AUTOMATIC CROP MONITORING SYSTEM USING ML AND RASPBERRY PI

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ABSTRACT –With the daily increase of Internet of Things (IoT) devices, which have reached tens of billions these days. The term IoT has become popular and available in our daily life even if we sometimes don't know and feel that. This work presented a friendly IoT system to help farmers, especially in the rural areas to visualize their farm data remotely, results in saving time, increasing crops productivity, and irrigating precisely. Everyone is capable to cultivate with the help of this system, contributing in solving issues like farmers leaving agriculture for mining. The design is done by using Wi-fi IoT platform to connect the physical devices in the field with the user mobile application, which makes the farmer visualizing the data. Raspberry pi 3b+ is the controller that is responsible for all processes such as sending and receiving the data with the help of sensors of temperature and humidity, soil moisture, Passive Infrared (PIR), and camera, in addition to DHT11, LDR. This system capable to perform three operations, firstly Soil Testing, which will help us to Provide the Suitable Crop. Secondly, Weather Monitoring With the help of DHT11(Temperature and Humidity) and LDR Sensors. Finally, objects detection, if there is any motion in the field, the system directly informs the user with a notification in the mobile application, and simultaneously the Live camera and the machine learning algorithm responsible for detecting the objects and tells the user via mobile application exactly which type of an object. With the Help of Rover, the Entire Crop Will be Monitor.

Key words: Machine Learning, Raspberry PI, Python.

I. INTRODUCTION

Agriculture, the backbone of civilization, encapsulates the cultivation of crops and the raising of livestock for human sustenance and economic prosperity. Spanning millennia, it has been the cornerstone of human progress, enabling societies to flourish by providing food security, raw materials, and livelihoods. From the dawn of agriculture in ancient Mesopotamia to the modern agribusinesses of today, it has evolved through innovation, technology, and scientific advancements. Agriculture encompasses diverse practices, including crop production, animal husbandry, forestry, and aquaculture, each contributing to the multifaceted tapestry of food production. With the global population swelling and environmental challenges looming, the future of agriculture hinges on sustainable practices, harnessing innovation to ensure food security while safeguarding the planet's resources for generations to come.

Agriculture is not merely a means of producing food; it is a complex interplay of ecological, economic, and social factors that shape landscapes and livelihoods. It involves the careful management of natural resources such as soil, water, and biodiversity to optimize productivity while minimizing environmental degradation. Traditional farming methods, passed down through generations, coexist with cutting-edge technologies like precision agriculture and genetic engineering, driving efficiency and productivity to new heights. Moreover, agriculture serves as a nexus for rural development, shaping communities and economies around the world. Its significance extends beyond the farm gate, influencing trade, policy-making, and global food security. As we navigate the challenges of climate change, resource scarcity, and demographic shifts, agriculture stands poised at the forefront of sustainable development, offering solutions to feed a growing population while preserving the planet for future generations.

II. LITERATURE SURVEY

Automatic crop monitoring systems employing machine learning algorithms and Raspberry Pi technology have emerged as promising tools in precision agriculture. These systems integrate various sensors to collect real-time data on environmental parameters such as soil moisture, temperature, and humidity. Machine learning algorithms are then deployed to analyze this data and provide insights into crop health, growth patterns, and potential issues like pest infestation or nutrient deficiencies. The Raspberry Pi serves as the central processing unit, facilitating data acquisition, storage, and analysis in a compact and cost-effective manner. By harnessing the power of machine learning, these systems can accurately predict crop yields, optimize resource allocation, and enable timely interventions to maximize productivity. Moreover, the scalability and affordability of Raspberry Pi make such systems accessible to small-scale farmers, empowering them with actionable insights to enhance agricultural practices and ensure food security. However, challenges such as data accuracy, model robustness, and scalability remain areas for further research and development in the field of automatic crop monitoring systems.

Mengzhen Kang; Fei-Yue Wang, explain in this paper that the concept of Knowledge Data Driven Model (KDDM)is used for new generation of smart agriculture which break the bottleneck of model application from laboratory environment to real world [2].

