0.411	0.123
		VGS - linear	147.12	3.12	16.19	160.98	158.91	0.2122	0.198	0.390	0.129
	DWT+BM3D	Homomorph	135.23	4.92	14.87	151.78	151.23	0.2111	0.167	0.571	0.178
		VGS - exp	111.89	5.89	13.97	146.03	137.99	0.2123	0.289	**0.611**	0.190
		VGS - linear	116.67	5.97	15.67	141.11	137.66	0.2441	0.222	0.322	0.088
	DWT+VTV	Homomorph	53.28	11.77	20.65	58.77	44.23	**0.6188**	0.501	0.011	0.905
		VGS - exp	**42.01**	**16.87**	**24.88**	**44.88**	**37.98**	0.5222	0.687	0.017	**0.990**
		VGS - linear	43.89	14.67	21.20	45.78	38.23	0.5290	**0.698**	0.006	0.755
Image 7	DWT+NLM	Homomorph	138.99	3.22	12.98	164.42	161.11	0.0989	0.187	0.482	0.633
		VGS - exp	108.21	5.89	15.28	131.88	145.23	0.1922	0.129	0.433	0.222
		VGS - linear	120.77	2.99	15.98	167.77	162.35	0.2222	0.219	0.355	0.122
	DWT+BM3D	Homomorph	158.89	5.77	12.91	150.91	147.67	0.2489	0.187	0.510	0.128
		VGS - exp	100.19	5.99	13.33	146.23	136.91	0.2129	0.239	**0.598**	0.188
		VGS - linear	117.89	4.18	14.87	146.90	134.56	0.2299	0.233	0.388	0.087
	DWT+VTV	Homomorph	54.87	12.89	**24.94**	53.47	49.55	**0.6187**	0.499	0.041	0.888
		VGS - exp	**40.89**	14.2	21.78	**44.31**	**35.09**	0.5321	**0.622**	0.027	**0.996**
		VGS - linear	44.19	**14.99**	22.01	43.11	37.89	0.5219	0.519	0.029	0.721
Image 8	DWT+NLM	Homomorph	145.55	3.89	15.22	164.32	145.55	0.1787	0.151	0.412	0.89

ISBN : 978-93-87793-95-8

		VGS - exp	122.29	5.89	14.89	138.91	143.33	0.1990	0.200	0.444	0.511
		VGS - linear	151.89	3.27	18.11	164.44	158.88	0.2212	0.199	0.333	0.401
	DWT+BM3D	Homomorph	135.21	4.10	14.87	152.22	154.44	0.2111	0.194	0.500	0.121
		VGS - exp	112.22	5.76	16.62	142.22	147.89	0.2222	0.234	**0.588**	0.187
		VGS - linear	115.45	5.11	15.21	145.59	141.11	0.3434	0.222	0.322	0.077
	DWT+VTV	Homomorph	57.89	13.88	22.18	50.88	44.54	**0.6339**	0.501	0.011	0.066
		VGS - exp	**41.45**	**16.02**	**23.89**	**44.10**	**36.01**	0.5431	**0.511**	0.019	**0.982**
		VGS - linear	44.28	14.26	21.44	46.99	38.44	0.5123	0.500	0.021	0.712
Image 9	DWT+NLM	Homomorph	146.66	3.59	14.22	165.56	158.89	0.1888	0.162	0.421	0.629
		VGS - exp	122.25	5.87	16.11	150.87	132.34	0.1911	0.182	0.480	0.185
		VGS - linear	153.34	4.88	16.39	162.22	158.67	0.2349	0.223	0.333	0.139
	DWT+BM3D	Homomorph	140.40	4.99	13.11	160.01	149.00	0.2123	0.189	0.511	0.119
		VGS - exp	111.11	6.18	15.67	144.99	138.09	0.2122	0.229	**0.619**	0.189
		VGS - linear	108.89	6.88	14.00	130.01	136.65	0.2433	0.289	0.333	0.089
	DWT+VTV	Homomorph	56.69	12.55	22.34	55.52	45.77	**0.6122**	0.542	0.033	0.901
		VGS - exp	**41.52**	**15.29**	**24.58**	**44.44**	**37.90**	0.5233	0.689	0.011	**0.988**
		VGS - linear	44.88	14.51	21.09	46.61	38.89	0.5223	**0.698**	0.009	0.759
Image 10	DWT+NLM	Homomorph	145.56	2.19	12.11	164.44	162.22	0.0978	0.145	0.428	0.622
		VGS - exp	111.11	5.33	15.12	130.09	141.11	0.1911	0.345	0.441	0.256
		VGS - linear	120.80	2.88	16.18	154.54	158.89	0.2267	0.222	0.333	0.123
	DWT+BM3D	Homomorph	160.00	5.66	12.04	150.09	147.71	0.2446	0.178	0.555	0.145
		VGS - exp	100.09	6.39	13.87	144.12	138.29	0.2178	0.254	**0.589**	0.188

		VGS - linear	114.45	4.28	14.77	146.39	136.11	0.2210	0.233	0.333	0.086
	DWT+VTV	Homomorph	55.89	12.81	**23.44**	55.99	46.66	**0.6133**	0.499	0.054	0.877
		VGS - exp	**41.22**	14.21	21.89	**44.89**	**36.21**	0.5445	**0.634**	0.022	**0.989**
		VGS - linear	46.67	**14.89**	22.55	43.88	37.51	0.5278	0.545	0.021	0.711
Average	DWT+NLM	Homomorph	140.01	3.27	13.01	162.28	156.62	0.0989	0.181	0.441	0.611
		VGS - exp	101.12	6.78	15.19	130.06	142.28	0.1911	0.121	0.411	0.232
		VGS - linear	118.89	3.45	14.59	166.66	161.11	0.2982	0.229	0.378	0.188
	DWT+BM3D	Homomorph	151.12	5.54	12.91	151.87	142.29	0.2521	0.178	0.511	0.178
		VGS - exp	103.34	5.11	12.88	141.21	135.00	0.2111	0.226	**0.600**	0.194
		VGS - linear	114.45	4.89	14.81	143.31	134.56	0.2228	0.238	0.391	0.045
	DWT+VTV	Homomorph	52.38	11.18	**25.01**	52.26	48.87	**0.6128**	0.500	0.042	0.880
		VGS - exp	**39.91**	14.34	21.72	**41.18**	**35.01**	0.5229	**0.628**	0.030	**0.989**
		VGS - linear	41.28	**14.89**	22.45	42.28	37.92	0.5222	0.527	0.026	0.731

The structural similarity index is very poor for homomorphic filter than the proposed approach for all the filters, especially for NLM, the curve drops down heavily. The correlation between the original and the filtered image hold better for NLM with homomorph and the proposed method performs better for the filters applied on wavelet decomposed images. The Image Enhancement Factor is the best for the proposed method of speckle conversion from multiplicative to additive with NLM and BM3D without decomposition.

From these plots, it is well understood that the proposed variable gradient summation cystolithic approach gives a good competition with the traditional homomorphic filtering and is better in terms of most of the performance evaluation metrics. Fig.8 a and b shows the residual analysis for the homomorphic filtering and the proposed VGS approach.

Residuals are the removed noise content from the noisy image. The residue of the VGS approach is more than the homomorphic filtering, indicating more amount of noise is removed by VGS. Fig.9 gives the results of the proposed VGS with DWT and VTV approach for the second to fifth sample images shown in Fig.5. Table 3 gives the performance comparison result

ISBN : 978-93-87793-95-8

of five different carotid artery images (Fig 5 a-e) with the traditional homomorphic approach and the proposed VGS approach.

Simulation is performed with NLM, BM3D and VTV denoising methods applied on Discrete Wavelet Transformed image. From Table 3, it can be inferred that the proposed Variable Gradient Summation applied on the patch based VTV with DWT gives best result in terms of MSE, PSNR, SNR, RMSE, MAE, IMGQ and IEF. Feature enhanced speckle reduction tried with homomorphic filtering gave best noise degradation in terms of margin sharpness, artificiality, contrast and conspicuity [16]. The same approach tried with the proposed multiplicative speckle conversion technique gave similar results.

CONCLUSION

Multiplicative speckle noise is the major issue of ultrasound images. The transform domain pre-processing and further machine level algorithms like segmentation and classification need the image to be an additive component. On converting the multiplicative speckle into additive, and denoising, the fine details and edges in the image need to be preserved.

In this paper, we have developed a framework to convert the multiplicative speckle noise into additive using a Variable Gradient Summation process, which gives better performance and is a good competitor to the traditional homomorphic approach, which does the conversion by applying logarithm transformation. Mathematical modelling and numerical analysis of both the methods are explained and it proves that the proposed VGS approach is more flexible and can be practically implemented easily similar to the traditional approaches. Homomorphic filtering and VGS approach are applied with some of the available good denoising filters with and without wavelet decomposition.

The methods are simulated for carotid artery B mode ultrasound images from a local scan center. The outcomes indicate that the proposed approach is very near in performance to the traditional approach and it even preserves more fine details. Hence the proposed VGS method can be used an alternative to the traditional homomorphic method of multiplicative speckle conversion and can be used extensively in ultrasound and SAR images which has predominant speckle content.

Further work will be devoted to applying our framework to denoising methods that treat three dimensional images. In the future, we would consider to make the model work for an image whose noise model is unknown. Our objective is to simulate an improvised methodology to fully automatically classify and identify the extent of plaque formation in the carotid artery.

ISBN : 978-93-87793-95-8

ACKNOWLEDGEMENTS

"The authors thankfully acknowledges the financial support provided by The Institution of Engineers (India) for carrying out Research & Development work in this subject".

REFERENCES

[1] Karen Panetta, Long Bao and SosAgaian, Sequence-to-Sequence Similarity-Based Filter for Image Denoising. IEEE Sensors Journal 2016, 16(11): 4380—4388.

[2] Q. H. Chang and T. Yang, A lattice Boltzmann method for image denoising. IEEE Transactions on Image Processing 2009, 18(12), 2797–2802.

[3] MehravarRafati, MasoudArabfard, MehrdadRafati Rahim Zadeh and MazaherMaghsoudloo, Assessment of noise reduction in ultrasound images of common carotid and brachial arteries. IET Computer Vision 2016, 10, 1--8.

[4] S. Osher and C. W. Shu, High-order essentially nonoscillatory schemes for Hamilton-Jacobi equations. SIAM Journal on Numerical Analysis, 1991, 28(4), 907–922.

[5] De-An Huang, Li-Wei Kang, Yu-Chiang Frank Wang and Chia-Wen Lin, Self-Learning Based Image Decomposition With Applications to Single Image Denoising. IEEE Transactions on Multimedia 2014, 16(1).

[6] B. Chen, Y. Li, and J.-L. Cai, Noisy image segmentation based on nonlinear diffusion equation model. Applied Mathematical Modelling 2012, 36(3), 1197–1208.

[7] Gabriela Ghimpe¸teanu, Thomas Batard, Marcelo Bertalmío, and Stacey Levine. A Decomposition Framework for Image Denoising Algorithms. IEEE Transactions on Image Processing 2016, 25(1).

[8] S. Hu, Z. Liao, D. Sun, and W. Chen, A numerical method for preserving curve edges in nonlinear anisotropic smoothing. Mathematical Problems in Engineering, 2011.

[9] S. D. Babacan, R. Molina, and A. Katsaggelos, Variationalbayesian blind deconvolution using a total variation prior. IEEE Transactions on Image Processing, 2009, 18, (1), 12–26.

[10] HosseinTalebi and PeymanMilanfar, Global Image Denoising. IEEE Transactions on Image Processing, 2014, 23(2).

[11] Si Wang, Ting-Zhu Huang, Xi-Le Zhao, Jin-Jin Mei and Jie Huang, Speckle noise removal in ultrasound images by first- and second-order total variation. NumerAlgor, 2017.

[12] Hacini, M, Hachouf, F. and Djemal, K, A new speckle filtering method for ultrasound images based on a weighted multiplicative total variation. Signal Process, 2014, 103, 214–229.

[13] DeepikaKoundal, Savita Gupta, Sukhwinder Singh, Nakagami-based total variation method for speckle reduction in thyroid ultrasound images. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 2015, 230:2, 97-110.

[14] Huang, J, Yang, X, Fast reduction of speckle noise in real ultrasound images. Signal Process. 2013, 93, 684–694.

[15] Li, F, Ng, M.K. Shen, C., Multiplicative noise removal with spatially varying regularization parameters. SIAM J. Imaging Sci., 2010, 3, 1–20.

[16] AimiliaGastounioti, Stavros Makrodimitris, SpyrettaGolemati, Nikolaos P. E. Kadoglou, Christos D. Liapis and Konstantina S. Nikita, A Novel Computerized Tool to Stratify Risk in Carotid Atherosclerosis Using Kinematic Features of the Arterial Wall. IEEE Journal of Biomedical and Health Informatics, 2015, 19(3).

[17] Filippo Molinari, Guang Zeng, and Jasjit S. Suri, Intima-Media Thickness: Setting a Standard for a Completely Automated Method of Ultrasound Measurement. IEEE Transactions on Ultrasonics 2010, Ferroelectrics, and Frequency Control, 57(5).

[18] StylianiPetroudi, Christos Loizou, MariosPantziaris, and ConstantinosPattichis, Segmentation of the Common Carotid Intima-Media Complex in Ultrasound Images Using Active Contours. IEEE Transactions on Biomedical Engineering 2012, 59(11).

[19] Gonzalo Vegas-Sanchez-Ferrero, Jose Seabra, Oriol Rodriguez-Leor, Angel Serrano-Vida, Santiago Aja-Fernandez, Cesar Palencia, Marcos Martin-Fernandez, and Joao Sanches, Gamma Mixture Classifier for Plaque Detection in Intravascular Ultrasonic Images. IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control 2014, 61(1).

[20] C.P. Loizou, M. Pantziaris, M.S. Pattichis, E. Kyriacou and C.S. Pattichis, Ultrasound image texture analysis of the intima and media layers of the common carotid artery and its correlation with age and gender. Computerized Medical Imaging and Graphics 2009, 33, pp. 317—324.

[21] ZhifanGao, Yanjie Li, Yuanyuan Sun, Jiayuan Yang, HuahuaXiong, Heye Zhang, Xin Liu, Wanqing Wu, Dong Liang, Shuo Li, Motion Tracking of the Carotid Artery Wall From Ultrasound Image Sequences: a Nonlinear State-Space Approach. IEEE Transactions on Medical Imaging, 2018, 37(1), pp.273-283.

[22] ZhifanGao, HuahuaXiong,Xin Liu, Heye Zhang, DhanjooGhista, Wanqing Wu, Shuo Li, Robust estimation of carotid artery wall motion using the elasticity-based state-space approach. Medical Image Analysis, 2017, Volume 37, pp 1-21.

[23] Jinbum Kang, Jae Young Lee and YangmoYoo, A New Feature-Enhanced Speckle Reduction Method Based on Multiscale Analysis for Ultrasound B-Mode Imaging. IEEE Transactions on Biomedical Engineering 2016, 63(6).

