Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 6 (2023)

Design and Analysis of a Machine learning based Agriculture bot

[1] Dr. Pradeep kumar N S, [2] Dr. Girish H, [3] B C Divakara, [4] Mrs. Swetha C S, [5] Mr Suhas S K, [6] Mrs.K Revathi

[1] Professor, Department of ECE, SEACET, Bangalore, Karnataka
[2] Professor, Department of ECE, Cambridge Institute of Technology, Bangalore, Karnataka
[3]Assistant Professor, Department of ECE, Global Academy of Technology, Bengaluru, Karnataka
[4]Assistant Professor, Department of MCA, BIT, Bengaluru, Karnataka
[5]Assistant Professor, Department of ECE, SEACET, Bangalore, Karnataka
[6]Assistant Professor, Department of ECE, SEACET, Bangalore, Karnataka

Abstract:- The detrimental impact of diseases on plants is a longstanding challenge, causing considerable harm and economic losses in crop yields. Mitigating these losses necessitates early disease detection, significantly enhancing product quality. Furthermore, accurate diagnosis is crucial to avoid the improper use of pesticides. The proposed system aims to revolutionize disease diagnosis in plants through the integration of image processing and artificial intelligence techniques, specifically applied to images of plant leaves. The system unfolds in two pivotal phases. In the initial phase, the plant is identified based on distinctive leaf features. This process encompasses the preprocessing of leaf images and feature extraction. Subsequently, an Artificial Neural Network (ANN) is employed for training and classification, enabling the system to recognize and categorize different plant species. The second phase focuses on disease classification within the identified plant. This intricate process involves K-Means-based segmentation to isolate defected areas on the leaf. Feature removal is then executed on the affected portions to extract disease-specific attributes. The final step entails an ANN-based classification, where the system accurately identifies and categorizes the type and severity of the disease afflicting the plant. The synergy of image processing and artificial intelligence in these two phases empowers the system to provide a comprehensive diagnosis. By ensuring accurate plant recognition and precise disease classification, the proposed system not only aids in curbing economic losses but also contributes to sustainable agriculture practices by promoting judicious pesticide use. This innovative approach heralds a new era in plant disease management, fostering improved crop yields and sustainable agricultural practices.

Keywords*: Artificial Neural Networks (ANN), Conventional Neural Networks (CNN), Artificial Intelligence (AI). Machine Learning, Agriculture bot.*

1. Introduction

Lorem The agricultural sector has witnessed remarkable progress in enhancing both the quality and quantity of food production. However, the persistent challenge of destructive insects and diseases affecting crops, particularly on leaves, poses a significant threat to the overall quality of agricultural products [1]. Unchecked infestations and delayed interventions can lead to a reduction in food production, triggering a cascade of adverse effects, including increased poverty, food insecurity, and mortality rates [2]. This impact is especially profound in nations where a substantial portion of the population relies on agricultural products for their livelihoods and sustenance [3].

Mitigating the growth of pests that negatively impact crop yields is a paramount concern for agriculturists. Pests, organisms that spread disease, cause damage, or become a nuisance, encompass a range of threats such as aphids, fungus, gnats, flies, trips, slugs, snails, mites, and caterpillars [4]. These pests can result in sporadic outbreaks of diseases, leading to famine and food shortages. Traditionally, farmers have manually detected pests through visual observation, a labor-intensive, inaccurate, and expensive task, particularly for large-scale farms [5]. The early detection of diseases on plants is crucial, as a small number of infected leaves can quickly spread the infection throughout an entire batch of fruits and vegetables, impacting storage and sales [6]. The consequences of plant diseases can be so devastating that some farmers are discouraged to the point of abandoning crop cultivation altogether [7]. Thus, there is a pressing need to identify these diseases early and provide solutions to minimize harm and increase

crop yields [8].
In this context, emerging technologies, such as plant recognition, crop yield estimation, and soil quality estimation, play a pivotal role. Image processing techniques, especially machine vision systems, offer an automated and efficient approach to leaf disease detection [9]. These techniques can significantly reduce computational time, enabling rapid and accurate identification of diseased leaves [10]. Looking ahead, the integration of digital image processing techniques in agriculture holds great promise. Farmers could benefit from consolidated views of their farms, along with decision support statistics for planning purposes. As climate change and sustainable agriculture become increasingly intertwined, addressing the challenge of efficient plant disease protection becomes imperative. In countries like India, where farmers cultivate a diverse range of crops, the presence of various pathogens in the environment severely impacts both crops and soil. Early identification of diseases on plant leaves, facilitated by advanced image processing techniques, marks a departure from traditional, time-consuming, and inaccurate observation methods. The convergence of agriculture and technology offers a pathway to more sustainable and resilient farming practices in the face of evolving challenges.