Yun Shi, Zhen Wang, XianfengWang, Shanwen Zhang**,** explain in this paper introduce the concept of Internet of things (IoT). plant diseases and insect pests causes significant reduction in quality as well as quantity of agricultural product so plant disease and insects pests forecasting are of great significance and quite necessary. By using machine learning algorithm, the main objective is to achieve the disease and insect pests monitoring information and collection of IoT.[9]

Carlos Cambra, Sandra Sendra, Jaime Lloret, Laura Garcia, explain in this paper present the design of a smart IoT communication system manager used as a low-cost irrigation controller. It shows how IoT, aerial images and SOA can be applied to large and smart farming system. Data is processed in smart cloud service based on the Drools Guvnor.[4]

Dr N. Suma, Sandra Rhea Samson, S. Saranya, G. Shanmugapriya, R.Subhashri, explain in this project includes various features like GPS based remote controlled monitoring, moisture and temperature sensing, intruders scaring, security, leaf wetness and proper irrigation facilities. It makes use of wireless sensor networks for noting the soil properties and environmental factors continuously.[5]

Xin Zhao, Haikun Wei, Chi Zhang, Kanjian Zhang, explain in this paper proposed a short-term wind speed for-casting model with samples selection by a new active learning algorithm. Active learning is used in sample selection for machine learning. In this study active learning was useful for applications characterized by a large number of training sample in wind speed prediction [6]

Giritharan Ravichandran, Koteeshwari R S, explain in this paper Artificial Neural Network is used which is one of the most effective tools in modeling and prediction. Feed forward Back Propagation Network is used together to implement the Artificial Neural Network. The proposed system is made as an Android Application, where the user could feed the inputs and obtain the desirable application.[7]

Harshal Waghmare, Radha Kokare**,** explain in this paper support vector machine and decision support system is used to identification of plant disease through the leaf texture analysis and pattern recognition. Decision Support Systems (DSS) for agriculture is based on the technology that can be useful for farmers and help to increase the agricultural productivity .by this paper we come to know that the DSS is time saving, enhance effectiveness, increase decision maker satisfaction [8]

Hemantkumar Wani, Nilima Ashtankar, explain in this paper machine learning algorithm is fitted for the prediction of diseases using naïve Bayes kernel algorithm. Naive Bayes kernel model where we are understanding correlation pattern between real time data and existing data set. Naïve Bayes kernel algorithm is for the classification of data sensed from the sensors.[3]

Snehal S. Dahikar, Prof. Dr. Sandeep V.Rode,Prof. Pramod Deshmukh**,** explain in this India farming is the main Occupation. Above 70% business are depending on farming. In these paper Artificial Neural Network technology was used. The intelligent system has brought artificial neural network (ANN) to become a new technology which provides assorted solution for the complex problem in agriculture researches. This project only presented the most commonly used type of ANN, which is the feed forward back propagation network. Here the ANN is used for the proper crop for particular soil and also suggesting proper fertilizer for that crop.[10]

In [1], a smart GPS based remote controlled robot to perform tasks like weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. All the operations will be controlled by any remote smart device connected to Internet and the operations will be recognized by interfacing sensors, Wi-Fi or camera, ZigBee modules, and actuators with raspberry pi and. micro-controller.

A smart agriculture system [2] using wireless sensor network. Different types of sensors are used to receive the information about crop conditions and environmental changes. This information is transmitted through network to the farmer and devices that starts corrective actions. Farmers are connected with network and aware of the agricultural field conditions at anytime from anywhere in the world.