[24] Radovan Jirik, Member, and TorfinnTaxt, High-Resolution Ultrasonic Imaging Using Fast Two-Dimensional Homomorphic Filtering. IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency control 2006, 53(8).

[25] J. M. Bioucas-Dias and M. A. T. Figueiredo, Multiplicative noise removal using variable splitting and constrained optimization. IEEE Transactions on Image Processing 2010. 19(7), 1720–1730.

[26] T. Rajalakshmi and Shanthi Prince, Retinal model-based visual perception. Applied for medical image processing. Biologically Inspired Cognitive Architectures, 2016.

ISBN : 978-93-87793-95-8

[27] C.Vimalraj, S.Esakkirajan, Thangaraj Veer kumar, P. Sreevidya, Direction sensitive wavelet packet for despeckling of ultrasound images. IET Computer Vision, 2016, 10(7).

[28] Yi Zhan, Mingyue Ding, Liangxia Wu and Xuming Zhang, Nonlocal means method using weight refining for despeckling of ultrasound images. Elsevier, Signal Processing 2014, 103, 201—213.

[29] NargesAfsham,AbtinRasoulian,MohammadNajafi,PurangAbolmaesumi,and Robert Rohling, Nonlocal Means Filter-Based Speckle Tracking. IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control 2015, 62(8).

[30] Igor Djurovic, BM3D filter in salt-and-pepper noise removal, EURASIP Journal on Image and Video Processing, 2016.

[31] Aram Danielyan, Vladimir Katkovnik, and Karen Egiazarian, BM3D Frames and Variational Image Deblurring. IEEE Transactions on Image Processing 2012, 21(4).

[32] Huiyan Liu, Fengxia Yan, Jubo Zhu, Faming Fang, Adaptive vectorial total variation models for multi-channel synthetic aperture radar images despeckling with fast algorithms. IET Image Process 2013, 7(9), 795–804.

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Classification of Carotid Artery Ultrasound Image using Random Forest Algorithm

S.Latha, S.Dhanalakshmi, R.Kumar

ECE Department, SRM Institute of Science and Technology, Kattankulathur- 603203

Abstract — This paper presents a novel technique to detect the existence of plaque in the carotid artery. Carotid artery is responsible for carrying blood to the brain, neck and face. The common carotid artery (CCA) branches into two parts, internal and external. Due to buildup of fatty deposits, a plaque is formed in the lumen of the artery which becomes calcified and causes an obstruction in the blood flow. This can lead to strokes. The thickness between the Intima and Media and identify plaque deposit is studied from Ultrasound images. The images are studied and various features are used to classify them using a random forest algorithm. The result of the project will yield information about the presence of plaque and whether the diagnosed person is suffering from carotid artery disease or not.

Keywords—*carotid stenosis, classification, random forest*

I. Introduction

A. Carotid Artery Disease

The carotid artery is a big blood vessels carrying pure blood to the face and the front of the brain. It is vulnerable to plaque inflammation, atherosclerosis. These plaques are made up of Lipid-Rich Necrotic Core (LRNC), bounded by exhausted even muscular cells and squeaky fibrous cap. Decreasing this is a definite indicator of threat for intrinsic or approaching neurological ischemic irregularities. Because of artery wall stress, emboli or thrombus could tear from plaque and enter the blood flow to the brain. The thrombus becomes attached to the vessel wall as the vessel becomes narrower and causes carotid artery stenosis. Carotid artery stenosis formation either reduces or limits blood flow to the brain, resulting in Transient Ischemic Attacks (TIAs). These are symbols of warning, often trailed by thromboembolic stroke. This condition may further increase leading to deterioration of brain function or death. Carotid stenosis is categorized as asymptomatic and symptomatic due to atherosclerosis. To select appropriate treatment, it is important to accurately identify and classify symptomatic and asymptomatic carotid stenosis.

B. Random Forest Algorithm

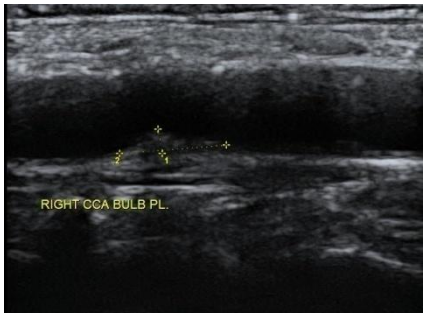
Medical diagnostic classification can help in the diagnosis of disease and predict results for the treatment. There have been many efforts to elevate the efficiency of the classification. We chose Voting Method, wherein the classifiers are integrated, to identify a better way to form the model. Major polling, based on random forest (RF) algorithm, is the most used method.

ISBN : 978-93-87793-95-8

Random forest classifiers can achieve better accuracy with respect to several classification approaches in data classification and minimalize the global classification error rate.

II. Ultrasound Carotid Artery Imaging

To detect thinning of the carotid arteries due to fat deposit, diagnostic examinations can be done by the doctor. Imaging can also disclose indication of several minor strokes. If there is less blood flow in the artery, it can be considered as carotid stenosis. Ultrasound is a non-invasive technique that assesses blood flow in the vessel using reflected sound waves. The ultrasound probe over the carotid arteries is placed on the neck. This test tells how much blood flows over the artery and how narrowed it is (i.e., 100 %, 80 %, 70 %, etc.).The images showing plaque are considered to be abnormal (Fig.1). Additionally, images showing intima-media thickness of more than 0.1cm are considered abnormal (Fig.2).



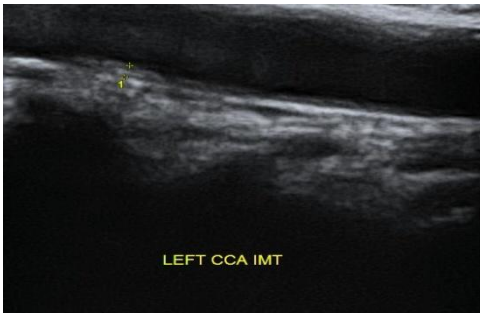


Fig 1. US Image showing plaque of diameter 0.95cm Fig 2. US Image showing IMT of 0.12cm

III. Feature Extraction

After an image has been segmented into regions of interest, it is very important to represent the image and to describe the image in a form suitable for further image processing. It is possible to represent a region in two ways. (1) With regard to its external features and (2) with regard to its internal features. It makes the data useful to choose a proper representation scheme.

Statistical texture analysis techniques use higher order moments of grayscale histogram to describe the texture of regions in an image. The most commonly used method for texture analysis is to excerpt different textural characteristics from a co-occurrence matrix of gray level (GLCM). The GLCM method is based on using gray image histogram second-order statistics.

The histogram - based characteristics used in this work are statistics of first order which include mean, variance, skewedness and kurtosis.

Calculated texture measurements using histograms suffer from the limitation that they do not carry any data about the relative position of pixels in relation to each other. Therefore, co-occurrence matrix based features are used to calculate contrast, energy and entropy.

IV. Classification

Random Forest algorithm is an algorithm that is used commonly in classification and regression. The key benefits of random forest is its capability to measure feature importance, this allows us to evaluate which feature is the most important in the database and provides it more weight so that it can be used as the root node while simulating the model using trees.

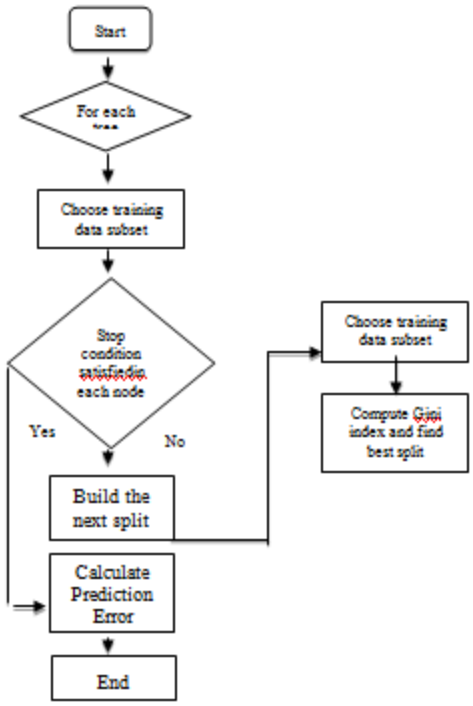


Fig 3. Random Forest Algorithm

The following algorithm is used to build each tree (Fig.3):

1. Training dataset is chosen for every tree.
2. One node is taken into consideration.
3. Gini impurity is calculated for all the features and the feature with the lowest Gini Impurity is considered.
4. The process of building a node proceeds till it reaches a point where the node cannot be split further.
5. This process goes on till all the datasets have constructed a decision tree.
6. Prediction error is calculated using the cumulative result obtained from all the trees.

ISBN : 978-93-87793-95-8

A new sample is sent to the tree for prediction. The training sample tag is assigned in the end node in which it ends up. This technique is reiterated throughout the ensemble's trees and the mean of all trees is testified as the prediction of random forest.

The Random Forest algorithm makes a bootstrapped dataset from the existing dataset and starts constructing nodes in the tree using the Gini impurity criterion. The tree formed is terminated when there are no divisions possible and has concluded with the final result being normal or abnormal. This is repeated with different combinations of bootstrapped datasets and trees are formed for each case. The result for each tree is then combined to make a confusion matrix.

Results and Conclusion

A. Experimental Results

The graph between balanced error rate and number of trees was obtained (Fig. 4). This graph depicts the optimum number of trees that the forest should build to obtain the least balanced error rate. For this specific case, that number was found to be 437.

A confusion matrix, is a tabular description that helps to study and analyse the performance of the algorithm. It gives us a detailed summary of how much data in the algorithm has been correctly classified normal and abnormal. The confusion matrix obtained for the model is shown below (Fig. 5).

The focus class is set as 'abnormal'. The true positives are 38, true negatives are 44, false positives are 4 and false negatives are 8. The accuracy is 86.96% and precision is 90.00%.

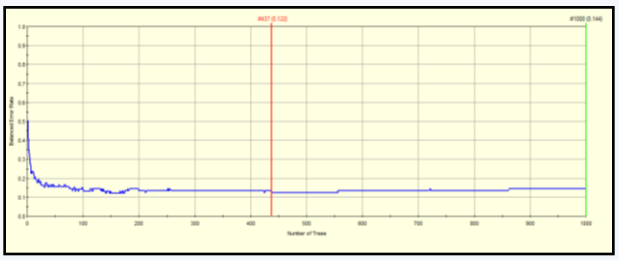


Fig 4. Graph between BER and number of trees

Actual Class	Total Class	Percent Correct	Predicted Classes: abnormal N = 40	Predicted Classes: normal N = 52
abnormal	44	81.82%	36	8
normal	48	91.67%	4	44
Total:	92			
Average:		86.74%		
Overall % Correct:		86.96%		
Specificity		91.67%		
Sensitivity/Recall		81.82%		
Precision		90.00%		
F1 statistic		85.71%		

Fig 5. Confusion Matrix

ISBN : 978-93-87793-95-8

B. **Conclusion**

The count of trees grown in the forest stops affecting the result after a certain point. The confusion matrix changes if the variable importance is changed. The values obtained from the confusion matrix depend on the focus class. The accuracy depends on the variable importance. The algorithm could successfully classify 90.00% of the data correctly.

References

[1] Executive Committee for the Asymptomatic Carotid Atherosclerosis Study, "Endarterectomy for Asymptomatic Carotid Artery Stenosis", the Journal of the American Medical Association, vol. 273. pp. 1421-1428, 1995.

[2] Rothwell PM, Eliasziw M, Gutnikov SA, Warlow CP, Barnett HJ, "Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis", North American SymptomaticCarotidEndarterectomyTrialCollaborators,TheNewEnglandJournalofMedicine, vol. 339, no.20, pp. 1415-1425, 1998.

[3] Hobson RW 2nd, et al., "Society for Vascular Surgery. Management of atherosclerotic carotid artery disease: clinical practice guidelines of the Society for Vascular Surgery", The Journal of Vascular Surgery, vol. 48, no.2, pp. 480-486, 2008.

[4] Faust Oliver, Acharya U Rajendra, SudarshanVidya K, San Ru, Hong Chai, Molinari Filippo, Hoong Kwan., "PhysicaMedica Computer aided diagnosis of Coronary Artery Disease, Myocardial Infarction and carotid atherosclerosis using ultrasound images: A review", Phys. Medica, vol. 33, pp. 1-15, 2017.

[5] Zhu M I N, Xia Jing, Jin Xiaoqing, Yan Molei, CaiGuolong, Yan Jing, NingGangmin, "Class Weights Random Forest Algorithm for Processing Class Imbalanced Medical Data," IEEE Access, vol. 6, pp. 4641-4652, 2018.

[6] A. Paul, D. P. Mukherjee, S. Member, and P. Das, "Improved Random Forest for Classification," IEEE Transactions on Image Processing, vol. 27, no. 8, pp. 4012-4024, 2018.

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Real time Wireless ECG signal based heart Disease prediction system using HVD and Artificial Intelligence

[1]Dr.C.G.Ravichandran [2]P.T. Kalaivaani [3]Raja Krishnamoorthy, [4]Pogu vignan,

[1] Professor and Principal, Department of ECE, Vivekanandha College of Technology for Women, Tiruchengode, Namakkal – 637205, Tamilnadu, India, cg_ravi@yahoo.com.

[2]Associate Professor, Department of ECE, Vivekanandha College of Technology for Women, Tiruchengode, Namakkal – 637205, Tamilnadu, India, ptkalaivaani@gmail.com.

[3]Professor, Department of ECE, CMR Engineering College, KandlakoyaVillaga, Hyderabad, Telangana-501401, India, krajameae@gmail.com.

[4]B.tech Scholar,Electronics and communication Department,CMR Engineering College,KandlakoyaVillage,MedchalRoad,Hyderabad,Telangana 501401,India,vignanpogu@gmail.com.

Abstract

In this paper, ECG signal based heart prediction system using Hilbert Vibrating Decomposition (HVD) is proposed for continuous cardiac health monitoring applications. This proposed work consists of four blocks 1)ECG signal sensing from human body(tx module) 2) uploading ECG signal to matlab(rx module) 3) ECG signal analysis 4) SQI and disease identification. Wireless ECG system is built by using AD8232 module and HC-05, electrical activity is taken from it and transmit it wireless to the USB to TTL via HC-05 ,all the live signal is saved in the form of matfile. In ECG signal analysis, raw signal is filtered by using HVD and it find RR intervals and QRS complex. In SQI it will check whether signal is good or diagnosis based on RR interval and QRS complex. if the condition is diagnosis it goes for disease identification , if any disease is identified all the data in form matfile is sent as email to doctor. The main moto is to design electronic T-shirt for continuous cardiac health monitoring. This system has enough potential for assessing biomedical diagnosis system.The same system can be implemented using high level thinking using artificial intelligent.