1.1 Image Processing

The definition of the Image processing involves the manipulation and analysis of images using mathematical and computational techniques. It plays a crucial role in various applications, including computer vision, medical imaging, remote sensing, and more. Here are some key basics of image processing they are Image Representation like pixel which is the basic building block of digital images. Pixels are the smallest controllable elements of an image. The number of pixels in an image determines its resolution. Higher resolution results in more detail. Image Types are as follows Binary Image: Consists of pixels that are either black or white (0 or 1). Grayscale Image: Each pixel has a different intensity level, usually represented by values ranging from 0 (black) to 255 (white). Color Image: Composed of multiple color channels (e.g., Red, Green, Blue).

1.2 Artificial Neural Networks

Artificial Neural Networks (ANNs) represent a computational paradigm inspired by the structure and functioning of the human brain. Artificial Neural Networks are computational models inspired by the structure and function of biological neural networks, such as the human brain. They are a fundamental component of machine learning and are used for tasks like pattern recognition, classification, regression, and more. The basic building blocks of an ANN are artificial neurons or nodes. Each node receives one or more inputs, processes them using a mathematical function, and produces an output. Neurons are organized into layers. The three main types of layers are: Input Layer receives initial data. Hidden Layer(s) are the Intermediate layers between the input and output layers where computations are performed. The Output Layer produces the final output. Connections between neurons have associated weights, which determine the strength of the connection. Biases are additional parameters that influence the output. Each neuron typically has an activation function that determines its output based on the weighted sum of inputs. Common activation functions include sigmoid, hyperbolic tangent (tanh), and rectified linear unit (ReLU).

ANNs operate in two main phases they are Feedforward and back propagation. In feedforward input data is passed through the network to produce an output. In backpropagation the network learns by adjusting weights and biases based on the error between predicted and actual output. This process is often guided by optimization algorithms like gradient descent. ANNs require training on labeled datasets. During training, the network learns to generalize patterns from the input data to make accurate predictions on new, unseen data. ANNs with multiple hidden layers are termed deep neural networks. Deep learning involves training deep neural networks to automatically learn hierarchical representations of data. ANNs may memorize training data and perform poorly on new data (overfitting). Regularization techniques are applied to prevent overfitting. A loss function measures the difference between predicted and actual output. During training, the goal is to minimize this loss. ANNs are used in various applications, including image and speech recognition, natural language processing, autonomous vehicles, healthcare, finance, and more.

1.3 Machine Learning Approach

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand- engineered, with enough training, ConvNets have the ability to learn these filters/characteristics.The architecture of a ConvNet is analogous to that of the connectivity pattern of Neurons in the Human Brain and was inspired by the organization of the Visual Cortex. Individual neurons respond to stimuli only in a restricted region of the visual field known as the Receptive Field. A collection of such fields overlap to cover the entire visual area.

The objective of the Convolution Operation is to extract the high-level features such as edges, from the input image. ConvNets need not be limited to only one Convolutional Layer. Conventionally, the first ConvLayer is responsible for capturing the Low-Level features such as edges, color, gradient orientation, etc [2]. With added layers, the architecture adapts to the High-Level features as well, giving us a network which has the wholesome understanding of images in the dataset, similar to how we would. Image recognition also known as classification is the first step done here. It is the process where an image is given to the neural network as an input and an output with a label for that image is expected. This is called as “feature extraction”, which is a vital ability of any neural network to extract minute details from an object.

