Design and Development of an Agricultural Robot for Disease Detection in Plants and Automated Agriculture

Nikhil R Bhardwaj, Monish R, Mukesh S, Sunil D M

Abstract— Convolutional neural networks (CNNs) has achieved splendid results in the field of image classification. This paper is concerned with an approach to the development of a plant disease recognition model based on leaf image classification, by the use of convolutional neural networks. The developed model recognizes different types of plant diseases, with an ability to distinguish diseased and healthy plant leaves. All necessary steps for implementing this disease recognition model are described throughout the paper, starting from gathering images in order to create a database to assessing the state of the plant leaves thereby providing an appropriate remedy to all the diseased leaves. The experimental results on the developed model achieved precision between 90% and 96%.The proposed method takes the advantages of the neural networks to extract the characteristics of diseased plants, and thus to classify target disease areas. The hardware module (Agri-bot) also surveils the farm thereby automating agricultural practices like ploughing, seeding, watering and leveling, thus minimizing the burden on farmers and in turn increasing the yield in crops.

Index Terms— Agri-bot, Automation, Convolution Neural Networks, Database, Deep Learning, Disease Recognition Module, Image Classification, Precision.

1 Introduction

Agriculture is the mainstay of Indian economy, as two-thirds of the population is dependent on it for food, fiber, feed and fuel which is essential for humanity. Agriculture is an important sector of Indian economy as it contributes to about 17% of the total GDP and provides employment to over 60% of the population. Agriculture has occupied almost 43 percent of India's geographical area. Despite being the largest sector in India there is a fall in the contribution to the GDP. This fall of the agricultural sector is due to lack of technological improvements and proper farming methods.

The bulk of the farmers live in rural India and most of them do not possess the know-how to deal with the diseases of the plants and are unaware of which fertilizer or pesticides to be used. This indiscriminate use of bio-fertilizers may result in not only damaging the crops but also may result in wide spread environmental pollution which takes its own toll on the crop yield and ecology.

India has taken major strides in technology; it is but natural for such a vast country to adopt automated techniques in agriculture. This will substantially increase yield at the time when farmers are hard-pressed to find laborers and are fighting mounting costs.

The use of deep learning algorithms such as Convolutional Neural Networks (CNN) in specific can be used to build machines capable of performing most of the agricultural practices. This project makes uses of these algorithms to develop robots that automate most of the labor-intensive tasks of agriculture. Therefore, the purpose of this project is to reduce the labor-intensive task of a farmer hence automating the agricultural practices by using an autonomous vehicle (Agri-Bot) and additionally being able to distinguish diseased plant leaves from the healthy ones with the help of Deep Learning Algorithms (Convolution Neural Network).

2 Literature Survey

Implementation of suitable management strategies for plant diseases such as suitable pesticide application and control measures could play a crucial role in early detection and control of pests hence facilitating the control of diseases and improving productivity.

T.Bhavatarini [1], implemented a Plant Disease Classification And Pesticide Suggestion Module using image processing techniques thereby performing feature extraction wherein the unnecessary green parts from the diseased portion are removed and features like color, shape, size are obtained. Then the features are ranked according to the impact of the disease. Finally, using Support vector machine (SVM), the plant diseases are classified to suggest the proper pesticide along with the correct dosage and provide some prevention methods in order to prevent the plants from future problems.

A M Ali Karol [2], proposed a system, which helps in identification of plant disease and provides remedies that can be used as a defense mechanism against the disease using Convolution Neural Network (CNN). Here, a drone model is also designed which can be used for live coverage of large agricultural fields to which a high resolution camera is attached and will capture images of the plants which will act as input for the software, based of which the software will tell us whether the plant is healthy or not.

Suryavrat Rao [3], propounds a design for an automated irrigation system for efficient water management with a plant disease detection system implemented for prevention of dis-

eases in plants. The objectives of this paper was to control the water motor automatically, monitor the plant growth using webcam, detect the disease of plant, intruder detection, and we can also watch live streaming of farm on smart phones by using Wi-Fi.

Mrunalini R [4], developed a system which represents the technique to classify and identify the different diseases through which plants are affected thereby bringing about improvements in the crop quality. The developed module is a Machine learning based recognition system which helps in classification and identification of the different disease affected plants. This study explores the image processing technique that visually differentiates between various crop diseases which are found in different parts of crop.