A Smart agriculture System [3] that uses advantages of cutting-edge technologies such as Arduino, IOT and Wireless Sensor Network. Monitor temperature, humidity, moisture and even the movement of animals which may destroy the crops in agricultural field through sensors using Arduino boar

III. METHODOLOGY

The methodology for developing an automatic crop monitoring system using machine learning (ML) and Raspberry Pi involves several key steps aimed at data collection, processing, analysis, and actionable insight generation. Firstly, the system requires the integration of various sensors such as temperature, humidity, soil moisture, and perhaps even imaging sensors for visual data. These sensors are connected to the Raspberry Pi, which serves as the central processing unit. Once the data is collected, it needs to be preprocessed to remove noise and inconsistencies. This preprocessing step is crucial for ensuring the accuracy and reliability of the subsequent ML algorithms. Next, ML algorithms are trained using historical data to recognize patterns indicative of crop health, growth stages, and potential issues like pest infestation or nutrient deficiencies. Supervised learning techniques such as classification and regression may be employed for this purpose.

The trained ML models are then deployed on the Raspberry Pi for real-time data analysis. This involves continuous monitoring of sensor inputs and running the ML algorithms to generate insights about the crop's status. The system may incorporate thresholds or rules based on the ML model outputs to trigger alerts or interventions when certain conditions are met. For example, if the ML model detects signs of water stress based on soil moisture and temperature data, it could send an alert to the farmer to initiate irrigation.

Additionally, the system should have a user-friendly interface that allows farmers to visualize the collected data, monitor the crop's progress, and receive actionable recommendations. This interface could be web-based or accessible through a mobile application. Through-out the development process, rigorous testing and validation are essential to ensure the system's accuracy, reliability, and scalability across different crop types and environmental conditions. Furthermore, the system should be designed with scalability and affordability in mind to make it accessible to small-scale farmers who may have limited resources.

Continuous monitoring and iterative improvements based on user feedback and technological advancements are necessary to enhance the system's performance and effectiveness over time.

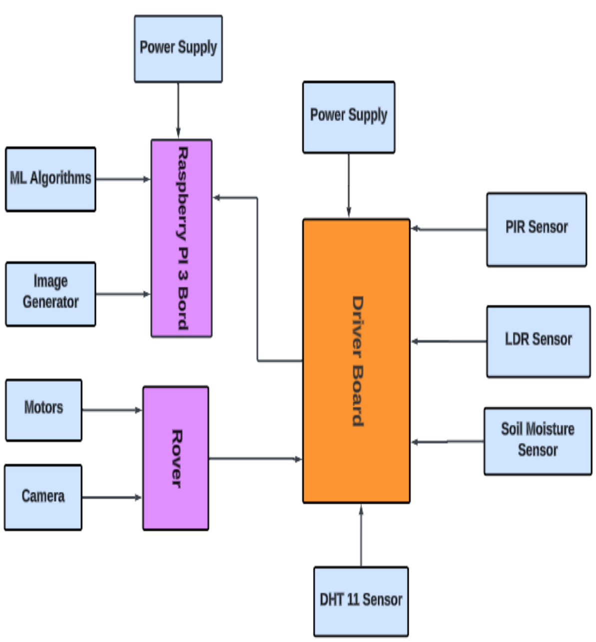


Fig 1: Block Diagram

IV. COMPONENTS REQUIRED

Raspberry pi 3B+:

Raspberry Pi is a microprocessor board, based on the Broadcom BCM2837, is a 64-bit ARMv7 Quad Core Processor. It has 40 general purpose input/output pins, USB ports, LAN port (Ethernet port), a Micro SD card slot, a DSI display port, a micro-USB power input, a composite video and audio output jack, a CSI camera port, and a HDMI video output. It contains everything needed to support the microprocessor. Connect it to a computer in which Raspbian OS is installed and power it with an adapter. Raspberry Pi 3 model B differs from all preceding boards in that it does not have an on-board WIFI, Bluetooth and USB boot capabilities. The Pi 3 is roughly 50% faster than all preceding boards. “Raspberry” is a reference to a fruit naming tradition in the old days of microcomputers. A lot of computer companies were named after fruit. “Pi” is because we are going to produce a computer that could only really run Python. So, the ‘Pi’ is for Python.