2. Literature Survey

The existing literature on plant disease detection and diagnosis underscores the critical importance of addressing the detrimental impact of diseases on crops. The utilization of advanced technologies, such as image processing and artificial intelligence, has emerged as a promising avenue to revolutionize traditional methods. The proposed system's two-phase approach, involving plant identification and disease classification, aligns with contemporary research in the field. Several studies highlight the significance of early disease detection in enhancing crop quality and mitigating economic losses. The use of image processing techniques, including preprocessing and feature extraction, is a common thread in recent literature. These methods lay the foundation for accurate plant recognition, a crucial step in effective disease management. The integration of Artificial Neural Networks (ANN) in plant disease diagnosis resonates with current trends in machine learning applications for agriculture.

The ability of ANNs to learn and classify based on extracted features aligns with the proposed system's methodology. The emphasis on ANN-based disease classification, informed by features obtained through K-Means-based segmentation, reflects a nuanced understanding of the complexities involved in identifying and categorizing diseases. Furthermore, the literature acknowledges the drawbacks of manual disease detection methods, emphasizing the need for automated and accurate systems. The proposed system's aim to reduce reliance on manual observation and provide a consolidated view of plant health aligns with these identified gaps in existing practices.

The overarching theme in the literature survey revolves around leveraging technological advancements to address challenges in plant disease management. The proposed system contributes to this narrative by offering a comprehensive solution that integrates image processing and artificial intelligence, paving the way for sustainable and efficient agriculture practices.

Survey-1
The Design of General Purpose Autonomous Agricultural Mobile-Robot: “AGROBOT” Halil Durmuş Burak Berk Üstündağ in 2015, Purpose of this work is to increase the production efficiency in agricultural field by developing a mobile autonomous robot which has the capability of processing and monitoring field operations like spraying remedies for precision farming, fertilization, disease diagnosis, yield analysis, soil analysis and other agricultural activities.

Survey-2
A Low Power IoT Network for Smart irrigation: Soumil Heble, Ajay Kumar, et al. in 2018, `proposed a low- power, low-cost IoT network for smart agriculture. For monitoring of the soil moisture content, they have used an in- house developed sensor.

Survey-3
Performance Analysis of Multipurpose AGROBOT: Sharif Ullah Al- Mamun, Md. Rabiul Islam, Arpita Hoque in2019, The goal of the AGROBOT projectis the implementation of a robotic system for agricultural operations such as plowing the field, sowing seeds, spraying fertilizers, nutrition deficiency and controlled use of fertilizers and pesticides. The agricultural scientists are experimenting to replace tractor driven mechanization with robotic agriculture by introducing “AGROBOT”.

Survey-4
Machine Vision and Machine Learning for Intelligent Agrobots: A review Bini D, Pamela D, Shajin Prince in2020, A machine vision-based Agrobots along with artificial intelligence provides unmanned ground vehicle and unmanned aerial vehicle to navigate the path and to implement the agricultural task for minimizing labour and increasing quality food production.

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 6 (2023)

3. Overview

The adverse impact of plant diseases on agricultural productivity has long been a significant challenge, causing substantial economic losses and harm to crop yields. Addressing this challenge requires a paradigm shift toward early disease detection to enhance product quality and mitigate economic losses. Furthermore, precise and accurate diagnosis is essential to prevent the inappropriate use of pesticides, promoting sustainable agricultural practices. The proposed system represents a revolutionary approach to plant disease diagnosis, leveraging the integration of cutting-edge image processing and artificial intelligence techniques, specifically tailored for images of plant leaves. The system unfolds in two pivotal phases, each contributing to a comprehensive and accurate diagnosis:

In this initial phase, the system focuses on identifying the plant based on distinctive features extracted from leaf images. The process encompasses advanced preprocessing techniques applied to leaf images, facilitating the extraction of relevant features. Subsequently, an Artificial Neural Network (ANN) is employed for rigorous training and classification, enabling the system to recognize and categorize different plant species with high accuracy.
Disease Classification Phase:

Following successful plant identification, the system delves into the intricacies of disease classification within the identified plant. This phase involves sophisticated processes, including K-Means-based segmentation to isolate defected areas on the leaf. Feature removal is then executed on the affected portions, extracting disease-specific attributes crucial for accurate classification. The final step employs an ANN-based classification system, where the system precisely identifies and categorizes the type and severity of the disease afflicting the plant.
The synergy of advanced image processing and artificial intelligence techniques in these two phases empowers the system to provide a comprehensive and precise diagnosis. By ensuring accurate plant recognition and disease classification, the proposed system not only contributes to curbing economic losses but also promotes sustainable agriculture practices by facilitating judicious pesticide use. This innovative approach heralds a new era in plant disease management, fostering improved crop yields and sustainable agricultural practices for the future.