Keywords – Electrocardiogram(ECG), Hilbert vibrating decomposition(HVD), Signal quality index(SQI), Universal serial bus(USB), Transistor transistor logic(TTL).

1. **Introduction:**

The detailed literature survey has been given below:

ISBN : 978-93-87793-95-8

Udeit et.al.,[1] porposed a novel signal quality aware Internet of Things (IoT) enabled electrocardiogram (ECG) telemetry system for continuous cardiac health monitoring application. BranislavVuksanovic and Mustafa Alhamdi [2] proposed a new ECG based

biometric system to detect arrhythmia by automatically classifying normal and two types of abnormal ECG signals. Keshavamurthy and Eshwarappa [3] proposed the survey of different techniques of denoising and an identification of person through ECG signal. The denoising signal processing techniques evaluated using mean square error and signal to noise ratio. Jian-Zhi Chen et.al.,[4] described an Electrocardiogram acquisition system comprised of ADS1291, MSP430 and CC2541. Patient can use it to acquire ECG signals effectively and simply. Tsair Kao et.al [5] proposed morphological method to retrieve ECG data on paper charts using optical scanner and computer. The results show that our method can erase the background noise and acquire the digital ECG signal from ECG paper charts correctly. Akanksha Agrawal and DhanashriH.Gawali [6] proposed different efficient methods of feature extraction based on the parameters such as sensitivity, predictivity and accuracy. The prominent methods presented in this paper are Pan-Tompkins, Hilbert transform, Histogram approach, Wavelet transform, Auto-regression(AR), Independent Component Analysis(ICA), Linear prediction(LP), Adaptive threshold. Yiming Miao et al.,[7] proposed Linear Discriminant Analysis (LDA) based on Multiple Features (LOMF) algorithm based on ECG mixed feature to solve time-overhead problem of big data training. LOMF includes ECG signal preprocessing, sub-block division, and block training. Jihong Chai [8] proposed convenient mobile ECG monitoring system solution as a solution to mobile ECG Monitoring. The monitoring terminal is designed by using MSP430 to achieve ECG signal acquisition, amplification and AID conversion. CC2540 integrating low power Bluetooth 4.0 BLE-Stack is also used. RupendraNathMitra et.al.,[9] proposed performance evaluation of the system developed for machine aided cardiac disease detection. AbdelkaderSellami et al.,[10] proposed a new method to analyze electrocardiogram (ECG) signal, extract the features, for the real time human identification using single lead human electrocardiogram.

This paper intends to implement a project which analyze ECG signal and detects whether any disease is identified or the condition of the person is normal.

- It is explained by 4 blocks which are:
  1) ECG signal sensing (TX module)
  2) Uploading ECG signal to Matlab (RX module)
  3) ECG signal analysis
  4) SQI and disease identification

ISBN : 978-93-87793-95-8

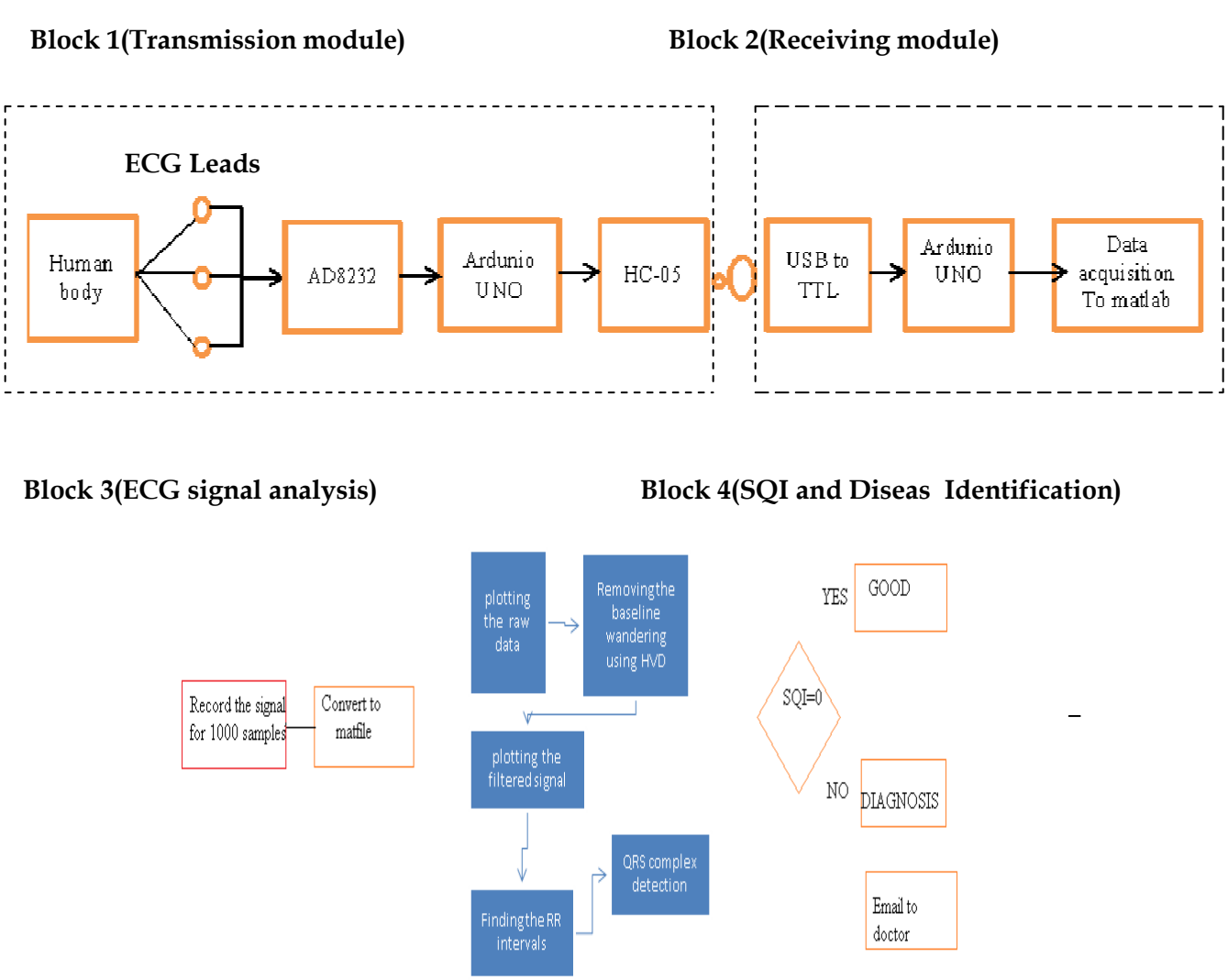


Fig 1 Block diagram of proposed method

This is the most pivotal part of the paper, where we analyze the ECG signal in the following steps.

Step 1: Plotting the raw data

Step 2: removing Baseline Wandering

Step 3: Signal Preprocessing (DWT)

Step 4: Peak Detection

ISBN : 978-93-87793-95-8

Step 5: RR Interval

Step 6: Heart Rate Variability

Step 7: QRS Complex Detection Using Artificial Intelligence

HVD correlated signal is matching with real time ECG signal and SNR is more in HVD compared to DWT in Table 1.

Table 1 Comparision of wavelet functions

Recorded ECG signal number in the data	Amplitude of the Baseline wandering	Correlation(γ)		SNR(dB)	
		Proposed method(HVD)	DWT	Proposed method (HVD)	DWT
100	200	0.976	0.886	21.09	20.73
	400	0.953	0.867	21.18	20.78
	600	0.904	0.871	21.41	20.12
	800	0.879	0.876	22.02	20.17
	1000	0.871	0.860	22.53	20.97
108	200	0.971	0.826	30.32	26.27
	400	0.951	0.812	29.37	26.06
	600	0.945	0.841	31.65	27.97
	800	0.936	0.854	27.87	26.08
	1000	0.906	0.827	28.01	26.88
121	200	0.965	0.787	34.98	30.21
	400	0.961	0.844	35.23	32.76
	600	0.954	0.761	33.21	30.20
	800	0.943	0.778	34.66	30.32
	1000	0.930	0.825	32.89	30.43

Results

Based on the BPM and QRS complex peak are required to identify condition of person .For that values we have added a sub function classifier to check the values of BPM and QRS duration .if the BPM is in between 60-100 and QRS duration is less than 0.1 sec .we can state that condition of person is NORMAL and its shown in fig 3

ISBN : 978-93-87793-95-8

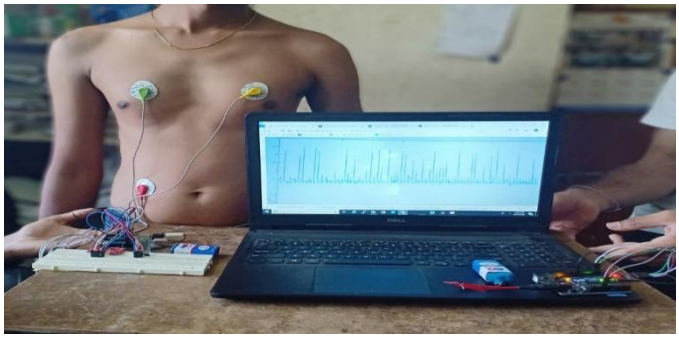


Fig 3 shows output of real time ECG signal based heart prediction system

Heart related diseases we identified which are listed below:

i. SINUSBRADYCARDIA

ii.SINUS TACHYCARDIA

iii.VENTRICULARTACHYCARDIAIDIO

iv.VENTRICULARRHYTHM

v.WOLF PARKINSON WHITESYNDROME

3.5 WOLF PARKINSON WHITE SYNDROME

Wolf Parkinson white syndrome is a heart rate disease if BPM is greater than 60 and and QRS complex is greater than 0.1 sec person may affected to Idio Ventricular Rhythm.

BPM >= 60 && BPM <= 100 && QRS > 0.1

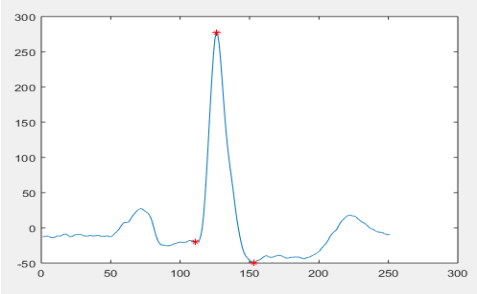


Fig 4 QRS complex peak when person is affected with WOLF PARKINSON WHITE SYNDROME

ISBN : 978-93-87793-95-8

For Wolf Parkinson white syndrome disease BPM must be in between 60-100 , which is shown in the fig 5 below.

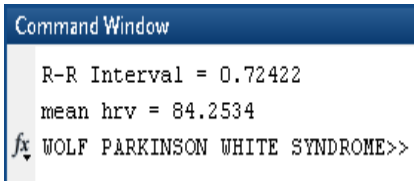


Fig 5 Result of WOLF PARKINSON WHITE SYNDROME

Conclusion and Future Work

Taking care about human life has been known heart disease is been important. ECG is the main method of diagnosis of heart disease. Purpose of the proposed work is that analysis of heart disease with real time ECG signal. This system is implemented by tiny hardware and MATLAB software and detecting the diseases based on RR intervals and QRS complex.The same system can be implemented using artificial intelligence to detect the abnormal conditions of patients and also to take necessary actions. It is light weight ,simple and low cost procedure for the diagnosis of various diseases which can be used in further study and education. This paper will reduce the workload of the doctors. It would be easier for doctor to verify later.

References

1. UditSatija, BarathramRamkumar and M. SabarimalaiManikandan (2017), 'Real-Time Signal Quality-Aware ECG Telemetry System for IoT-Based Health Care Monitoring', IEEE Internet of Things Journal, Vol. 4, no. 3, pp:815-823.
2. BranislavVuksanovic, Mustafa Alhamdi (2013), 'ECG Based System for Arrhythmia Detection and Patient Identification', In the Proceedings of the ITI 2013 35th Int. Conf. on Information Technology Interfaces, Cavtat, Croatia, doi:10.2498/iti.2013.0532
3. Keshavamurthy T G and Dr. M. N. Eshwarappa (2017), 'Review Paper on Denoising of ECG Signal', 2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT),**DOI:** 10.1109/ICECCT.2017.8117941.
4. Jian-Zhi Chen et.al., (2016), 'Design of ECG Signal Acquisition System Based on ADS1291',International Conference On Communication Problem-Solving (ICCP), **DOI:** 10.1109/ICCPS.2016.7751123
5. Tsair Kao et.al.,(2001), 'Computer Analysis of the Electrocardiograms from ECG Paper Recordings', Proceedings of the 23rd Annual EMBS International Conference, October 25-28
6. Akanksha Agrawal and DhanashriH.Gawali (2017),' Comparative Study of ECG Feature Extraction Methods', 2nd IEEE International

7. Conference On Recent Trends in Electronics Information & Communication Technology (RTEICT), May 19-20, 2017, India.
8. Yiming Miao et al.,(2017), 'Research and Implementation of ECG-Based Biological Recognition Parallelization', Special Section On Key Technologies For Smart Factory Of Industry 4.0, IEEE Access, Vol.6,PP:4759-4766.DoI:10.1109/ACCESS.2017.2771220.
9. Jihong Chai (2013),' The Design of Mobile EEG Monitoring System', IEEE 4th International Conference on Electronics Information and Emergency Communication, **DOI:** 10.1109/ICEIEC.2013.6835474
10. RupendraNathMitra et.al.,(2014), 'Pattern Classification of Time Plane Features of ECG Wave from Cell-Phone Photography for Machine Aided Cardiac Disease Diagnosis', 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, DOI:10.1109/EMBC.2014.6944699.
11. AbdelkaderSellamiet.al., (2017), 'ECG as a Biometric for Individual's Identification', The 5th International Conference on Electrical Engineering – Boumerdes (ICEE-B) October 29-31, Boumerdes, Algeria.

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Knowledge based Speech Recognition for Vehicle Safety using AI

C.Aarthi, Dr.C.Venkatesh

HoD/ECE Sengunthar Engineering College, Principal Sengunthar Engineering College

Abstract—

Speech recognition has become one of the widely used technologies, as it offers great opportunity to interact and communicate with automated machines. Specifically, the speech recognition facilitates its users and helps them to perform their daily routine tasks, in a more convenient and effective way.

The goal of automatic Speech recognition is to develop techniques and systems that enable computers to accept speech input. This paper intends to present the illustration of recent technological advancements, which are associated with artificial intelligence.

The different Statistical models were developed for decoding the speech. Some of the models are acoustic model (AM), language model (LM), lexicon model, and hidden Markov models (HMM). The research will help in understanding all of these models of speech recognition. The Various Speech Recognition techniques are considered for every model. These models are analyzed for accurate Speech recognition and it is applied as a Speech recognition tool for Vehicle Safety Mechanism. [1]

Representations of Speech Signals:

The Representations of Speech Signals includes the method of encoding the speech signals before it recognized. The Digital representations of Speech signals describe wave form based analysis which considers the measurements such as peak and energy, Zero crossing and auto correlations. [2] The parametric representation uses cepstral analysis for recognition. The compression can be achieved by Vector quantization.