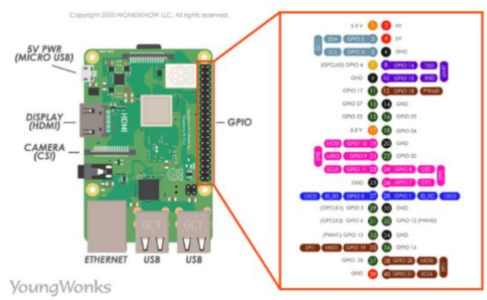


Fig 2: Raspberry PI 3b+

Ethernet:

The Ethernet connection on a Raspberry Pi provides reliable and high-speed networking capabilities essential for various projects. Utilizing an RJ45 connector, it allows users to establish wired connections to routers, switches, and other network devices.

Fig 3: Ethernet

With Ethernet, the Raspberry Pi can seamlessly access the internet, share files across local networks, and communicate with other devices. This wired connection offers stability and consistent data transfer rates, ideal for tasks requiring uninterrupted network access.

PIR Sensor:

A PIR (Passive Infrared) sensor is a type of motion sensor that detects infrared radiation emitted by objects in its field of view. It’s commonly used in security systems, automatic lighting, and other applications where detecting motion is important. When it detects motion, it sends a signal to trigger an action, such as turning on lights or sounding an alarm.

Fig 4: PIR Sensor

DHT 11 Sensor:

The DHT11 sensor is a compact and cost-effective digital temperature and humidity sensor widely used in various applications, particularly in the field of electronics and IoT (Internet of Things). Developed by a strong Electronics, this sensor is designed to provide accurate and reliable measurements of temperature and relative humidity. The DHT11 sensor consists of a humidity sensing component, a temperature measuring component, and an integrated analog-to digital converter and signal conditioning circuitry. It communicates with micro controllers through a single-wire digital interface, making it easy to integrate into projects. With its simplicity, affordability, and ability to provide basic environmental data, the DHT11 sensor is a popular choice for weather stations, home automation systems, and other projects where monitoring temperature and humidity is essential.

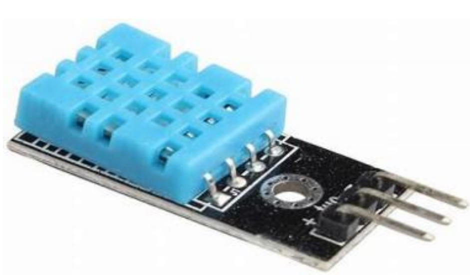


Fig 5: DHT 11 Sensor

Soil Moisturization Sensor:

A soil moisture sensor is an electronic device designed to measure and monitor the moisture content of soil. These sensors are invaluable tools in agriculture, gardening, and environmental monitoring. They typically consist of probes or sensors that are inserted into the soil at different depths to measure the water content. The sensor uses various methods to assess soil moisture, with the most common being electrical conductivity or capacitance. In the case of electrical conductivity-based sensors, they measure the electrical resistance of the soil, which is inversely proportional to its moisture content. As the soil becomes wetter, its electrical resistance decreases, and the sensor can provide accurate readings.

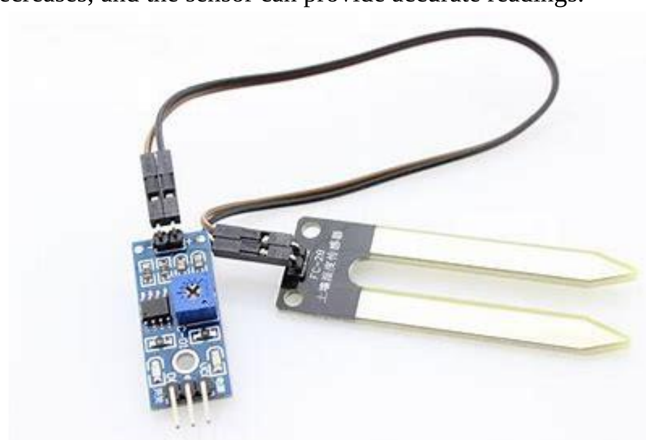


Fig 6: Soil Moisturization Sensor

LDR Sensor:

A Light Dependent Resistor (LDR), also known as a photo resistor, is an electronic component that exhibits changes in its electrical resistance in response to varying levels of incident light. This means that the resistance of an LDR decreases as the ambient light intensity increases, and conversely, it increases as the light level decreases. LDRs are typically made from semiconductor materials and rely on the principle of photo conductivity. When exposed to light, photons energize the semiconductor's electrons, allowing them to move more freely and reducing the resistance. This change in resistance can be measured and utilized in various applications, such as automatic street lighting, daylight sensing for indoor lighting control, and in photography equipment for adjusting exposure settings. LDRs are simple and cost-effective light sensors, making them a popular choice for a wide range of applications that require light-dependent control and automation.

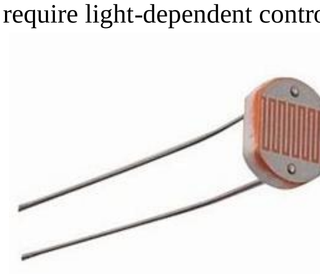


Fig 7: LDR Sensor

Motors:

DC Motors: Direct current (DC) motors are commonly used in rovers due to their simplicity and ease of control. They can be controlled using pulse-width modulation (PWM) for speed control and can provide sufficient torque for driving the rover over various transferals DC (BLDC) Motors: BLDC motors offer higher efficiency and better performance compared to brushed DC motors. They are often used in more advanced rovers that require higher speeds and precision control.

Fig 8: Motor

Camera:

All cameras use the same basic design: light enters an enclosed box through a converging or convex lens and an image is recorded on a light-sensitive medium. A shutter mechanism controls the length of time that light enters the camera.

Fig 9: Camera

Wheels:

The motor selection may vary based on the rover's wheel configuration. For example, a 4-wheel drive (4WD) rover will require four motors, one for each wheel, while a 2-wheel drive (2WD) rover may only require two motors. Differential steering systems may require motors with different speed and torque characteristics to enable precise control and maneuverability.

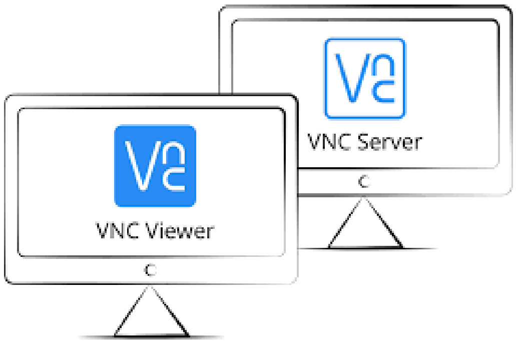
Driver Board:

A driver board, also known as a controller board or interface board, serves as a crucial component in electronic systems, particularly in display technologies such as LCDs, LEDs, and stepper motors. This board facilitates communication between the main processing unit and the display or motor, converting input signals into the appropriate format for the device. Driver boards often include integrated circuits and other components that handle tasks like voltage regulation, signal amplification, and timing control.

Fig 10: Driver Board

They come in various forms and designs, tailored to specific applications and device requirements. For example, in LCD displays, driver boards manage tasks such as pixel addressing and color control. In stepper motor systems, they orchestrate the precise timing and sequence of motor movements. The flexibility and functionality of driver boards make them indispensable in a wide range of electronic devices, from consumer electronics to industrial automation systems. Additionally, advancements in driver board technology continue to drive innovations in display quality, energy efficiency, and motor control precision.

Virtual Network Computing (VNC) is a remote desktop sharing system that allows users to remotely access and control computers over a network. With VNC, users can view the desktop interface of a remote computer and interact with it as if they were physically present at that machine. This technology is particularly useful for remote technical support,



VNC operates by transmitting screen updates and user input between the local and remote computers, typically using a client-server model. While there are various VNC implementations available, they all share the common goal of providing a seamless remote desktop experience across different platforms and operating systems. VNC applications are widely used in business environments, education, IT support, and personal computing, offering convenience, flexibility, and security for remote access needs.