Fig 1: Pictorial representation of the Agribot

Fig 2: Demo Model of Agribot

4. Research Objectives

The research objectives of the proposed system are:
Develop an Integrated System
Accurate Plant Recognition
Disease Classification
K-Means-Based Segmentation
Feature Extraction
ANN-Based Classification
Comprehensive Diagnosis System
Economic Loss Mitigation
Promote Sustainable Agriculture Practices
Innovation in Plant Disease Management

5. Literature Survey

The results of previous studies under review include driving and steering aspects of smart wheelchair control. The topic of controlling a wheelchair using a variety of methods—including brain waves, tongue-drivensystems, face movement control, and hand gesture control—is covered. A Health Monitoring System that may befitted into a wheelchair and uses a range of sensors was only briefly discussed in a few articles. There is a researchpotential due to the accessibility of inexpensive sensors and the paucity of in-depth research on health-monitoringsmart wheel-chairs.

The selection of a wheelchair is challenging and dependent on a number of factors, including the user's pathology, morphology, rate of evolution, and surroundings (at home, in the office, etc.). As a result, there is no such thing as a "model" wheelchair. As a result, the wheelchair is chosen based on both financial and technological considerations. Where one force sensor is positioned for every zonal pressure area, then the force sensor (each one) in the module could be identified [7][8].

A overview of the various types of smart wheel chairs is accessible in Sibai & Manap's research work. They also talk about joy-stick steering's, head / chin / tongue movements, and gaze / face direction on the HMI. Sip and Puff Technology, EEG (Brain Signals), Voice Input, Hand Gesture Control, Navigation Methods & Devices, and Future Work on Health Monitoring are all discussed in the study. For those with severe disabilities, Kim et al. discuss a Smart Wheel Chair with a Tongue Driven System (TDS). Purnomo et al., explore upcoming technologies and recent developments in Pervasive Biomedical Engineering [9][10].

6. Methodology

The working module is shown in the below fig 3. The plant is first captured by the camera which is connected to the raspberry pi. The captured image is processed in the raspberry pi4 model. The raspberry pi can be considered as minicomputer [1]. The raspberry pi is programmed to detect whether the plant is healthy or it is infected by a disease. If the plant is said to be infected, then which type of disease the plant is suffering from is also checked, using different machine learning algorithms and the datasets. The raspberry pi compares the input data with the standard data provided in the dataset and hence the disease is detected from which the plant is suffering. The raspberry pi camera takes the image as the input. The raw input is then sent to the raspberry pi for processing the image. An image is made up of pixels arranged in a form of square matrix, a two-dimensional view having coordinates as x and y.

