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Smart Pest Detection and Pesticide Sprayer with Machine Learning and IoT Enhanced Security

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Abstract: In order to meet the demands of the expanding population, agriculture plays a vital role in boosting food supply. Unfortunately, conventional techniques for identifying diseases and applying pesticides to crops are labor-intensive, slow, and frequently ineffective. We suggest improving a machine learning-based pest recognition and pesticide sprayer in order to address the aforementioned problems. The goal of this project is to use IOT and artificial intelligence technology to automate disease diagnosis and pesticide spraying procedures. For intruder detection and control, the robot makes use of an Arduino microcontroller, motors, motor drivers, a Bluetooth module, and a PIR sensor. We also employ machine learning models for plant disease identification that are available on Google Colab. This technique seeks to increase food security, decrease the need for physical labor, minimize the use of pesticides, and increase agricultural output.

Keywords: Machine Learning, Pest Recognition, Pesticides Spray, Google Colab, Internet of Things (IOT).

I. Introduction

Agriculture is the primary industry in our nation. The nation's economy and employment are mostly dependent on agricultural productivity. More than 50% of Indians work in agriculture. It guarantees food security for the populace, makes a major contribution to GDP and exports, and has a big impact on rural development and the fight against poverty.

Human needs and lifestyle have experienced many ups and downs in the last few years. Farmers that must meet consumer demands through production will face additional challenges as a result. However, low agricultural production brought on by outdated techniques, the effect of climate change on crop yields, degraded soil and limited acreage, market accessibility, cost, and losses after harvest are the obstacles forcing farmers to fall behind. Damage from pests and diseases to crops and human Dependency on labor are some of the challenges faced.

One important factor in boosting agricultural productivity is the management of pests and diseases. Pests of all kinds can harm plants as they develop. Spraying pesticides frequently is the primary solution for controlling pests, according to pesticide manufacturers.Pesticides sprayed by hand have detrimental effects on health, including terrible infections such as lung disorders, asthma, skin diseases, and cancerous growths. Furthermore, standard sprayers usually lack the necessary security features to stop pesticide misuse or theft. The use of pesticides in agriculture may be harmful to both human and environmental health. By addressing the problem of pests and diseases, our creative pest control method improves crop quality.

By creating an agricultural pesticide spraying robot with integrated plant disease detection capabilities, the project seeks to revolutionize agricultural methods. PIR sensors are also integrated for security purposes. With goals centered on increasing productivity, decreasing labor-intensive tasks, using less pesticide, and improving crop health, the project provides useful answers to problems that farmers have. The Machine Learning based pest detection and pesticides sprayer is a big step toward maximizing yields and guaranteeing food security for a growing population since it streamlines procedures and makes it possible for prompt responses.

II. Related Works

Prior research in the topic has investigated a range of methods for using diverse technologies in security systems, pesticide spraying, and pest identification. One study used neural networks to determine plant health in order to create

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an Internet of Things-based model for autonomous pesticide application and disease detection. This method was discovered to be time-consuming and ineffective, nevertheless. Another initiative put into practice an Internet of Things system that lets farmers remotely regulate pesticide spraying through a mobile app, which lessens physical labor and improves accessibility for various kinds of land. In a different investigation, PIR sensors and a Raspberry Pi were utilized to detect items or intruders, recording video and issuing alarms when movement was detected. Additionally, an Arduino-powered electric vehicle was developed for remote control and navigation within particular areas.

In the field of environmental monitoring, an IoT-based sensor-based system was created to detect weather variations in villages, giving users the ability to modify pesticide spraying schedules based on up-to-date information. In order to improve agricultural productivity and safety, additional research looked into an Internet of Things pesticide sprayer that is connected with a solar-powered safety system. This system provides monitoring, precise irrigation, and intruder detection. Finally, the use of a pre-trained Convolutional Neural Network (CNN) similar to AlexNet in Google Colab for object categorization and recognition was covered, with examples of applications in real-time translation and autonomous vehicles.

III. BLOCK DIAGRAM

Using an Arduino UNO Microcontroller, a vehicle kit, DC motors, a motor driver, and batteries, a machine learning-based pest detection and pesticide sprayer with IOT-based security creates a dynamic robot that the user controls with a cloud-based mobile application (Blynk).

An Arduino is integrated with PIR sensors to detect intruders, and a buzzer is included for alarm purposes. A machine learning model that is installed in Google Colab provides real-time response, and a spraying module that can be adjusted to spray pesticides to impacted areas using a sprinkler pump and pesticide tank.

There is a camera to take pictures of the plant leaves, which are then sent into the machine learning model as illustrated in Fig. 1.

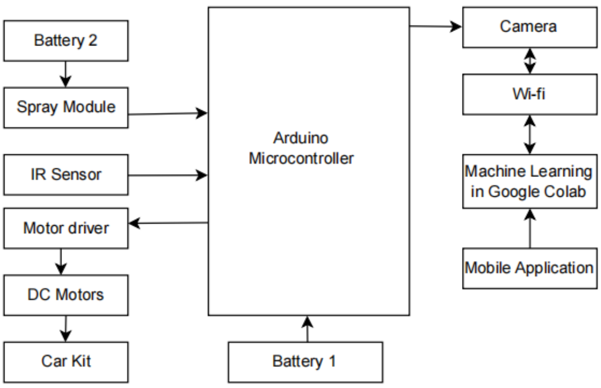

Fig. 1 Block Diagram

Fig. 1 shows the proposed system's block diagram. The upcoming chapter provides a detailed explanation of the hardware and software requirements.