Picon, A. Alvarez-Gila [5], this work analyses the performance of early identification of three relevant European endemic wheat diseases: Septoria (Septoria triciti), Tan Spot (Drechslera triciti-repentis) and Rust (Puccinia striiformis & Puccinia recondita). The analysis was done using different mobile devices, and more than 8178 images were captured in two pilot sites in Spain and Germany during 2014, 2015 and 2016. Obtained results reveal an overall improvement of the balanced accuracy from 0.78 (Johannes 2017) up to 0.87 under exhaustive testing, and balanced accuracies greater than 0.96 on a pilot test performed in Germany. The use of Deep Convolutional Neural Networks (CNNs) has proven tremendously successful for different visual classification.

3 METHODOLOGY

Our system is divided into two parts, the Robot Module (Agri-Bot) and the Leaf Disease Detection Module. This section provides the implementation and working of the robot module and the leaf disease detection module. The main aim of the robotic module is to carry out the agricultural practices like digging, seeding, watering, leveling and pesticide spraying. While the main objective of the leaf disease detection module is to predict whether a leaf is healthy or not. This section provides the in-depth implementation and working of the above objectives mentioned.

A. The Robot Module:

- The Agri-bot consists of an Arduino which is responsible for the movement of the robot.
- The Arduino is connected to the H-bridges which helps drive the DC motors forward or backward.
- An addition 12V power supply is used to drive the DC motors.
- Relay switches: 1-channel relay is used for seeding operation while the 2-channel relay is used to control the operation of pesticide and water tanks.
- The moisture sensor is used to indicate the humidity content in the soil.
- The temperature sensor is used to detect the temperature of the surrounding area.

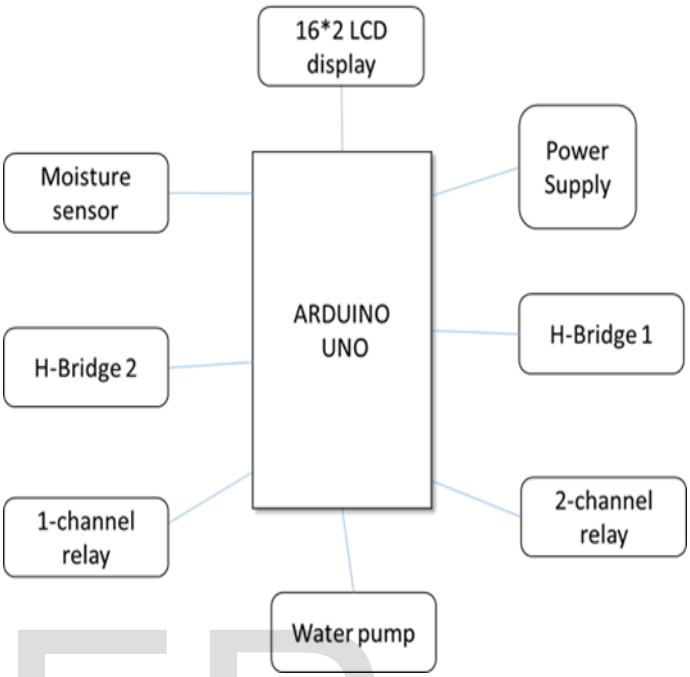

Figure 1 - Image showing the components involved in the Robot Module

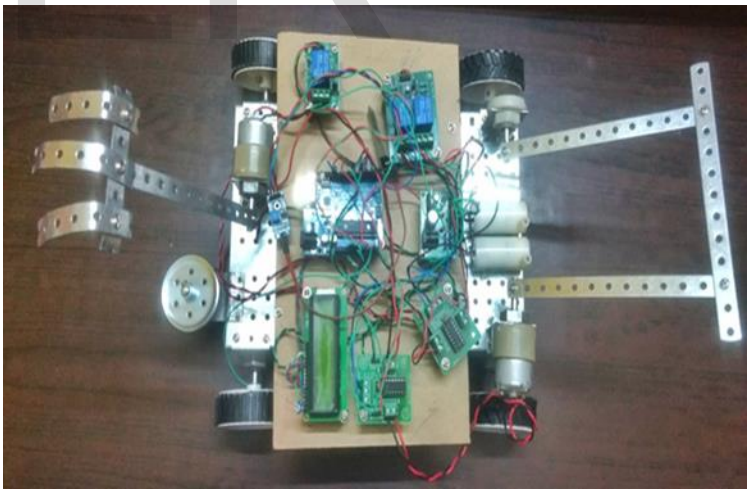

Figure 2- Image of the Robot Module

B. The Leaf Disease Detection Module:

The main objective of the leaf disease detection module is to identify the plant diseases using image processing principles with the help of CNN Algorithm. After identification of the disease, the module propounds the name of pesticide to be incorporated and the remedy to be followed so