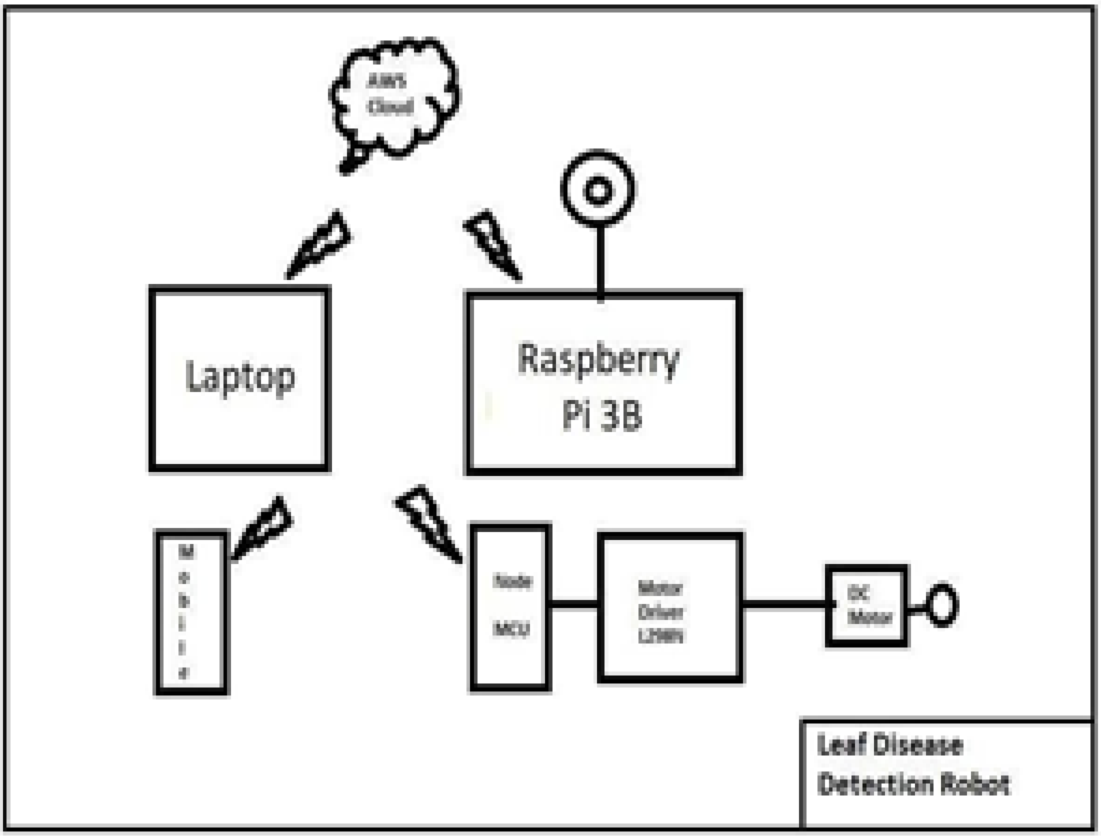

Fig 3: Block Diagram of working Module

The agrobot will survey the crop by scanning the image of the crop through the raspberry pi camera. The camera takes the image as input for raspberry pi and starts with the pre- processing which include the elimination of the undesirable distortions from the image. The raspberry pi then extracts the features of the image and proceed with the classification of the image as a normal or abnormal one [4].

If the image is classified to be normal then the crop is not infected whereas if the image is classified as abnormal then it detects the disease with which the plant is suffering. The classification is done by using the machine learning algorithms which checks the feature extracted image with the training dataset whose prediction accuracy is checked by the test dataset [3] as soon as the disease is detected.

7. Results & Discussion

Image Aquisition

The images are obtained using the digital camera that is connected to the Latte panda as shown in fig 4. The images captured are subjected to further preprocessing. For each observation of an individual leaf, we systematically varied the following image factors: perspective, illumination, and background. We captured two perspectives per leaf in-situ and in a non- destructive way: the top side and the back side, since leaf structure and texture typically substantially differ between these perspectives. If necessary, we used a thin black wire to arrange the leaf accordingly [5].

Fig 4: Image Acquisition

Image Preprocessing

The images obtained from the camera are subjected to preprocessing for increasing the quality of the images. The preprocessing steps may include color transformation, noise removal, histogram equalization, green masking etc as shown in fig 5. Here we use the technique of color transformation for increasing the quality of the image .Conversion of RGB image into Grey and also HSI to increase the quality.

Fig 5: Image preprocessing

Image Segmentation

Image segmentation are of many types such as clustering, threshold, neural network based and edge based. In this implementation we are using the clustering algorithm called mean shift clustering for image segmentation. This algorithm uses the sliding window method for converging to the center of maximum dense area. This algorithm makes use of many sliding windows to converge the maximum dense region.

Fig 6: Image segmentation

8. Applications, Advantages, Outcome and Limitations

Applications:

Agriculture Sector Enhancement: The proposed system significantly contributes to the agricultural sector by providing early and accurate disease diagnosis, leading to enhanced crop yield and quality.
Economic Loss Mitigation: By curbing the detrimental impact of plant diseases, the system aids in minimizing economic losses associated with crop damage.
Precision Agriculture: Enables farmers to adopt precision agriculture practices by targeting specific areas affected by diseases, optimizing resource utilization.