Speech Recognition Techniques:

The Various techniques used in Speech Recognition are Acoustic Phonetic approach, Pattern Recognition approach, Artificial Intelligence approach. In this paper we have considered the AI based approach. AI approach is the hybrid of the Acoustic Phonetic approach, Pattern

ISBN : 978-93-87793-95-8

Recognition approach. This approach consists of Knowledge based and Connectionist approaches. [3]

Vehicle Safety:

The Safety of the Vehicle requires continual decision based upon Surveillance of highway and surroundings. The discrimination between hazardous and nonhazardous conditions and taking action like pattern recognition and speech recognition reveal a considerable success. However the inattentiveness, incapacitation and inadequate skill can lead to accidents. So an automatic system which is based on Speech recognition which is developed to avoid accidents. [4]
This System Considerably improves driver's safety and user friendliness of Man-Machine interfaces. The Quality of driving, Stress and Strain Situations have been considerably studied based on this system and the result shows that , with speech input, the feeling of being distracted from driving is smaller and the safety has been improved. Here the multimodal interface can be selected in the vehicle. When we select the "Speech input only" the interaction mode will be changed. The performance of Speech recognized interfaces is very reliable because of the Speaker independent recognition model. [5]

Knowledge based approach:

The Knowledge based design involves the direct and explicit incorporation of expert's speech knowledge in to a recognized system. This Knowledge is derived from careful study of spectrograms with rules and procedures. It is carefully designed around a specific acoustically difficult task that recognizes the speech accurately. [6]

References:

[1] Khaled M. Alhawiti,"Advances in Artificial Intelligence UsingSpeech Recognition"World Academy of Science, Engineering and Technology International Journal of Computer and Information Engineering Vol:9, No:6, 2015

[2] R.W.Schafer and L.R.Rabiner, "Digital Representations of Speech signals" Mourgan Kaufmann Publishers., 1990

[3] Mridudmita Sharma,Kandarpa kumar sarma, "Soft-Computational Techniques and Spectro-Temporal features for Telephonic speech Recognition: An overview and Review of Current State of the Art"Page-161 , A Volume in the Advances in Computational intelligence and Robotics (ACIR) book series, 2016

ISBN : 978-93-87793-95-8

[4] John B. Hopkins , "Anticipatory Sensors for Collision Avoidance and Crash Protection as applied to Vehicle Safety Research" , Vehicle Safety Resarch Symposium,Washington, 1973

[5] IosifMporos, TodorGanchev, OtiliaKocsis, Nikos Fakotakis,2009 "Performance Evaluation of a Speech Interface for Motorcycle Environment"Artificial Intelligence Applications and Innovations: IFIP International Federation of Information Processing, a Springer Series in Computer Science, Volume 296, pp.259-266

[6] V.W.Zue, "The Use of Speech Knoweldge in Automatic Speech Recognition" Mourgan Kaufmann Publishers., 1990

National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

BORE WELL TRAPPED PEOPLE RESCUE SYSTEM BY USING AI

[1]Dr.M.Selvakumar, [2] P.Jagadeeswaran,

[1] Associate Professor cum HoD, Department of Mechanical Engineering, .

Sengunthar Engineering College, Tiruchengode

[2] Assistant Professor, Department of Mechanical Engineering, Sengunthar Engineering College, Tiruchengode

ABSTRACT

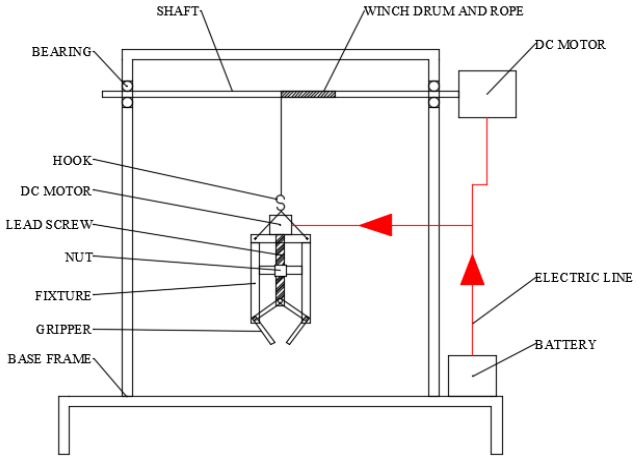
In the past few years, there have been several accidents of children falling into abandoned bore wells in India. Abandoned bore wells that have turned into death pits for children. The problem is all over India. Rescue teams spend hours and sometimes days in futile attempts to save these little kids. A lot of money is also spent in these missions. In most cases they are unable to save the kids. Such events have happened umpteen times in the past, and every time either the government or the bureaucracy is blamed. The rescue process to save the child from bore well is a long and complicated process now. The rescue team tries to approach the victim from a parallel well that take about 20 - 60 hours to dig. This complicated process makes 70% of the rescue operations fail. The design of handling system is made in such a way that the baby/victim never gets hurt and this rescue system is sent through the same well where the victim is felt inside to bring back the victim safe through an autonomous control of drives. Our design constitutes a best ergonomic design and performs safest rescue operation

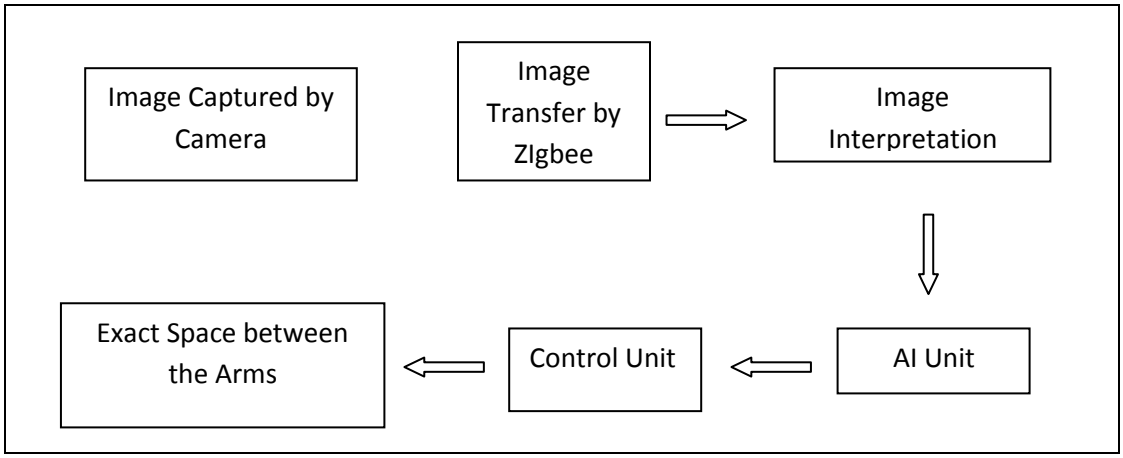
MAJOR COMPONENTS

1. Bearing
2. Shaft
3. D.C motor
4. Battery
5. Spur gear
6. Lead screw
7. Frame
8. Rope
9. Gripper
10. Zigbee
11. Camera

ISBN : 978-93-87793-95-8

WORKING PRINCIPLE





The rescue system arrangement is placed near the bore well where the victim is felt inside and it is verified that the gripper is properly inserted into the bore well without any distractions. Initially the DC motor for powering the winch drum is turned on to rotate counter clock wise, thus the rope wounded on the drum get released with respect to the rotation experienced on the drum. The victim image captured by camera .The image was transformed by using Zigbee to the System. By using interpretation techniques width of the victim image captured. The AI techniques used to calculate and control the exact space between the arms.

The extension of rope causes the gripper which is tied with it to travel inside the bore well due to the gravitational force, thus the gripper arrangement reaches victim. At that position the winch drum motor gets turned off and the motor to power the gripper is turned on to rotate clock wise thus the victim get gripped by the gripper and once the victim get held tightly the

ISBN : 978-93-87793-95-8

gripper motor is stopped and again the winch drum motor is activated in clock wise direction. This causes the rope to wound on the winch drum and makes the gripper with victim to move up.

ADVANTAGES

1. The system is controlled by simple switch activation and even complete automation can also be in build to this system for the future advancement
2. Even a less skilled operators can handle and use this system to rescue the victim
3. Less maintenance, very cheap
4. The bore well rescue system is highly safe for the victim who have been carried for rescue

CONCLUSION

Human life is precious. Our smart bore well child recue system is a significant attempt to save the life of the victim of bore well accidents. In the current design of bore well child saver machine is has been made to suit every possible situation may occur in rescuing operation. We like to conclude with the help our project, We can able to rescue without any damage.

REFERENCES

[1] B Bharathi, B Suchitha Samuel, Design and Construction of Rescue Robot and Pipeline Inspection Using Zigbee, International Journal of Scientific Engineering and Research , 1(2), 2013, 42-49.

[2] Palwinder Kaur, Ravinder Kaur, Gurpreet Singh, Pipeline Inspection and Bore Well Rescue Robot, International Journal of Research in Engineering and Technology, 2(5), 2014, 04-12.

[3] K Saran, S Vignesh, Marlon Jones Louis, Bore-well Rescue Robot, International Journal of Research Aeronautical and Mechanical Engineering, 1(4), 2014, 61-80.

[4] V Venmathi, E Poorniya, S Sumathi, Borewell Rescue Robot, International Journal of Computer Applications, 1(3), 2015, 14-23.

[5] Chen, H., Chang,L., Design and Implementation of a ZigBee-Based Wireless Automatic Meter Reading System Przegląd Elektrotechniczny (Electrical Review)

[6] Pipeline inspection and borewell rescue robot "Palwinder kaur, Ravinder kaur, Gurpreet singh". IEEE, VOL3

[7] Safety balloon-Direct web search on google.com

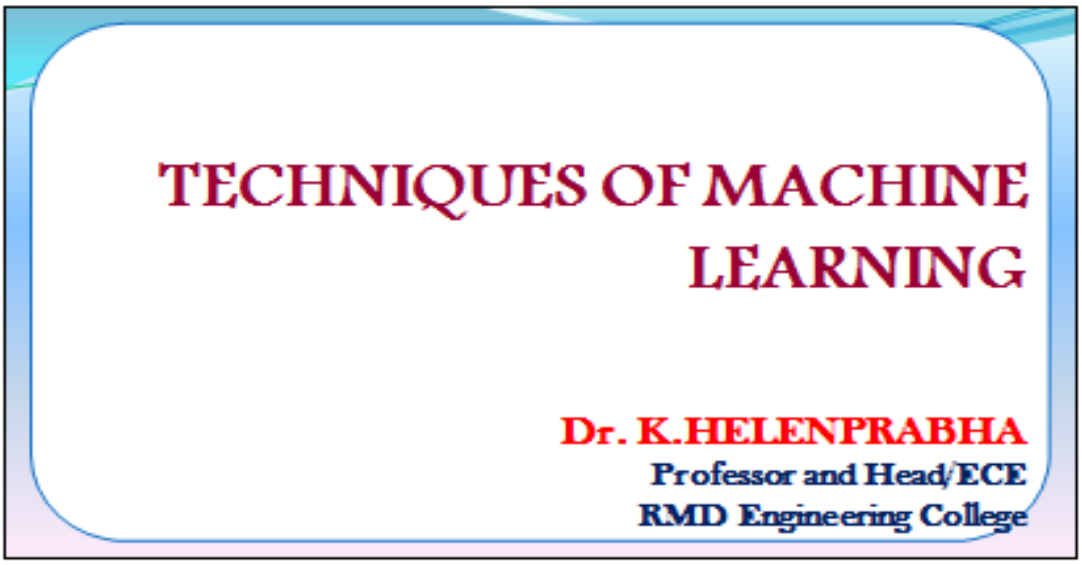
[8] Manish Raj, P.Chakraborty and G.C.Nandi "Rescue robotics in bore well Environment" Cornell university library

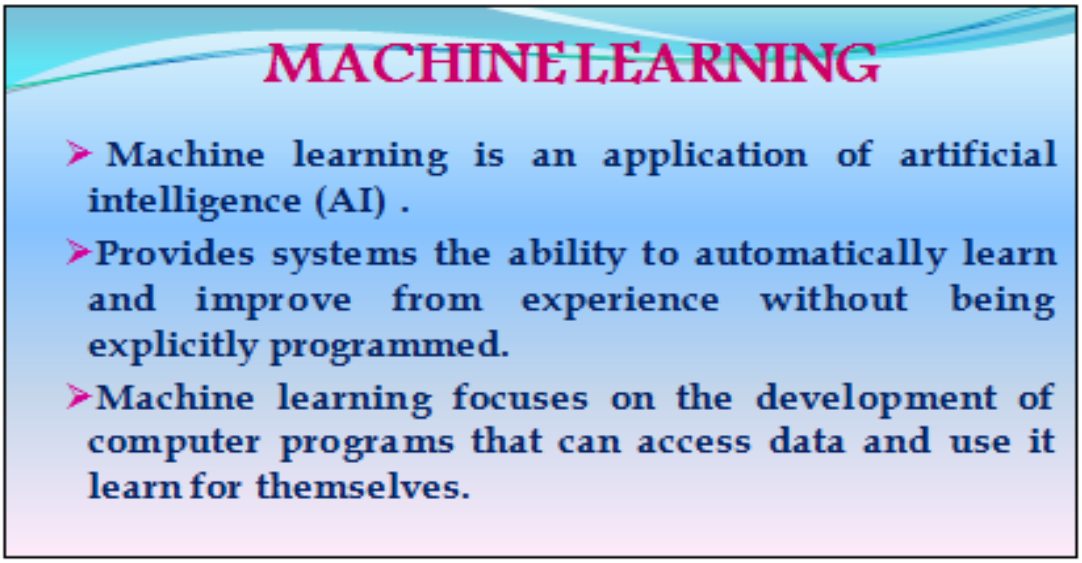
National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