as to extricate the plant from further malady. Over the last few years, leaf disease detection has grown leaps and bounds when it comes to image disease detection. The deep learning algorithms have produced tremendous success in classification task. In this paper, the CNN Algorithms is trained to identify and classify the two most common endemics in plants: Bacterial Spot and Yellow Leaf Curl Virus.

The series of steps involves in disease detection module are as shown in the flowchart below:

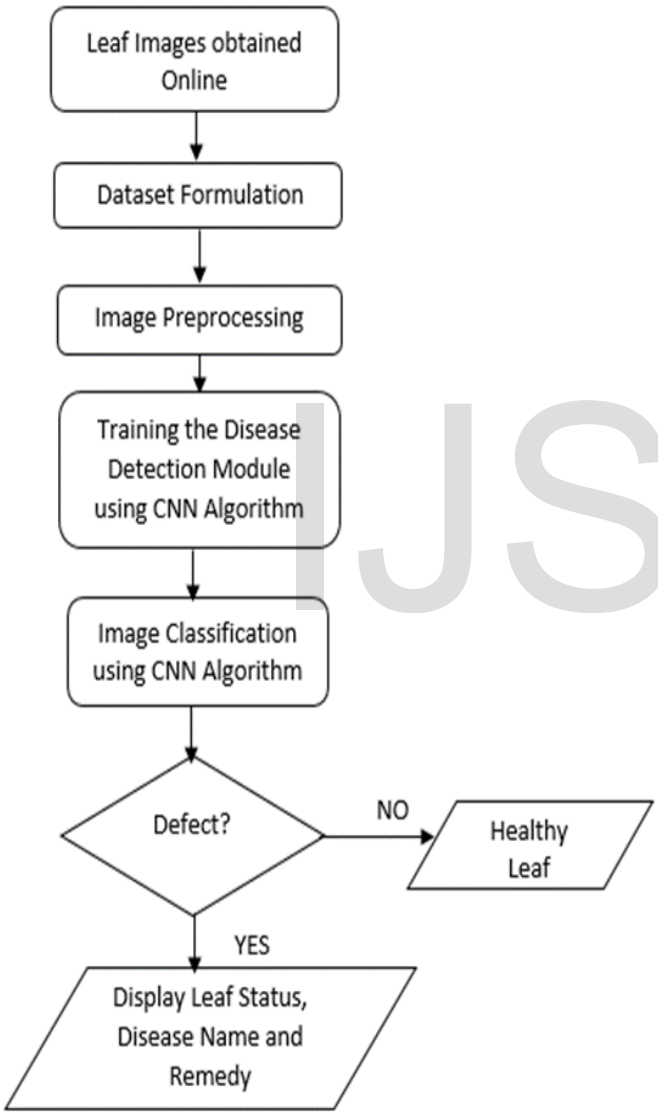

Figure 3- Flowchart of Disease Detection Module

The various steps in the leaf disease detection module are as follows:

1. Database Formulation:

The first step for the disease detection module is acquiring a desired database which is convincing and appropriate. The dataset used in this project is formulated from leaf images obtained online. Typically, the standard database consisting of leaf images was preferred, but, here an ideal database favoured could not be found, hence, we have collected leaf images obtained online and formulated our own database. Images of the dataset were then subjected to preprocessing followed by assigning the collected leaf images with appropriate labels. The images selected for dataset are images with best possible resolution. After selecting images for the dataset, the required knowledge about the different leaves and the disease was obtained from *plantvilllage*. Different types of plant images are studied and correspondingly suitable labeling is done to the various images of the dataset.