Advantages:

- Early Disease Detection: Facilitates early detection of diseases, preventing the spread and severity of infections in crops.
- Accurate Diagnosis: The integration of image processing and artificial intelligence ensures precise plant recognition and disease classification.
- Sustainable Practices: Contributes to sustainable agriculture by promoting judicious use of pesticides, reducing environmental impact.
- Improved Crop Yields: Revolutionizes plant disease management, fostering improved crop yields and overall agricultural productivity.

Outcome:

The proposed system aims to achieve several outcomes:

Improved Plant Health Management:

- Enhanced tools for managing plant health.
- Minimizes the detrimental impact of diseases on plants, leading to improved overall crop health.

Economic Loss Mitigation:

- Early disease detection and precise diagnosis.
- Reduces economic losses by preventing the spread of diseases and optimizing the use of pesticides.

Sustainable Agriculture Practices:

- Judicious use of pesticides and efficient disease management.
- Promotes sustainability by minimizing environmental impact and supporting responsible agricultural practices.

Innovative Disease Management Approach:

- Integration of image processing and artificial intelligence.
- Represents a cutting-edge and innovative approach to plant disease management, fostering improved crop yields.

Comprehensive Diagnosis:

- Accurate plant recognition and disease classification.
- Provides a comprehensive diagnosis, ensuring targeted and effective treatment strategies.

Technological Advancement in Agriculture:

- Integration of advanced technologies like image processing and AI.
- Positions agriculture at the forefront of technological advancement, offering modern solutions to age-old challenges.

9. Conclusive Remarks

India is a global agricultural power house where the most of the farmers are failed to implement new strategies from the containment of the leaf disease. Leaf disease is a wide spread infectious disease which affects the whole crop on the fields by spreading. To overcome this problem faced by farmers in leaf disease recognition. We are using robotics that is agricultural surveillance robot which will help farmers to clear out their problems regarding the leaf disease by the working process as discussed in this paper which will ever reduce the man power and also time and helps the farmers to spray the pesticides on time so that they can overcome the loss faced by them due to leaf disease. Also these robots go way ahead for the future use. The robot is controlled by using android application.

In the proposed system, the leaf disease detection was only constricted to a specific disease in the proposed system. The number of diseases to be identified can be extended for more diseases in future with the development of the robot. In future the robot can be integrated with another machine learning. It can also be fixed with another camera that can be used for navigational purpose and later robot will be trained to navigate through the entire field and later it is allowed to move independently and take actions.

10. Advantages & Scope for Future Works

The use of agricultural surveillance robots enhances precision in disease detection and treatment. This targeted approach minimizes resource usage, such as pesticides, and reduces environmental impact. Robots can operate continuously and cover large areas, ensuring timely detection and treatment of leaf diseases. This efficiency leads to better crop health and increased yields. Automation reduces the dependency on manual labor for tasks like disease detection and pesticide spraying. This can alleviate the labor shortage issues faced by farmers. While the initial investment in robotic technology is significant, the long-term cost benefits arise from optimized resource utilization and increased crop productivity. Robots equipped with advanced imaging systems can detect leaf diseases in their early stages, allowing for prompt intervention. Early detection is crucial for effective disease management. Farmers can remotely monitor their fields using the mobile application, providing real-time insights into crop health and disease status. This remote accessibility is convenient for farmers. The robot's capabilities can be customized based on the specific needs of different crops and regions. This adaptability makes it suitable for diverse agricultural scenarios. Expand the capabilities of the robotic system to identify and differentiate between various leaf diseases. Integration with advanced machine learning algorithms can enhance disease recognition accuracy. Incorporate additional sensors, such as infrared or hyperspectral cameras, for more comprehensive data collection. This can provide insights beyond visible symptoms and aid in early disease detection. Integrate advanced navigation systems to enable robots to navigate autonomously through fields. This can include obstacle detection and avoidance for efficient coverage. Train the robot to learn from field data over time. Implement machine learning algorithms that continuously improve disease recognition accuracy based on evolving patterns. Explore the possibility of deploying multiple robots that collaborate and share information. This collaborative approach can cover larger areas and improve overall efficiency. Work on developing energy-efficient robotic systems, possibly incorporating renewable energy sources, to ensure prolonged operation in the field. Design the robotic system to be scalable, allowing farmers to deploy multiple robots based on the size of their agricultural land. Integrate the robotic system with precision farming techniques, incorporating data analytics and decision support systems for comprehensive farm management.