TECHNIQUES OF MACHINE LEARNING

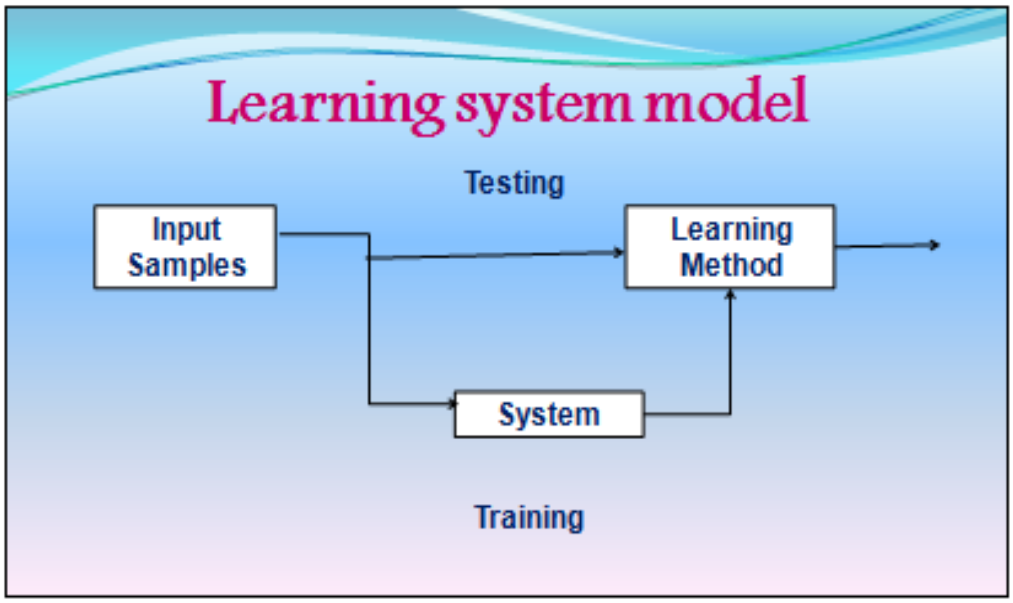
[1]Dr.K.Helenprabha

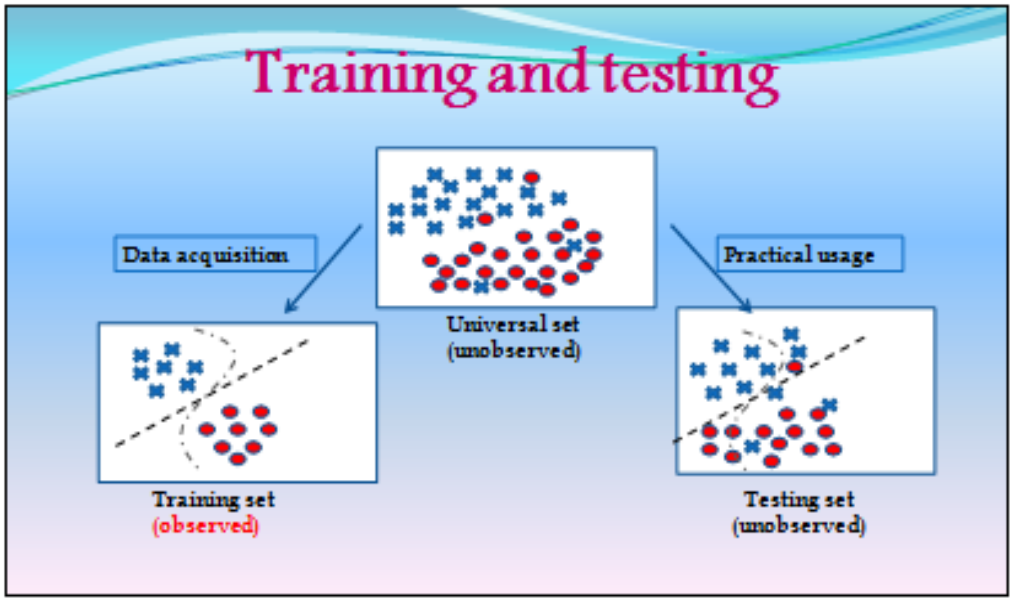
[1]Professor cum HoD, ECE, RMD Engineering College





ISBN : 978-93-87793-95-8

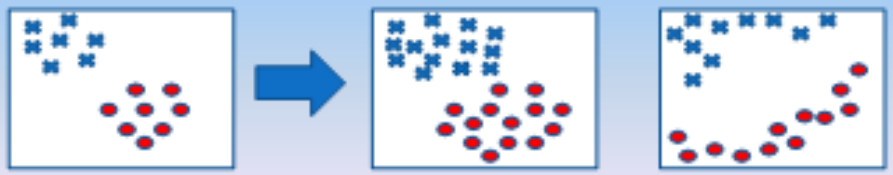




ISBN : 978-93-87793-95-8

Training and testing

- Training is the process of making the system able to learn.
  - Training set and testing set come from the same distribution
  - Need to make some assumptions or bias



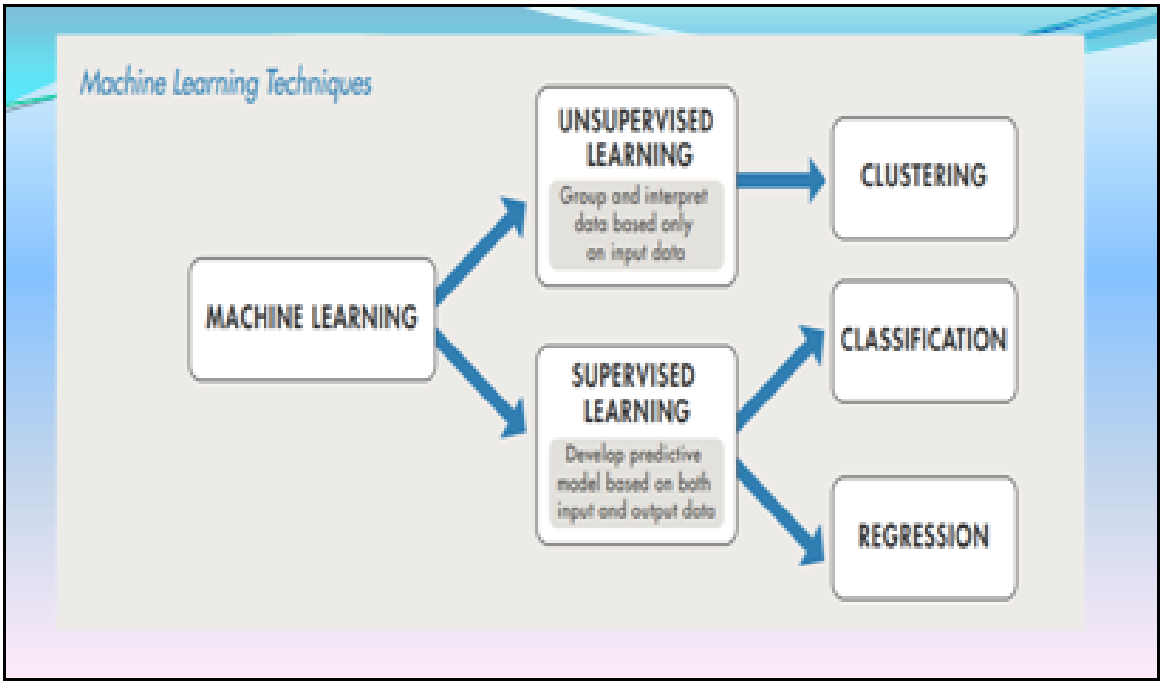
Performance

- There are several factors affecting the performance:
  - **Types of training** provided
  - The form and extent of any initial **background knowledge**
  - The **type of feedback** provided
  - The **learning algorithms** used
- Two important factors:
  - Modeling
  - Optimization

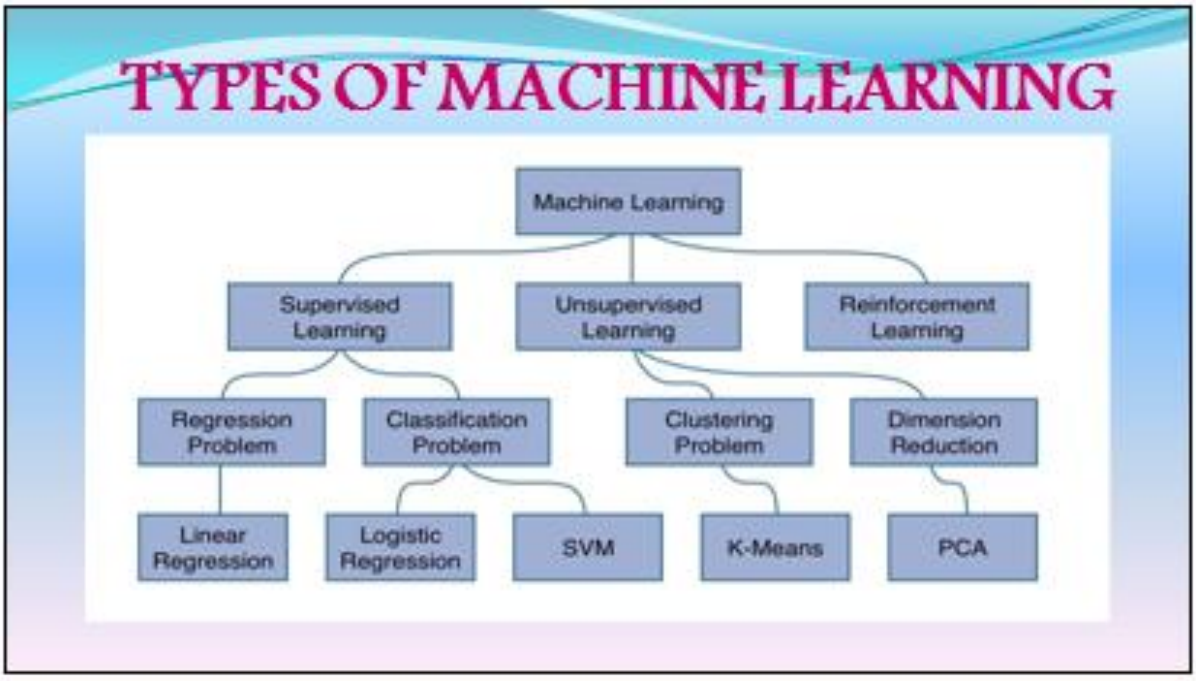
ISBN : 978-93-87793-95-8

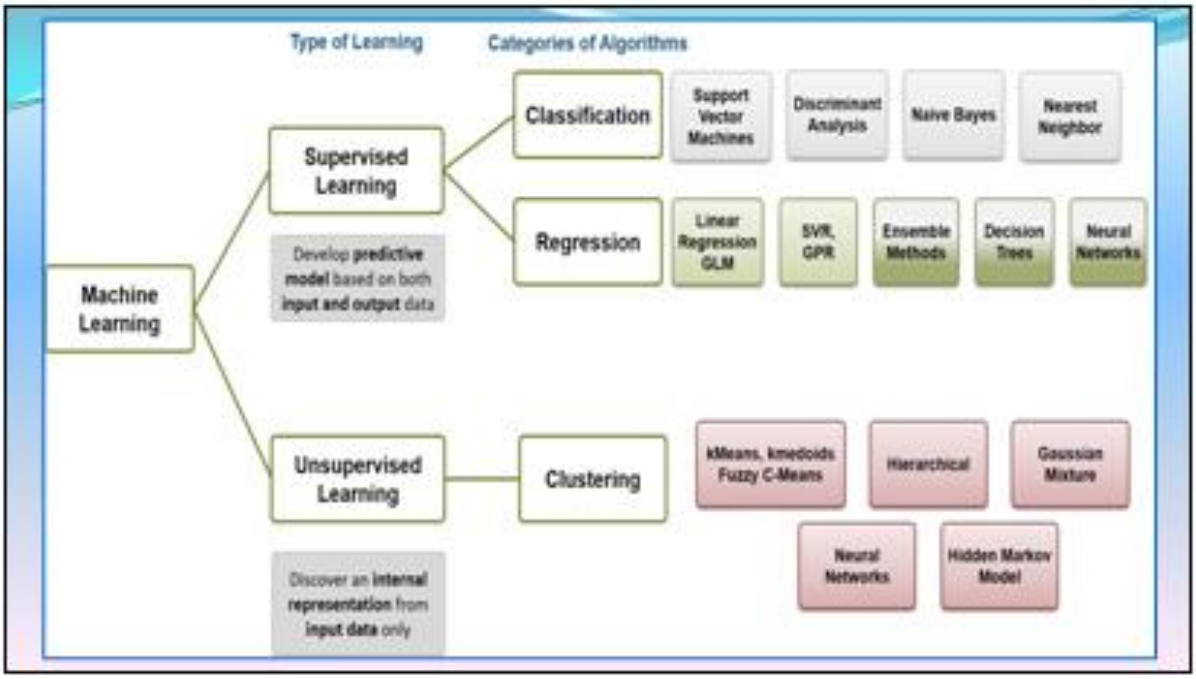
Algorithms

- The success of machine learning system also depends on the algorithms.
- The algorithms control the search to find and build the knowledge structures.
- The learning algorithms should extract useful information from training examples.