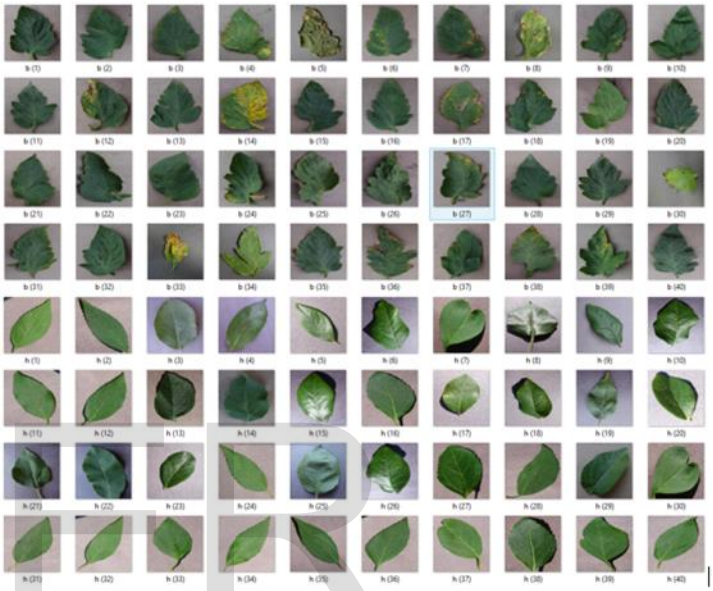

Figure 4- Dataset consisting of Leaf Images Formulated

2. Preprocessing and Training the Disease Detection Module:

Here, the dataset is subjected to preprocessing such as image reshaping, resizing and then the images are converted to an array form, hence suppressing undesirable distortions thereby enhancing image features important for feature extraction. The preprocessing steps are performed on all images of the dataset. After preprocessing, the dataset consisting of different plant leaf images are used as test images for the software. Corresponding processing steps are also performed on images loaded in the test folder. The train dataset is used to train the CNN module so that it can recognize the test image and therefore arrive at the disease present in the leaf image.

After the CNN model is trained successfully, the software can differentiate between healthy and unhealthy (diseased) leaf images contained in the dataset. After preprocessing and training the CNN model, comparison of the test image and trained model takes place to detect diseases in leaf images.

3. REMEDY:

After the disease is detected, suitable remedy for the disease present is displayed so as to prevent further harm to the

diseased plants. The module is trained with high accuracy when it comes to disease detection. The module is designed such that once a leaf image is analyzed, the module states the status of the leaf image i.e. if the leaf image is healthy or unhealthy, the disease the leaf image possesses, suitable pesticide to be incorporated and remedies that has to followed for the well health of the plant.

However, the leaf images which turn out to be healthy, the module states the same and no remedy is provided for a healthy leaf.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The developed module was designed with consideration for the welfare of farmers and the agricultural sector.
As discussed, the developed system can detect disease in plant and also provide the remedy that can be taken against the disease. By proper knowledge of the disease, the remedies obtained can be taken into consideration for improving the health of the plants.
The series of steps involved in arriving at the results are as follows:

1. After running the code, the first step in the simulation process that arrives at the results of the project involves selection of an image from the created dataset. Here, one image from the created dataset is selected as shown below:

Figure 5- Image taken during simulation process

2. After selecting an image from the dataset (shown in figure 4), analysis of the image is carried out:

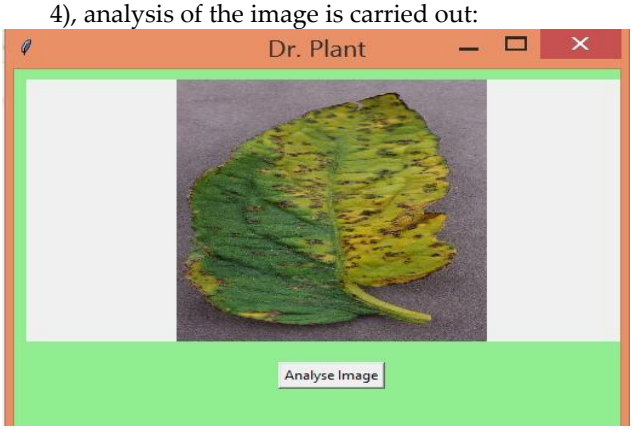

Figure 6-Image of Simulation Results of a leaf image (with Bacterial Spot) selected from Dataset.