Fig 11: VNC Application

V. VNC (VIRTUAL NETWORK COMPUTING) DATA

Integrating a VNC (Virtual Network Computing) application with a suite of sensors including a camera, PIR (Passive Infrared) sensor, and environmental sensors measuring temperature, humidity, soil moisture, and light (LDR) values has propelled agricultural monitoring into the digital age. This comprehensive system allows for remote monitoring and control of agricultural environments with unprecedented precision. The camera captures visual data, providing real-time imagery of crop growth and environmental conditions. The PIR sensor detects motion, enabling the system to track movement within the monitored area, which is crucial for security and wildlife management. Additionally, the environmental sensors continuously measure key parameters such as temperature, humidity, soil moisture, and light intensity, providing valuable insights into the health and growth of crops. The integration of these sensors with a VNC application facilitates remote access to the data collected, allowing farmers and researchers to make informed decisions and adjustments to optimize agricultural practices from anywhere with internet connectivity.

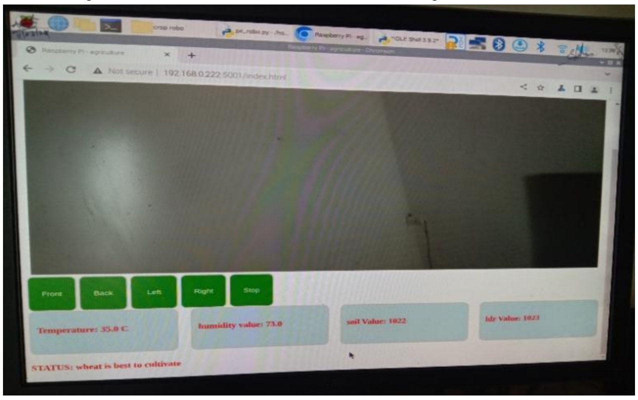


Fig 12: HTML Screen for Display

TELEGRAM BOT DATA:

The output of a Passive Infrared (PIR) sensor in a Telegram bot is pivotal for real-time monitoring and notifications. When motion is detected by the PIR sensor, the bot promptly sends an alert message to the designated Telegram channel or user, providing immediate awareness of potential intrusions or activity. This instant notification capability ensures timely response and enhanced security measures. Additionally, the bot can log motion events, providing a historical record for review and analysis. Integration of the PIR sensor output with Telegram offers convenient access to monitoring data and enables users to stay informed remotely. This seamless interaction enhances surveillance capabilities and contributes to a more responsive security infrastructure.

Fig 13: Motion Detected by PIR Sensor

VI. RESULTS AND DISCUSSIONS

The deployment of a rover equipped with a suite of sensors, including PIR (Passive Infrared), LDR (Light Dependent Resistor), soil moisture, DHT11 (Temperature and Humidity), and a camera, presents a versatile solution for comprehensive monitoring tasks. This rover, designed for agricultural monitoring applications, operates autonomously. The PIR sensor detects motion, enabling the rover to identify the presence of living organisms or any movements within its vicinity, thus aiding in security surveillance and wildlife tracking. The LDR sensor measures ambient light levels, providing insights into lighting conditions crucial for plant growth and environmental assessments. Soil moisture sensors monitor soil moisture levels, essential for optimizing irrigation and ensuring proper plant hydration. The DHT11 sensor captures temperature and humidity data, vital for assessing environmental conditions influencing crop health and growth. Additionally, the integrated camera offers visual monitoring capabilities, enabling real-time observation of crops, land conditions, or any anomalies within the monitored area. This rover's multi-sensory approach provides a holistic view of the monitored environment, empowering users with valuable data for informed decision-making and efficient resource management.