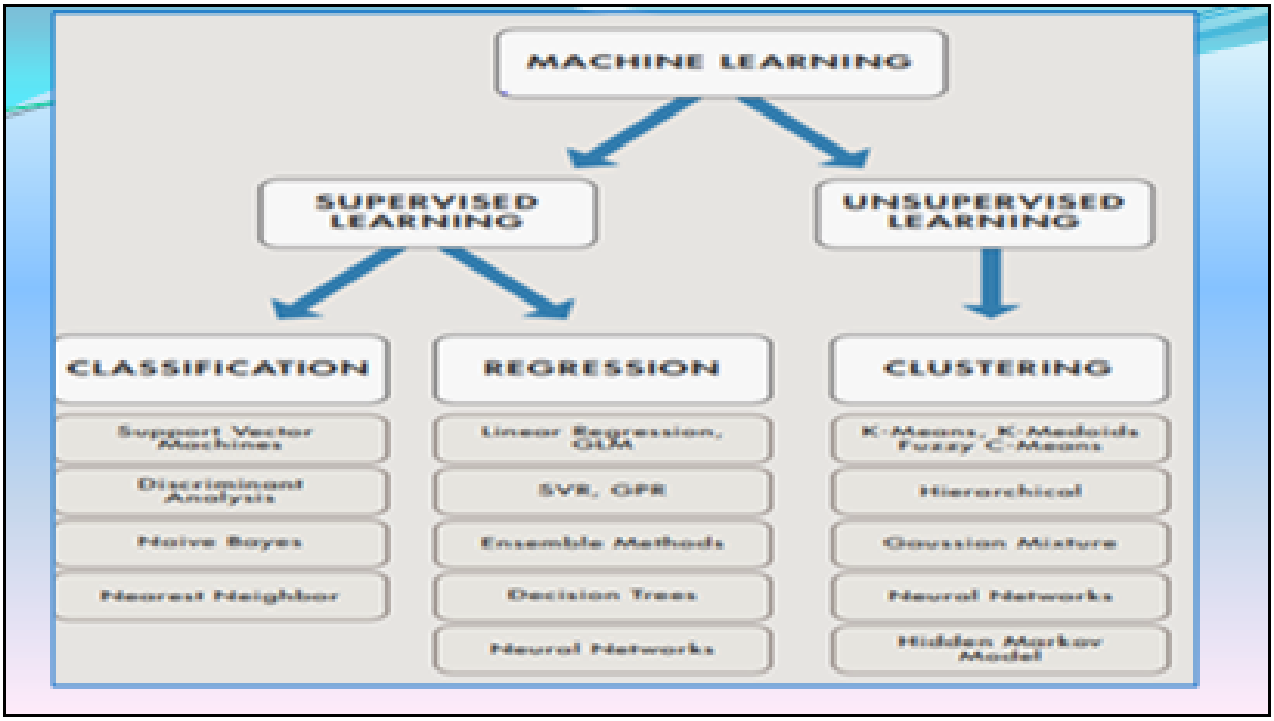


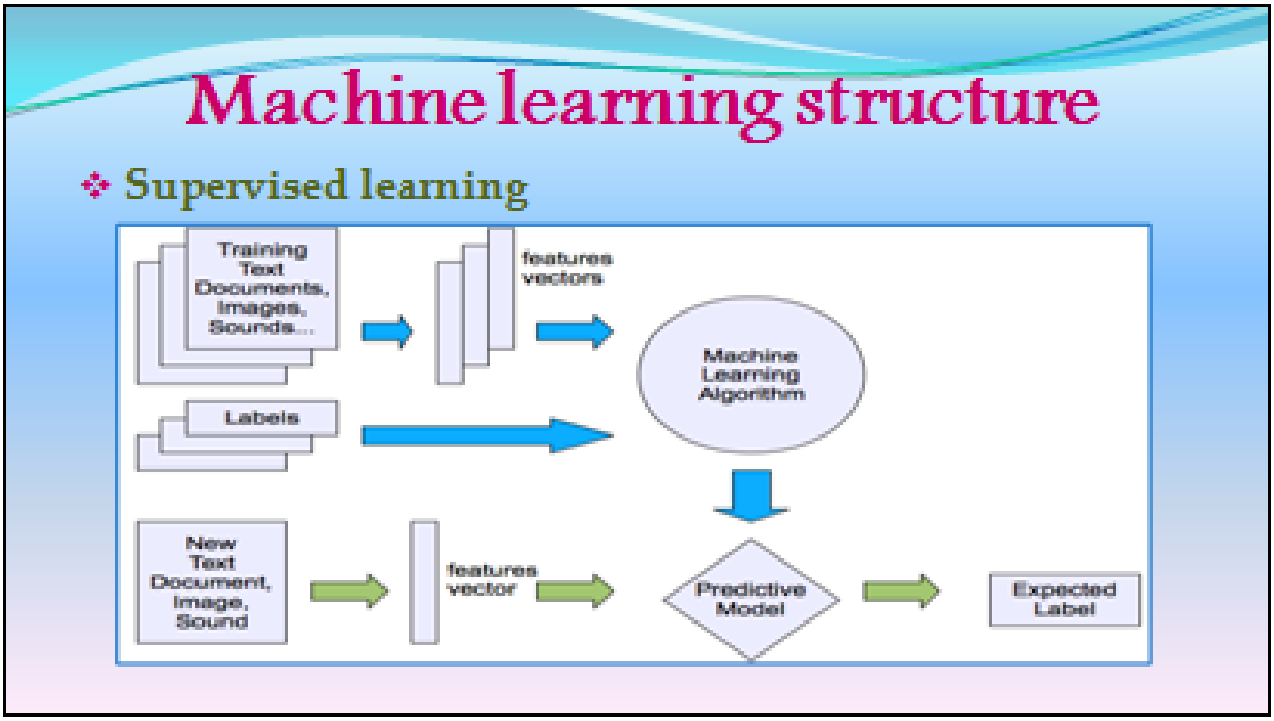
ISBN : 978-93-87793-95-8



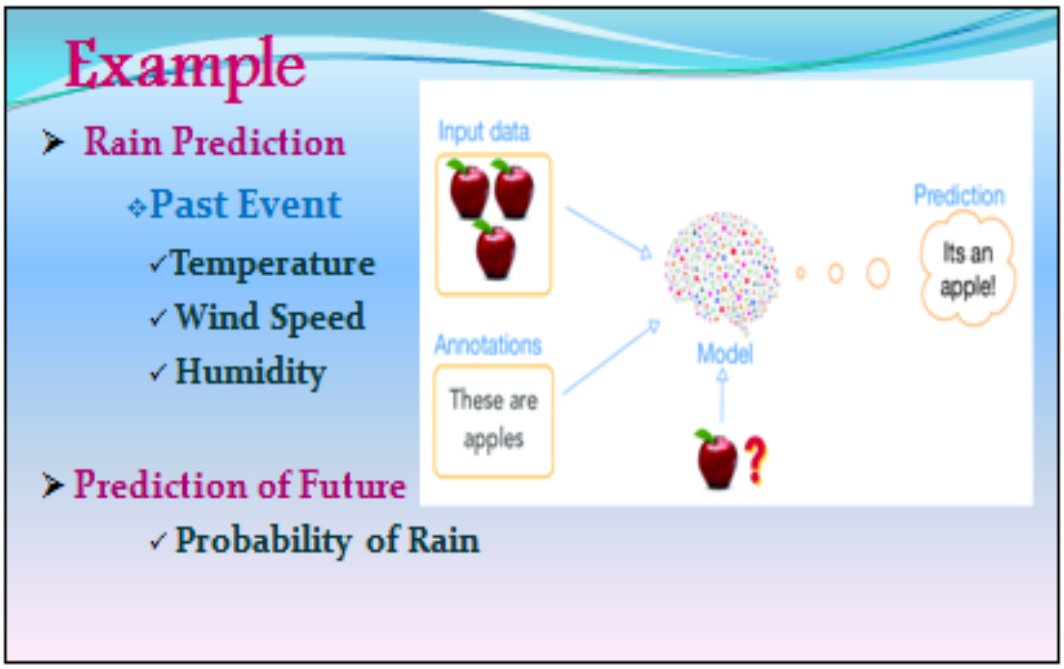


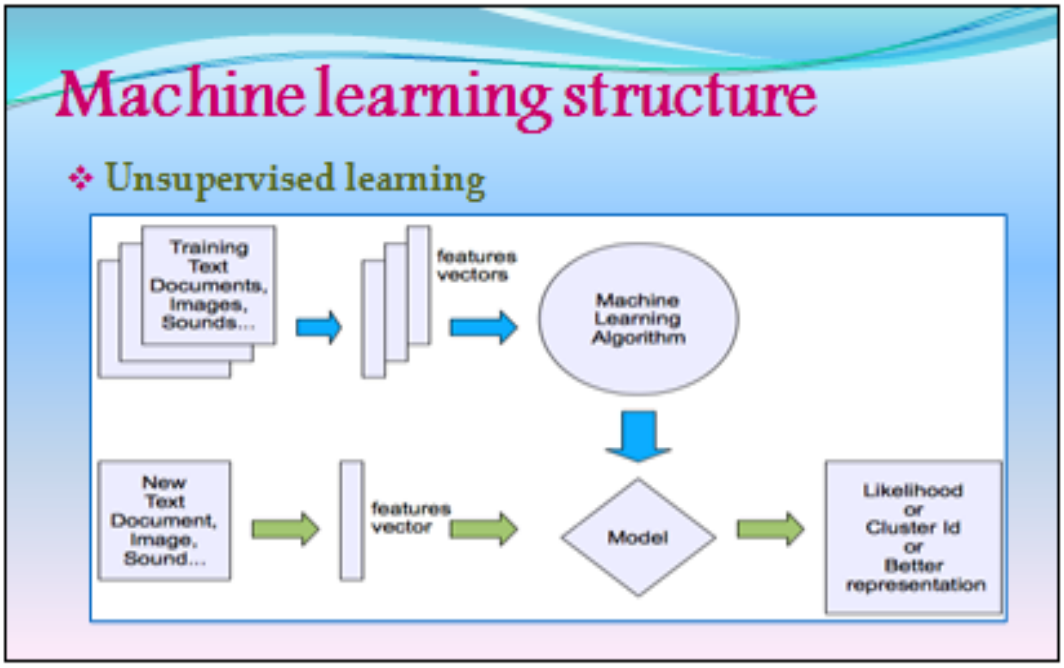
ISBN : 978-93-87793-95-8



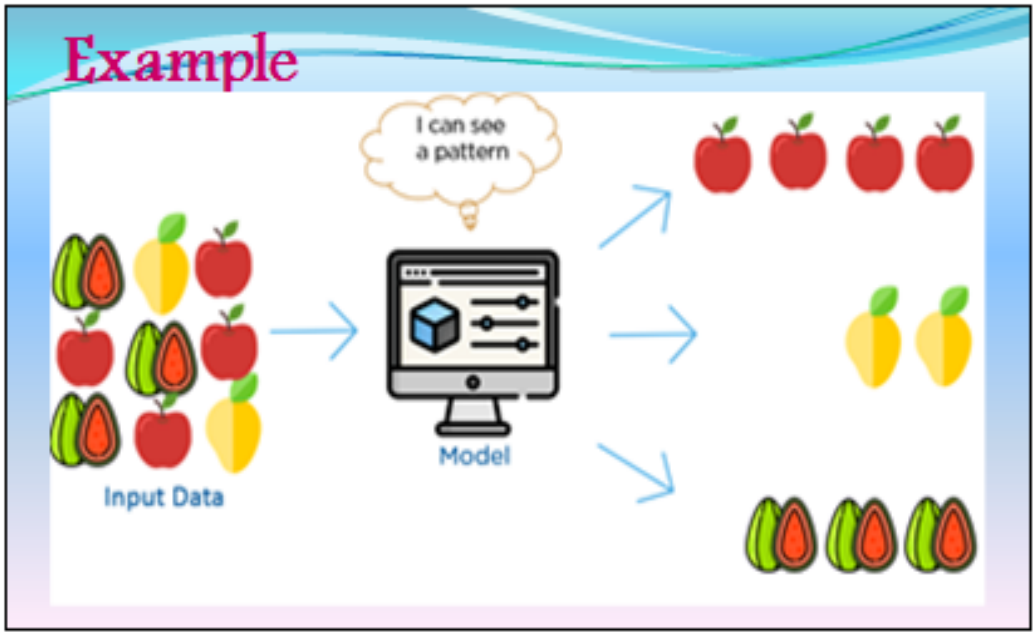


ISBN : 978-93-87793-95-8





ISBN : 978-93-87793-95-8



Reinforcement Learning

- Psychological Parameter
  - ✓ Bell ring - dog will get food
- Positive Reinforcement
  - ✓ Decision will give gain
- Negative Reinforcement
  - ✓ Decision will give loss

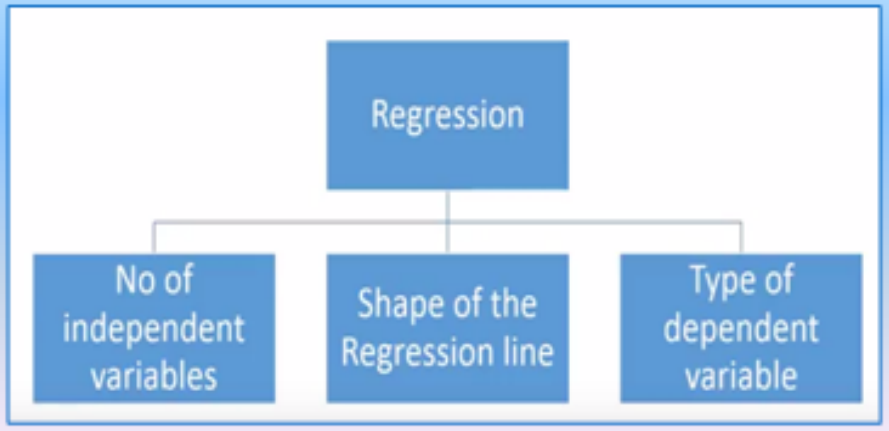
Example : Chess Game

ISBN : 978-93-87793-95-8

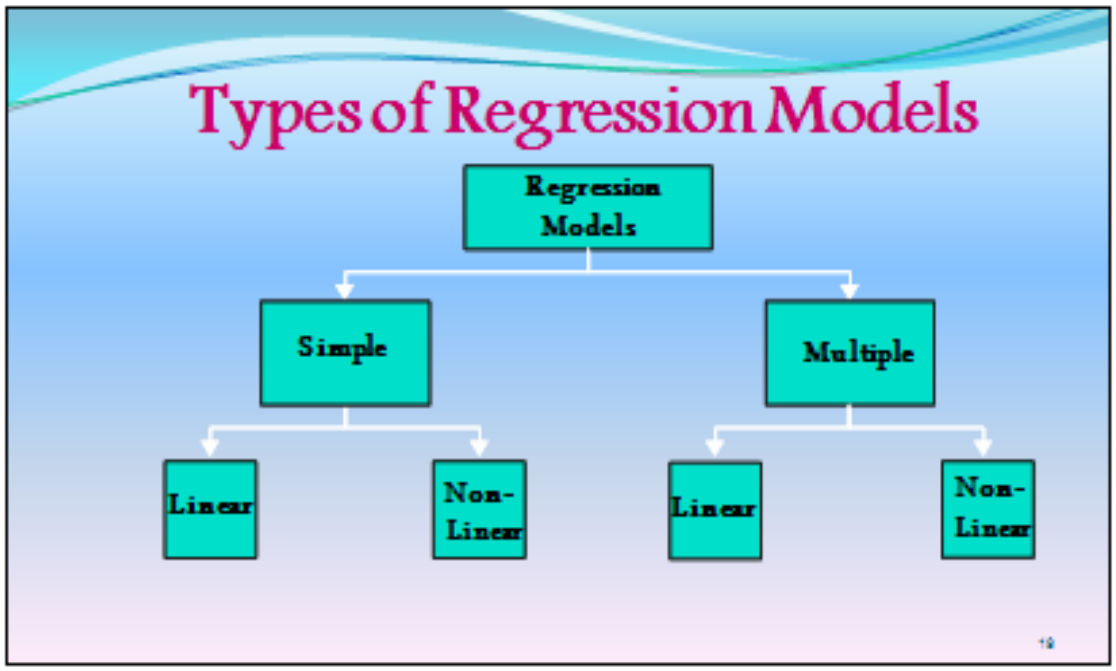
Regression

- Regression is a statistical approach to find the relationship between variables.
- Regression is a statistical way to establish a relationship between a dependent variable and a set of independent variable(s).

Regression types



ISBN : 978-93-87793-95-8



Regression model

- Relation between variables where changes in some variables may "explain" or possibly "cause" changes in other variables.
- Explanatory variables are termed the independent variables and the variables to be explained are termed the dependent variables.
- Regression model estimates the nature of the relationship between the independent and dependent variables.
  - Change in dependent variables that results from changes in independent variables, ie. size of the relationship.
  - Strength of the relationship.
  - Statistical significance of the relationship.