3. After analysis of the selected image, the state of the image is found i.e. if the leaf is healthy or unhealthy.

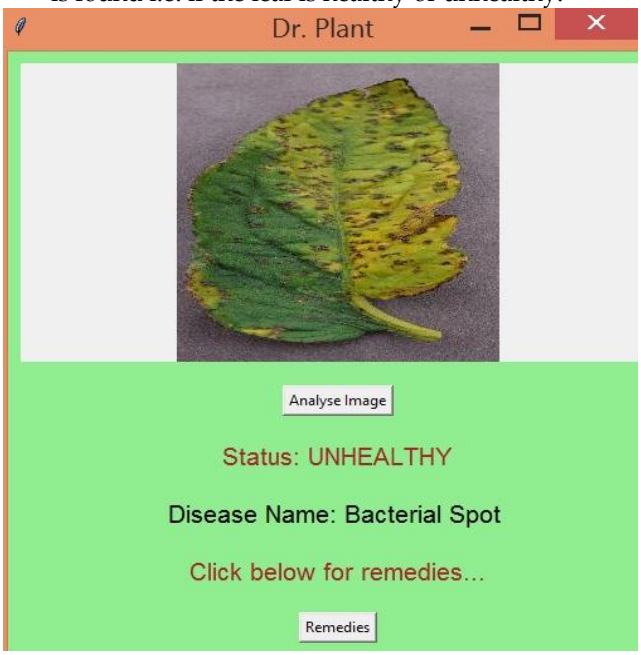

Figure 7- Image of Simulation Results of an leaf image (with Bacterial Spot) with the status of the leaf

4. If the state of the leaf is unhealthy, suitable remedies are provided i.e. preventive measure and use of suitable pesticide is recommended as shown below:

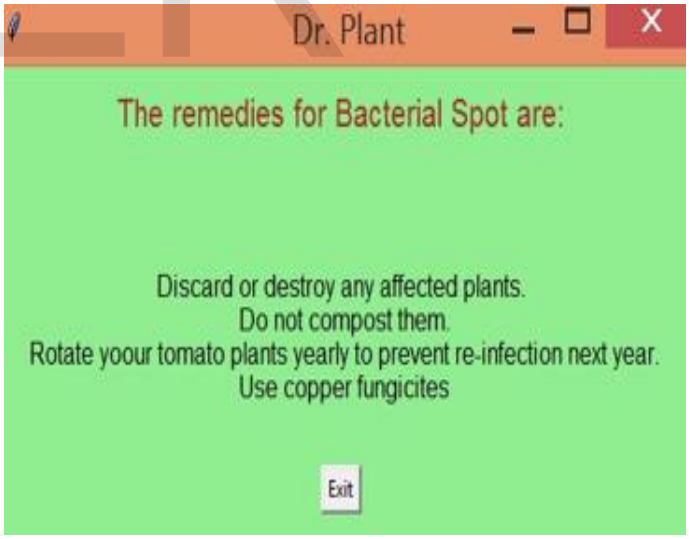

Figure 8- Image of Simulation Results of a leaf image (with Bacterial Spot) with the remedies to the disease.

Similarly, here are the results obtained for the disease Yellow Leaf Curl Virus (YLCV):

Figure 9- Image showing Simulation Results of leaf image with YLCV.

The remedies provides for YLCV are as shown below:

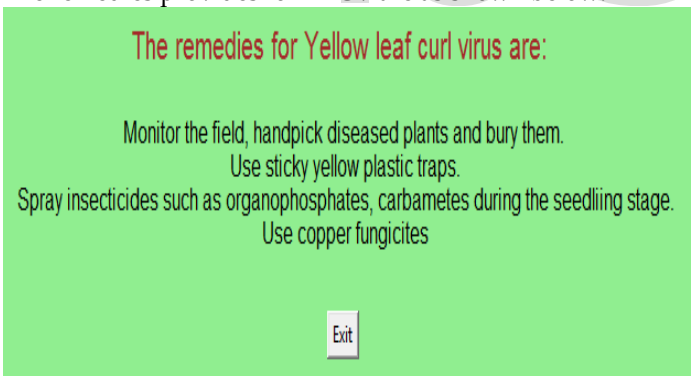

Figure 10- Image of Simulation Result showing remedies for YLCV

However, if the selected leaf image from the dataset turns out be a healthy image, the module states the same and does not offer any remedy for un-affected leaves:

Figure 11- Image of Simulation Result of an Healthy Leaf (selected from dataset)

5. CONCLUSION AND FUTURE WORK

The methodology has been implemented successfully and performance tested on the dataset has yielded accurate results. The leaf disease module is able to successfully identify diseases that occur most commonly in plants like the Bacterial Spot and Yellow Leaf Curl Virus. Likewise, the robot module (Agri-Bot) developed is able to automate agricultural practices easing the burden on farmers and hence making the labor intensive tasks of farmers less arduous.