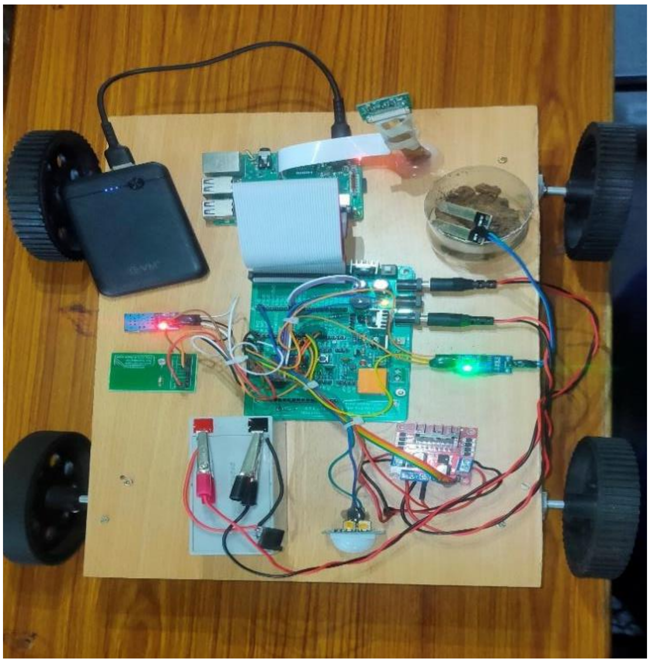


Fig 14: Prototype

Prediction Matrices Values:

This figure shows the result of an Automatic Crop Monitoring System using ML and Raspberry Pi, matrices serve as data representations for various aspects of crop health and environmental factors. These matrices encompass values such as pixel intensity in images captured by Raspberry Pi cameras, weather data including temperature, humidity, and precipitation, as well as soil properties like moisture levels and nutrient content. Through ML algorithms, these matrices are analyzed to detect patterns, anomalies, and correlations crucial for assessing crop health, predicting yield, and optimizing resource management. By leveraging matrices, the system can process and interpret complex data sets efficiently, facilitating informed decision-making for farmers. Additionally, matrices aid in the visualization of data trends, enabling users to gain actionable insights into crop conditions and make timely interventions for maximizing productivity and sustainability.

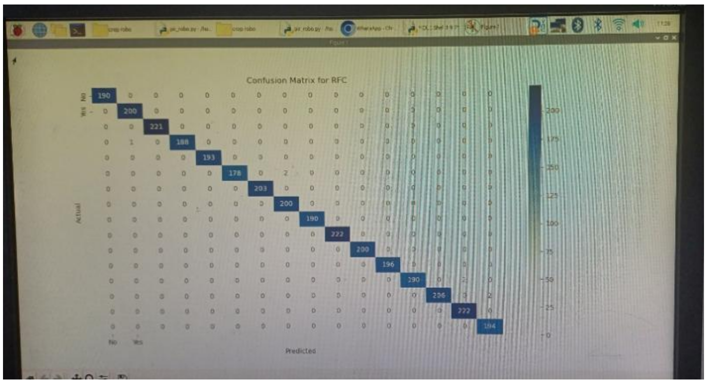


Fig 15: Confusion Matrix for RFC

Prediction Graphical Values:

Automatic crop monitoring systems leveraging machine learning (ML) algorithms combined with Raspberry Pi technology have revolutionized modern agriculture. These systems utilize ML algorithms to analyze data collected from various sensors installed in fields, providing real-time insights into crop health, growth patterns, and environmental conditions. The integration of Raspberry Pi enables on-site data processing, reducing reliance on internet connectivity and cloud services. A bar graph comparison between traditional monitoring methods and ML-based systems reveals significant improvements in efficiency and accuracy. The graph illustrates metrics such as yield prediction accuracy, resource utilization, and response time to crop anomalies. ML-enabled systems demonstrate higher accuracy rates and faster response times compared to conventional methods, making them indispensable tools for precision agriculture.

Vertical Axis: Accuracy
Horizontal Axis: Classifiers

Fig 16: Classifier Training and Accuracy Comparison

VII. FUTURE SCOPE

The future of smart agriculture monitoring is poised to revolutionize the agricultural sector through the integration of advanced technologies. Precision agriculture will be a key focus, harnessing data from sensors, drones, and satellite imagery to optimize resource usage and enhance productivity. IoT integration will see a proliferation of connected devices collecting real-time data on soil conditions, weather patterns, and crop health, enabling remote monitoring and management. Data analytics and AI will play a central role in extracting actionable insights from agricultural data, empowering farmers to make informed decisions.