ISBN : 978-93-87793-95-8

Types of Regressions

- Linear Regression
- Logistic Regression
- Polynomial Regression
- Stepwise Regression
- Ridge Regression
- Lasso Regression
- Elastic Net Regression

Which to use

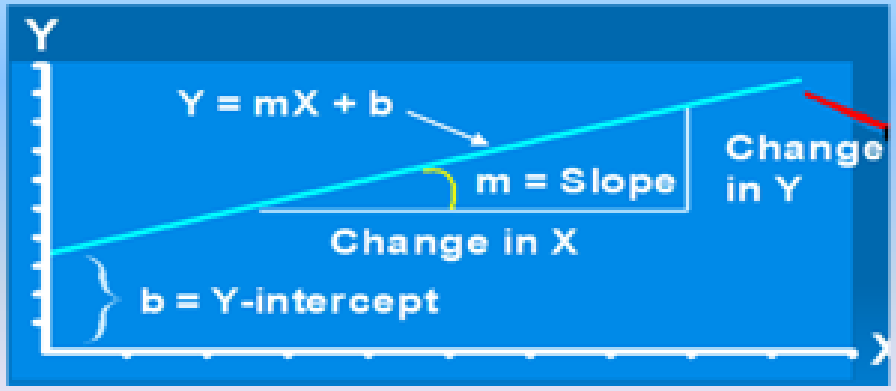
- If the outcome is continuous –use linear regression.
- If it is binary – use logistic regression.
- If the power of independent variable is more than 1 – use polynomial regression.
- If it is with High dimensionality and multi co linearity among the variables in the data set - Regression regularization methods(Lasso, Ridge and Elastic Net)

ISBN : 978-93-87793-95-8

Linear Regression

- Dependent variable and independent variable

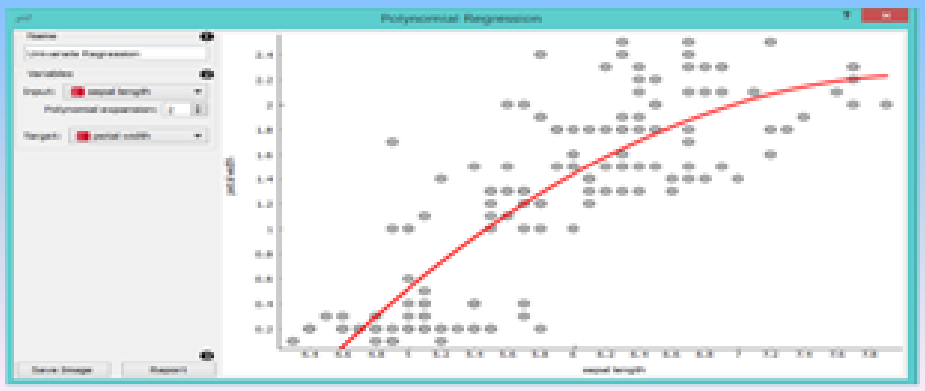
Linear regression is a linear model, e.g. a model that assumes a linear relationship between the input variables (x) and the single output variable (y)



Multiple Linear Regression - When there are multiple input variables

Polynomial Regression

- In statistics, **polynomial regression** is a form of **regression** analysis in which the relationship between the independent variable x and the dependent variable y is modeled as an nth degree **polynomial** in x.



ISBN : 978-93-87793-95-8

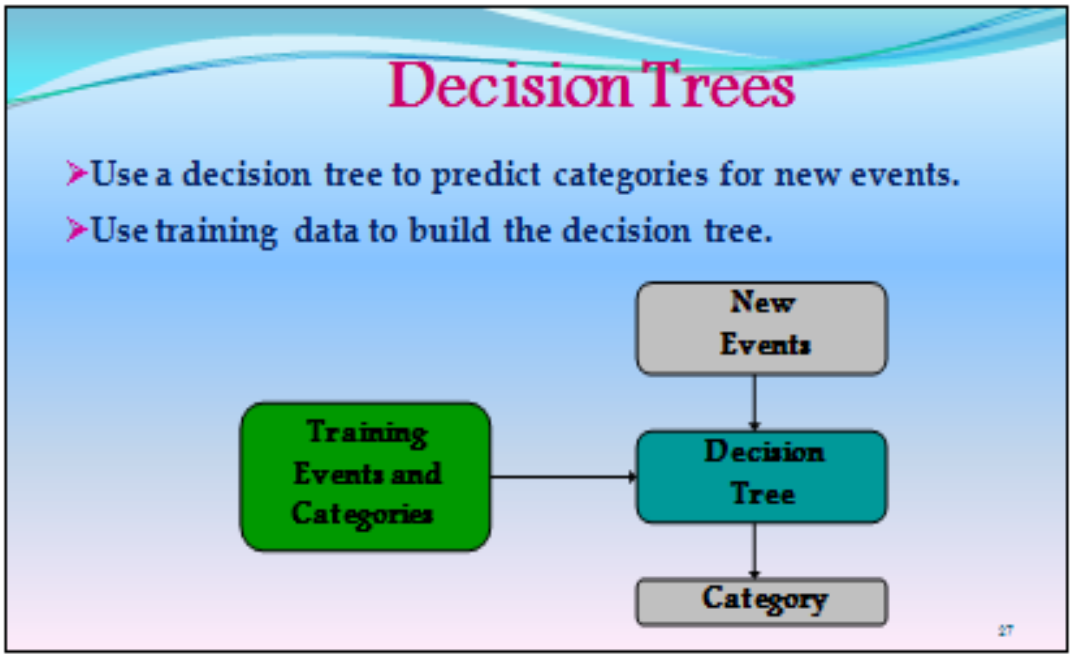
Logistic Regression

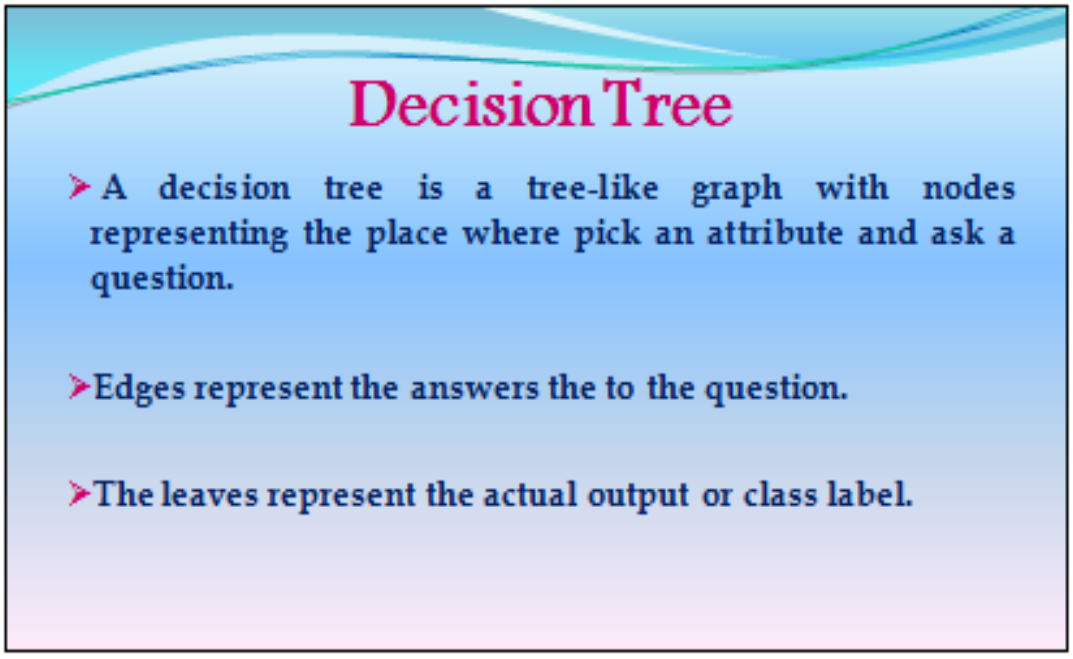
- It is misleading name, even though the name suggest regression but in reality it is a classification technique.
- It is use to estimate the probability of binary response.
- It can be generalized to predict more than two categorical values.

K nearest neighbor

- It is a classification technique.
- Were an object is classified by a majority vote of it's neighbor.
- The observation is assigned to the class which is most common among it's K nearest neighbors.
- The best choice of K depends upon the data generally, larger values of K reduce the effect of noise on the classification.

ISBN : 978-93-87793-95-8





ISBN : 978-93-87793-95-8

K– Means clustering

- Clustering algorithm that aims to partition n observations into K clusters.
- Unsupervised learning technique.
- It is the task of grouping together a set of objects in a way that objects in the same cluster are more similar to each other than to objects in other clusters

Principal Component Analysis

- It is technique used to Emphasize variation and bringing out strong patent in a dataset.
- First Principal Component has the largest possible variant (i.e. Accounts for as much of the variability in the data as possible.
- Each Succeeding component in turn has highest variance possible.

Applications

- Face detection
- Object detection and recognition
- Image segmentation
- Multimedia event detection
- Economical and commercial usage

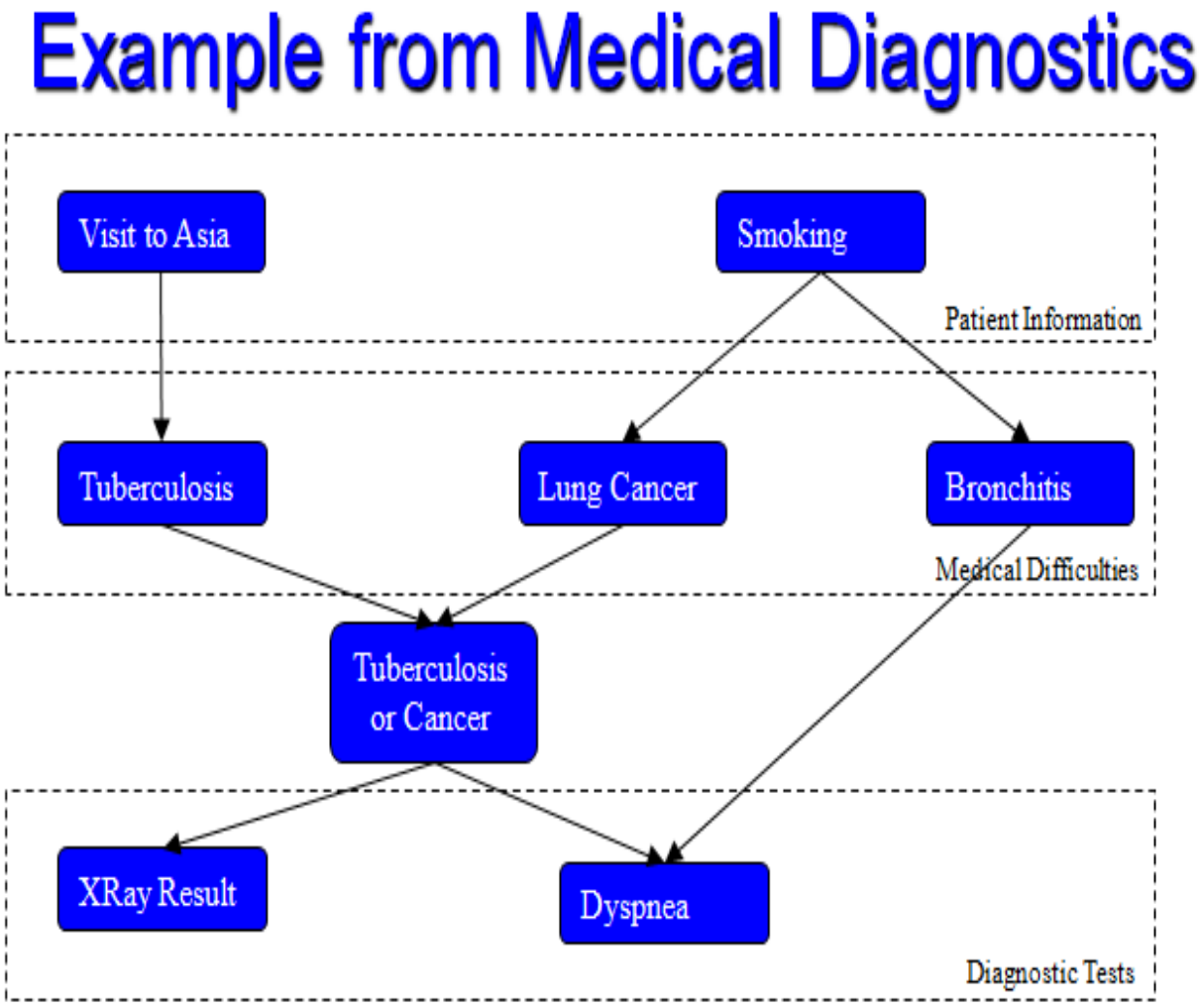
National Seminar on
"High Level Thinking Using Artificial Intelligence"
14th June 2019
ISBN : 978-93-87793-95-8

Graphical Models and Applications – Machine Learning

Dr.S.Sujitha

Associate Professor, Department of Electrical and Electronics Engineering

New Horizon College of Engineering. Bangalore



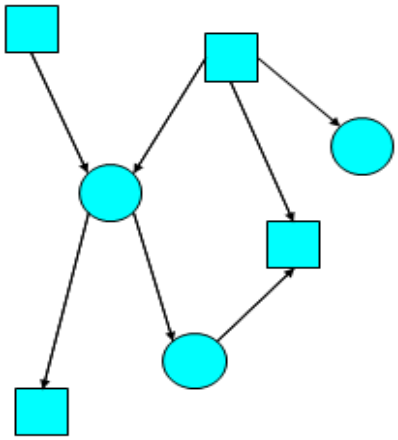
ISBN : 978-93-87793-95-8

What is a graphical model ?

A graphical model is a way of representing probabilistic relationships between random variables.

Variables are represented by nodes:

Conditional (in)dependencies are represented by (missing) edges:



Undirected edges simply give correlations between variables (**Markov Random Field** or **Undirected Graphical model**):

Directed edges give causality relationships (**Bayesian Network** or **Directed Graphical Model**):

"Graphical models are a **marriage between probability theory and graph theory**.

They provide a natural tool for dealing with two problems that occur throughout applied mathematics and engineering – **uncertainty and complexity** –

and in particular they are playing an increasingly important role in the design and analysis of **machine learning algorithms**.

Fundamental to the idea of a graphical model is the **notion of modularity** – a complex system is built by combining simpler parts.

ISBN : 978-93-87793-95-8

Probability theory provides the **glue** whereby the parts are combined, ensuring that the system as a whole is consistent, and providing ways to interface models to data.

The **graph theoretic** side of graphical models provides both an intuitively appealing interface by which humans can model highly-interacting sets of variables as well as a data structure that lends itself naturally to the design of efficient general-purpose algorithms.

Many of the classical multivariate probabilistic systems studied in fields such as statistics, systems engineering, information theory, pattern recognition and statistical mechanics **are special cases of the general graphical model formalism** -- examples include mixture models, factor analysis, hidden Markov models, Kalman filters and Ising models.

The graphical model framework provides a way to view all of these systems as instances of a **common underlying formalism**.