Refrences

[1] G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. (references) M. Sardogan, A. Tuncer and Y. Ozen, "Plant Leaf Disease Detection and Classification Based on CNN with LVQ Algorithm," 2018 3rd International Conference on Computer Science and Engineering (UBMK), 2018,

pp. 382-385.

[2] D. Bini, D. Pamela and S. Prince, "Machine Vision and Machine Learning for Intelligent Agrobots: A review" 2020 5th International Conference on Devices, Circuits and Systems (ICDCS), 2020, pp. 12- 16.

[3] G. M. Sharif Ullah Al- Mamun et al., "Performance Analysis of Multipurpose AGROBOT," 2019 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), 2019, pp. 1-4.

[4] H Durmuş, E. O. Güneş, M. Kırcı and B. B. Üstündağ, "The design of general purpose autonomous agricultural mobile-robot: "AGROBOT"," 2015 Fourth International Conference on Agro- Geoinformatics (Agro- geoinformatics),2015,pp.49-53.

[5] N G. Kurale and M. V. Vaidya, "Classification of Leaf Disease Using Texture Feature and Neural Network Classifier," 2018 International Conference on Inventive Research in Computing Applications (ICIRCA),2018,pp. 1-6.

[6] H. Girish, T. G. Manjunat and A. C. Vikramathithan, "Detection and Alerting Animals in Forest using Artificial Intelligence and IoT," 2022 IEEE Fourth International Conference on Advances in Electronics, Computers and Communications (ICAECC), 2022, pp. 1-5, doi: 10.1109/ICAECC54045.2022.9716679.

[7] A. Devipriya, H. Girish, V. Srinivas, N. Adi Reddy and D. Rajkiran, "RTL Design and Logic Synthesis of Traffic Light Controller for 45nm Technology," 2022 3rd International Conference for Emerging Technology (INCET), 2022, pp. 1-5, doi: 10.1109/INCET54531.2022.9824833.

[8] S. Vaddadi, V. Srinivas, N. A. Reddy, G. H, R. D and A. Devipriya, "Factory Inventory Automation using Industry 4.0 Technologies," 2022 IEEE IAS Global Conference on Emerging Technologies (GlobConET), 2022, pp. 734-738, doi: 10.1109/GlobConET53749.2022.9872416.

[9] T G Manjunath , A C Vikramathithan , H Girish, "Analysis of Total Harmonic Distortion and implementation of Inverter Fault Diagnosis using Artificial Neural Network", Journal of Physics: Conference Series, Volume 2161, 1st International Conference on Artificial Intelligence, Computational Electronics and Communication System (AICECS 2021) 28-30 October 2021, Manipal, India. https://iopscience.iop.org/issue/1742-6596/2161/1

[10] GIRISH H , "Internet of Things Based Heart Beat Rate Monitoring System", © September 2022 | IJIRT | Volume 6 Issue 4 | ISSN: 2349-6002 IJIRT 156592 INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN TECHNOLOGY 227

[11] Dr Girish H, Dr. Mangala Gowri , Dr. Keshava Murthy , Chetan Naik J, Autonomous Car Using Deep Learning and Open CV, PAGE NO: 107-115, VOLUME 8 ISSUE 10 2022, Gradiva review journal, ISSN NO : 0363-8057, DOI:10.37897.GRJ.2022.V8I8.22.50332

[12] Girish H. "Intelligent Traffic Tracking System Using Wi-Fi ." International Journal for Scientific Research and Development 8.12 (2021): 86-90.

[13] Girish H, Shashikumar D R, "Emission monitoring system using IOT", Dogo Rangsang Research Journal, UGC Care Group I Journal, ISSN: 347-7180, Vol – 8 Issue-14, No.6, 2020.

[14] Girish H, Shashikumar D R, "Display and misson computer software loading", International journal of engineering research & Technology (IJERT), ISSN: 2278-0181, Vol – 10 Issue-08, No.13, August 2020.