Future Scope:

- The system developed can be installed on Drones so that aerial surveillances of crop fields can be done.
- The robotic modules can be build using machine vision for plant pathology and management, and emerging agricultural technologies.

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REFERENCES

[1] T.Bhavatarini, V.Priyadharshini, M.Radhakrishnan and C.Murale "A Machine Learning Approach for Plant Disease Classification and Pesticide Suggestion Using Rank Based Attribute Selection" International Journal of Scientific & Engineering Research, Volume 11, Issue 3, March-2020

[2] Adnan Mushtaq Ali Karol, Drushti Gulhane, Tejal Chandiwade "Plant Disease Detection using CNN & Remedy", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 8, Issue 3, March 2019.

[3] Suryavrat Rao, "IOT Based Smart Irrigation and Plant Disease Detection", " International Journal of Scientific & Engineering Research, Volume 10, Issue 1, January-2019 ,ISSN 2229-5518.

[4] Satjot Kaur, Kiranpreet Kaur,"The Classification and Feature Extraction Technique for Plant Disease Detection",
International Journal of Scientific & Engineering Research Volume 10, Issue 4, April-2019 878 ISSN 2229-5518

[5] Sandhya Tippannavar and Shridevi Soma, "A Machine Learning System For Recognition Of Vegetable Plant And Classification Of Abnormality Using Leaf Texture Analysis", International Journal of Scientific & Engineering Research Volume 8, Issue 6, June-2017, ISSN 2229-5518.

[6] Mrunalini R. Badnakhe and Prashant R. Deshmukh [4] "An application of K-Means Clustering and Artificial Intelligence in Pattern Recognition for Crop Diseases", *International Conference on Advancements in Information Technology, 2011, IPCSIT vol.20.*

[7] Picon, A. Alvarez-Gila, M. Seitz, A. Ortiz-Barredo, J. Echazarra, and A. Johannes, "Deep convolutional neural networks for mobile capture device-based crop disease classification in the wild," Computers and Electronics in Agriculture, vol. 161, pp. 280–290, Jun. 2019.

[8] S.Raj Kumar, S.Sowrirajan," Automatic Leaf Disease Detection and Classification using Hybrid Features and Supervised Classifier". International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 5, Issue 6, 2016.

[9] R. Pydipati, T. F. Burks, and W. S. Lee, "Identification of citrus disease using color texture features and discriminant analysis," *Computers and Electronics in Agriculture*, vol. 52, no. 1-2, pp. 49–59, 2006.

[10] Rangarajan, AravindKrishnaswamy, Raja Purushothaman, and Niirudh Ramesh. "Tomato crop disease classification using pre-trained deep learning algorithm." *Procedia computer science, Vol* 133, pp.1040-1047, 2018.

AUTHOR BIOGRAPHY

Mr. Nikhil R Bhardwaj is a student who is pursuing his B.Tech degree in the specialization of Electronics and Communication Engineering at REVA University, Bangalore, India. His research areas include Image Processing and Computer Vision.

Mr.Monish R is a student who is pursuing his B.Tech degree in the specialization of Electronics and Communication Engineering at REVA University, Bangalore, India. His research areas include Image Processing and Data Mining.

Mr. Mukesh S is a student who is pursuing his B.Tech degree in the specialization of Electronics and Communication Engineering at REVA University, Bangalore, India. His research areas include Computer Vison and Data Mining.

Mr. Sunil D M is working as an Assistant Professor in REVA University at Bangalore in India. He obtained his Bachelor's degree and Master's Degree from Visvesvaraya Technological University, Bangalore. His research areas include Image Processing, SQL, Artificial Intelligence and Database Management Systems.