Remote sensing technologies, such as satellite imagery and LiDAR, will provide comprehensive monitoring of agricultural areas, facilitating proactive management practices. Automation and robotics adoption will increase for tasks like planting, harvesting, and weed control, reducing labor dependency and enhancing efficiency. Integrated farm management systems will emerge, combining data from various sources to provide holistic insights and optimize resource utilization. Overall, the future of smart agriculture monitoring promises increased efficiency, sustainability, and profitability for farmers, paving the way for a more resilient and productive agricultural sector.

VIII. CONCLUSION

The proposed system aims to tackle the issue of unauthorized tree cutting by using various MEMS sensors. These sensors can promptly alert forest officials whenever a tree is being illegally poached or tilted. The system also incorporates forest fire detection functionality using fire sensors and temperature sensors. This will quickly notify authorities about a forest fire and potentially activate a water pump to extinguish it. Additionally, the system will actively monitor the well-being of wildlife in the forests. It will notify authorities if animals leave the protected wild reserves/habitats. By integrating different sensors and components like the Arduino micro controller, LCD display, Wi-Fi module etc., the system can collect and analyse sensor data in real-time. Based on the analysed sensor data, the system can generate timely alerts and notifications to combat threats from illegal poaching activities as well as monitor the health of wildlife populations. In summary, the proposed system utilizes a combination of sensors, edge devices and communication modules to continuously monitor forest areas. It aims to detect unauthorized activities like tree cutting as well as forest fires to enable quick responses. The system also keeps track of wildlife health within protected reserves.

IX. REFERENCES

[1] . Hegde, N.G, Water scarcity and security in India. A presentation by Narayan Hegde, BAIF at the Indian Science Congress 2012, https://www.indiawaterportal.org/articles/water-scarcity-and-securityindia, on 20/03/2020.

[2] . Dholu, M. and Ghodinde, K.A., 2018, May. Internet of things (iot) for precision agriculture application. In 2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI) (pp. 339-342). IEEE.

[3] National Investment Profile. Water for Agriculture and: Sudan,http://www.fao.org/fileadmin/user_upload/agwa/docs/ NIP_Sudan_Fi nal.pdf , on 14/01/2020.

[4].. Bhatta, N.P. and N. Thangadurai, 2019. Utilization of IOT and AI for agriculture applications. Int. J. Eng. Adv. Techno l., 8: 2731-2735

[5] . Ananthi, N., Divya, J., Divya, M. and Janani, V., 2017, April. IoT is based on smart soil monitoring system for agricultural production. In 2017 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR) (pp. 209-214). IEEE.

[6] . Ahmed E. M. E, Abdalla K. H. B, and Eltahir I. k, "Farm Automation based on IoT," 2018 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE), Khartoum, 2018, pp. 1-4, doi: 10.1109/ICCCEEE.2018.8515853.

[7] . Mittal, A., Sarma, N.N., Sriram, A., Roy, T. and Adhikari, S., 2018,April. Advanced Agriculture System Using GSM Technology.In 2018 International Conference on Communication and Signal Processing (ICCSP) (pp. 0285-0289). IEEE.

[8] . Suma, N., Samson, S.R., Saranya, S., Shanmugapriya, G. and Subhashri, R., 2017. IOT based smart agriculture monitoring system. International Journal on Recent and Innovation Trends in computing and communication, 5(2), pp. 177-181.

[9] . Padalalu, P., Maharajah, S., Dabir, K., Mitkar, S. and Javale, D., 2017, April. Smart water dripping system for agriculture/farming. In 2017 2nd International Conference for Convergence in Technology (I2CT) (pp. 659-662). IEEE.

[10] .Paperfigures.https://drive.google.com/file/d/1sehEsrMw XiQyPusYuA7RueBrhxnMYhmb/view?usp=sharing.