[15] Girish H, Shashikumar D R, "A Novel Optimization Framework for Controlling Stabilization Issue in Design Principle of FinFET based SRAM", International Journal of Electrical and Computer Engineering (IJECE) Vol. 9, No. 5 October 2019, pp. 4027~4034. ISSN: 2088-8708, DOI: 10.11591/ijece.v9i5.pp.4027-4034

[16] Girish H, Shashikumar D R, "PAOD: a predictive approach for optimization of design in FinFET/SRAM", International Journal of Electrical and Computer Engineering (IJECE) Vol. 9, No. 2, April 2019, pp. 960~966. ISSN: 2088-8708, DOI: 10.11591/ijece.v9i2.pp.960-966

[17] Girish H, Shashikumar D R, "SOPA: Search Optimization Based Predictive Approach for Design Optimization in FinFET/SRAM", © Springer International Publishing AG, part of Springer Nature 2019 Silhavy (Ed.): CSOC 2018, AISC 764, pp. 21–29, 2019. https://doi.org/10.1007/978-3-319-91189-2_3.

[18] Girish H, Shashikumar D R, "Cost-Effective Computational Modelling of Fault Tolerant Optimization of FinFET-based SRAM Cells", © Springer International Publishing AG 2017 R. Silhavy et al. (eds.),

Cybernetics and Mathematics Applications in Intelligent Systems, Advances in Intelligent Systems and Computing 574, DOI 10.1007/978-3-319-57264-2_1.

[19] Girish H, Shashikumar D R, “A Survey on the Performance Analysis of FinFET SRAM Cells for Different Technologies”, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-4 Issue-6, 2016.

[20] Girish H, Shashikumar D R, “Insights of Performance Enhancement Techniques on FinFET-based SRAM Cells”, Communications on Applied Electronics (CAE) – ISSN: 2394-4714, Foundation of Computer Science FCS, New York, USA .Volume 5 – No.6, July 2016 – www.caeaccess.org

[21] Girish H, Shashikumar D R, “DESIGN OF FINFET”, International Journal of Engineering Research ISSN: 2319-6890) (online), 2347-5013(print) Volume No.5 Issue: Special 5, pp: 992-1128, doi: 10.17950/ijer/v5i5/013 2016.

[22] Dr. MANGALA GOWRI S G, Dr. SHASHIDHAR T M, Dr. SUNITHA R, SHYLAJA V, Dr. GIRISH H, “DESIGN OF 3-BIT CMOS WALLACE MULTIPLIER” , Seybold report, ISSN 1533-9211, Volume 18, Page No: 1260-1271 DOI: 10.5281/zenodo.8300481

[23] Dr. Mangala Gowri S G, Dr. Girish H, Ramesh N, Dr. Nataraj Vijaypur, “IOT based plant monitoring system and smart irrigation using new features” ResMilitaris, vol.13, n°2, January Issue 2023 https://resmilitaris.net/menu-script/index.php/resmilitaris/article/view/3312/2608

[24] Girish H.2023, Smart Theft Securityvehicular System Using Iot. Int J Recent Sci Res. 14(02), pp. 2881-2884. DOI: http://dx.doi.org/10.24327/ijrsr.2023.1402.0591

[25] Dr. Mangala Gowri S G, Dr. Girish H, Dr. Santosh Dattatray Bhopale, Weed Detection based on Neural Networks, International Journal of All Research Education and Scientific Methods (IJARESM), ISSN: 2455-6211 Volume 11, Issue 3, March-2023, Impact Factor: 7.429, Available online at: www.ijaresm.com DOI: https://doi.org/11.56025/IJARESM.2023.11323351

[26] Shashidhara, K.S., Girish, H., Parameshwara, M.C., Rai, B.K., Dakulagi, V. (2023). A Novel Approach for Identification of Healthy and Unhealthy Leaves Using Scale Invariant Feature Transform and Shading Histogram-PCA Techniques. In: Shetty, N.R., Patnaik, L.M., Prasad, N.H. (eds) Emerging Research in Computing, Information, Communication and Applications. Lecture Notes in Electrical Engineering, vol 928. Springer, Singapore. https://doi.org/10.1007/978-981-19-5482-5_47