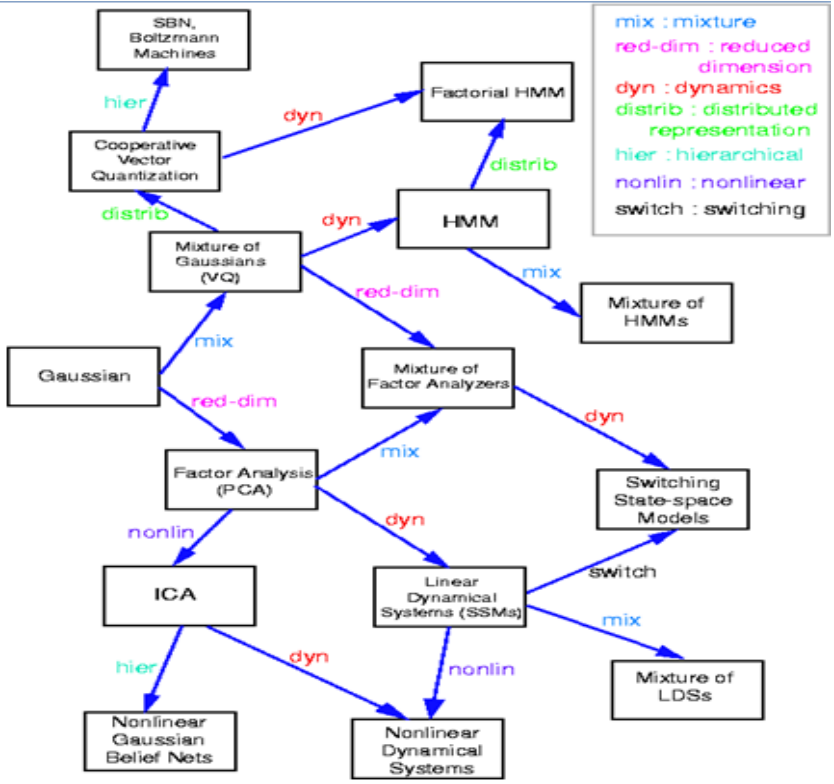
This view has many advantages -- in particular, **specialized techniques** that have been developed in one field can be **transferred between research communities** and exploited more widely.

Moreover, the graphical model formalism provides a **natural framework for the design of new systems**."

--- Michael Jordan, 1998.

ISBN : 978-93-87793-95-8

We already know many graphical models:



(Picture by Zoubin Ghahramani and Sam Roweis)

OUTLINE

- **Introduction to Graphical Models (Polito)**
  - **Basics on graphical models and statistics**
  - **Learning from data**
  - **Exact inference**
  - **Approximate inference**
- **Applications to Vision (Perona)**
- **Applications to Coding Theory (McEliece)**
- **Belief Propagation and Spin Glasses**

ISBN : 978-93-87793-95-8

OUTLINE

- **Introduction to Graphical Models (Polito)**
  - **Basics on graphical models and statistics**
  - **Learning from data**
  - **Exact inference**
  - **Approximate inference**
- **Applications to Vision (Perona)**
- **Applications to Coding Theory (McEliece)**
- **Belief Propagation and Spin Glasses**

Basics on graphical models and statistics

- Basics of graph theory.
- Families of probability distributions associated to directed and undirected graphs.
- Markov properties and conditional independence.

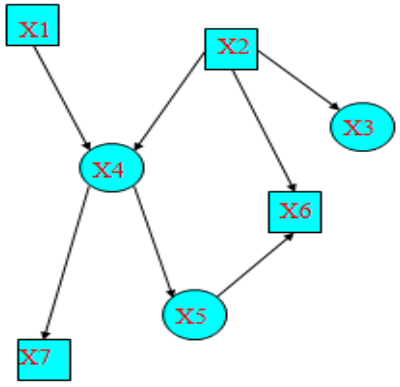
- Statistical concepts as building blocks for graphical models.
- Density estimation, classification and regression.

ISBN : 978-93-87793-95-8

Basics on graphical models and statistics

Graphs and Families of Probability Distributions

There is a family of probability distributions that can be represented with this graph.

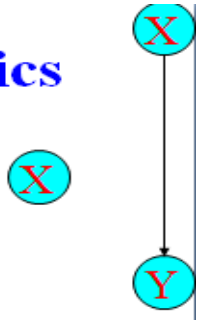


1) Every P.D. presenting (at least) the conditional independencies that can be derived from the graph belongs to that family.

2) Every P.D. that can be factorized as $p(x1,\ldots,x7)=p(x4|x1,x2)\,p(x7|x4)\,p(x5|x4)\,p(x6|x5,x2)\,p(x3|x2)$ belongs to that family.

Basics on graphical models and statistics

Building blocks for graphical models

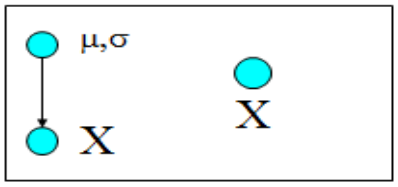


$p(X)$= ??? $p(Y|X)$= ????

Bayesian approach: every unknown quantity (including parameters) is treated as a random variable.

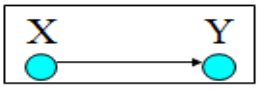
Density estimation

Parametric and nonparametric methods



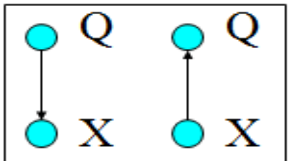
Regression

Linear, conditional mixture, nonparametric



Classification

Generative and discriminative approach



ISBN : 978-93-87793-95-8

OUTLINE

- Introduction to Graphical Models (Polito)
  - Basics on graphical models and statistics
  - Learning from data
  - Exact inference
  - Approximate inference
- Applications to Vision (Perona)
- Applications to Coding Theory (McEliece)
- Belief Propagation and Spin Glasses

Learning from data

- Model structure and parameters estimation.
- Complete observations and latent variables.
- MAP and ML estimation.
- The EM algorithm.
- Model selection.

ISBN : 978-93-87793-95-8

Structure	Observability	Method
Known	Full	ML or MAP estimation
Known	Partial	EM algorithm
Unknown	Full	Model selection or model averaging
Unknown	Partial	EM + model sel. or model aver.

OUTLINE

- **Introduction to Graphical Models (Polito)**
  - **Basics on graphical models and statistics**
  - **Learning from data**
  - **Exact inference**
  - **Approximate inference**
- **Applications to Vision (Perona)**
- **Applications to Coding Theory (McEliece)**
- **Belief Propagation and Spin Glasses**

ISBN : 978-93-87793-95-8

Exact inference

- The junction tree and related algorithms.
- Belief propagation and belief revision.
- The generalized distributive law.
- Hidden Markov Models and Kalmann Filtering with graphical models.

Exact inference
Conditional independencies

Given a probability distribution p(X,Y,Z,W),

How can we decide if the groups of variables X and Y are "conditionally independent" from each other once the value of the variables Z is assigned ?

With graphical models, we can implement an algorithm reducing this global problem to a series of local problems (see Matlab demo of the Bayes-Ball algorithm)

ISBN : 978-93-87793-95-8

Exact inference

Variable elimination and Distributive Law

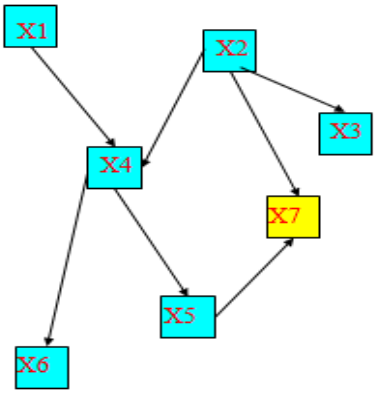
$$p(x1,\ldots,x6,x7)=p(x4|x1,x2)p(x6|x4)p(x5|x4)\,p(x3|x2)p(x7|x2,x5)$$

Marginalize over x7:

$$p(x1,\ldots,x6)=\Sigma_{x7}\ [p(x4|x1,x2)p(x6|x4)p(x5|x4)\,p(x3|x2)p(x7|x2,x5)]$$

Applying a "distributive law":

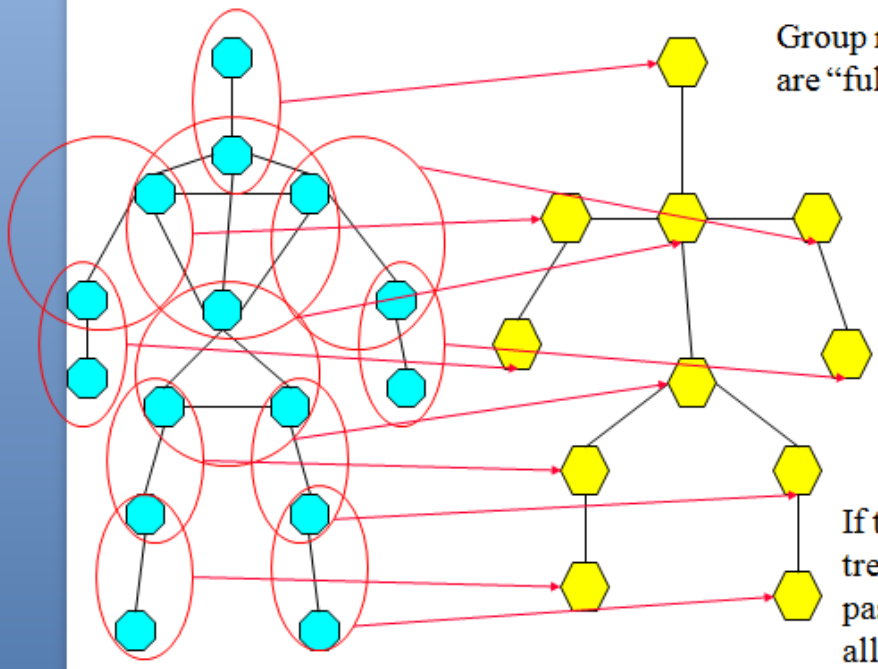
$$p(x1,\ldots,x6)= p(x4|x1,x2)p(x6|x4)p(x5|x4)\,p(x3|x2)\,\Sigma_{x7}\,[p(x7|x2,x5)]$$



The language of graphical models allows a general formalization of this method.

Exact inference

Junction graph and message passing



Group random variables which are "fully connected".

Connect group-nodes with common members: the "junction graph".

Every node only needs to "communicate" with its neighbors.

If the junction graph is a tree, there is a "message passing" protocol which allows exact inference.

ISBN : 978-93-87793-95-8

OUTLINE

- Introduction to Graphical Models (Polito)
  - Basics on graphical models and statistics
  - Learning from data
  - Exact inference
  - Approximate inference
- Applications to Vision (Perona)
- Applications to Coding Theory (McEliece)
- Belief Propagation and Spin Glasses

Approximate inference

- Kullback-Leibler divergence and entropy.
- Variational methods.
- Monte Carlo Methods.
- Loopy junction graphs and loopy belief propagation.
- Performance of loopy belief propagation.
- Bethe approximation of free energy and belief propagation.

ISBN : 978-93-87793-95-8

Approximate inference

Kullback-Leibler divergence and GM

The graphical model associated to a P.D. p(x) is too complicated.

AND NOW ?!?!?

We choose to approximate p(x) with q(x), obtained by making assumptions on the junction graph corresponding to the graphical model.

Example: eliminate loops, bound the number of nodes linked to each node.

A good criterion for choosing q: mimimize the cross-entropy, or Kullback-Leibler divergence:

$$D(p \,\|\, q) = \int p(x) \log \frac{p(x)}{q(x)} \, dx$$

Approximate inference

Variational methods

Example: the QMR-DT database

$$p(f_i = 0 \mid d) = \exp(-\sum_{j \in \pi(i)} a_{ij} d_j - a_{i0})$$

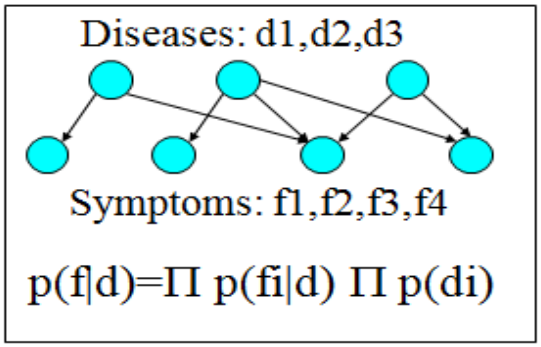
$$p(f_i = 1 \mid d) = 1 - \exp(-\sum_{j \in \pi(i)} a_{ij} d_j - a_{i0})$$

By using the inequality:

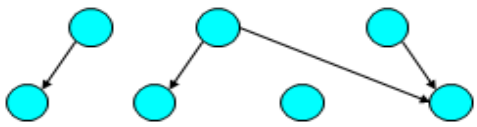
$$1 - e^{-x} \leq e^{\lambda x - H(\lambda)}$$

We get the approximation:

$$p(f_i = 1 \mid d) \leq \exp(\lambda_i a_{i0} - H(\lambda_i)) \prod_{j \in \pi(i)} \exp(\lambda_i a_{ij})^{d_j}$$



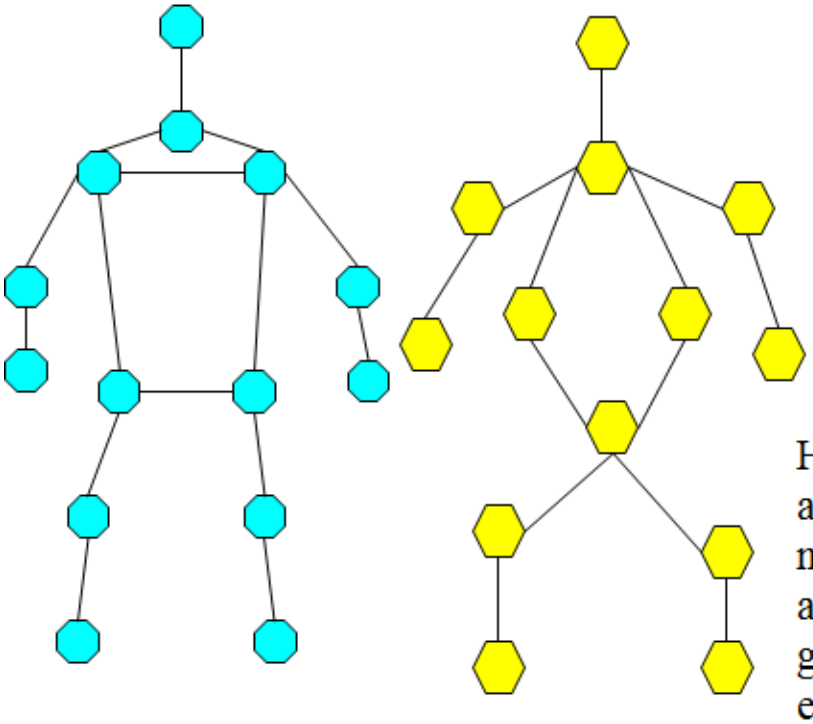
The node fi is "unlinked":



ISBN : 978-93-87793-95-8

Approximate inference

Loopy belief propagation



When the junction graph is not a tree, inference is not exact: roughly speaking, a message might pass through a node more often, causing trouble.

However, in certain cases, an iterated application of a message passing algorithm converges to a good candidate for the exact solution.

ffp