IV. HARDWARE REQUIREMENTS

A. Arduino UNO Microcontroller

Arduino is a microcontroller that may be programmed to do specific activities that the user or client requests. One platform that can be used to build electrical equipment is open-source. The digital and analog input and output pins of the Arduino board are wired to breadboards via connection pins. Numerous different circuits as well as extension boards can be attached to it.An ATmega328PU-specified controller board is the Arduino UNO. The Arduino board comprises approximately twenty pins, six of which are analog inputs. It also features a resonator, a USB port, a power supply unit to supply the required electricity for its operation, and a reset button.

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Fig 2: Arduino Microcontroller

B. Motor Driver

Fig. 3 Motor Driver (LN298)

A popular dual H-bridge integrated circuit for efficiently driving DC motors and stepper motors is the L298N motor driver. This integrated circuit is appreciated for its adaptability and stability in a variety of applications, including robots and DIY projects.Its dual H-bridge configuration allows both motors to be freely controlled. The L298N provides strong performance with a voltage handling capacity of up to 46V and a current rating of 2A per bridge. It has basic safety protections that protect the hardware from back electromagnetic fields, such as implicit flyback diodes. In addition, its compatibility with well-known microcontrollers like Arduino and Raspberry Pi makes it accessible to a wider user base. Additionally, the L298N has a heat sink for efficient intensity dissipation, which ensures steady performance even under demanding loads.

C. Car Kit

For robotics projects, this four-wheel robot car chassis kit is the ideal mechanical framework. This kit comes with every piece of hardware and mechanical part required to assemble the robot, such as wheels, motors, chassis, nuts, and bolts, among other things. To program the robot, just connect the Arduino/Raspberry Pi and motor driver electronics controllers.

Fig. 4 Car Kit

Large predrilled holes on its surface allow for the use of sensors and microcontrollers in accordance with specifications. You can easily prepare your mechanical platform with this robot chassis. You can devote more of your time and energy to programming your robot rather than building your own chassis. Because they are easy to build,

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maintain, and utilize, wheeled robots are the most widely used type of robots. The easiest robot platform to assemble and program is the kit vehicle shown above. This kit can be used by experts as well as beginners. In addition to being less priced, this two-wheel DIY robot car chassis kit is simple to assemble, maintain, and program. Our four-wheeled kit allows you to drive faster, lift more objects, and carry a bigger load than the three-wheeled kit.

D. DC Motors

Fig. 5 DC Motor

Direct current motors, or DC motors, primarily transform electrical energy into mechanical energy.The primary factors influencing their widespread use are controllability and reliability.It works on the basis of a coil that has current flowing through it while in a magnetic field and a force rotating the coil.It is composed of the motor's armature, which rotates primarily.There is a stator in place to produce a magnetic field.Stators in many motors contain electromagnets.The DC motor's armature creates a magnetic field when a voltage is applied, and this magnetic field interacts with the stator's magnetic field.The force created by this reaction causes the motor to revolve.A motor's rotational direction can be adjusted by applying an opposing voltage. DC motors find application in various domains such as electric vehicles, robots, home appliances, wipers, pumps, fans, vacuum cleaners, and aviation systems.

E. IR Sensor

Fig. 6 IR Sensor

An infrared light produced nearby is recognized by a infrared (IR) sensor. These devices are easier to use than their dynamic counterparts thanks to IR sensors. The utility of a IR sensor may be more difficult to understand. First of all, realize that every living thing, including humans, animals, and some things, emits a certain amount of infrared radiation. The glow and material design of the body or object completely determines how much infrared radiation it emits. Although infrared radiation is invisible to humans, the authors have designed electronic devices that can detect its signals. Typically, they are employed in motion detection alerts, security warnings, and automated lighting applications.

V. SOFTWARE REQUIREMENTS

A. Arduino IDE

Fig. 7 Arduino IDE

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It is essentially a framework for writing code for the Arduino microcontroller to carry out particular tasks.Its capabilities, such as code suggestions and auto-indentation, will aid us in writing the code.The client can upload the code to the Arduino board via a USB connection once the code has been written, compiled, and checked for faults.

B. Bluetooth Terminal Mobile Application

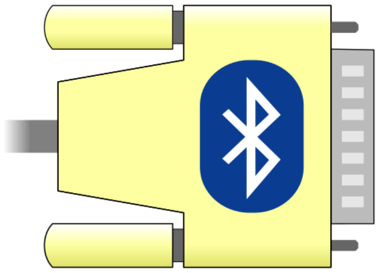

Fig. 8 Bluetooth Terminal Mobile Application

The Bluetooth mobile application is a helpful resource for developing Internet of Things projects and utilizing cellphones to operate robotic components or gear. The client can interact or communicate with several devices and sensors that are connected to controllers by utilizing the Blynk application. The application is compatible with a number of microcontrollers, including Arduino, Raspberry Pi, and others. Widgets included in the program can be used to create custom interfaces. It is possible to control the linked gadget in real time from any location in the world. The client is notified when the device responds, whether it be by sensor readings, robot movement, etc.

C. Google Colab

Fig. 9 Google Colab

Google offers a cloud-based tool called Google Colab that lets users write and run Python code in a collaborative environment. Because of its accessibility and integration with well-known libraries like TensorFlow and PyTorch, it is frequently used by researchers, data scientists, and students. Colab functions similarly to Jupyter Notebooks in that it lets users create documents with live code, equations, visualizations, and prose that explains things.

Free access to GPUs and TPUs, which speed up computations and are especially useful for machine learning jobs, is one of its noteworthy characteristics. Additionally, several users can work together on the same Colab notebook at once, which promotes cooperation and academic pursuits. Colab's integration with Google Drive makes version control, sharing, and access to Drive-stored datasets effortless. All things considered, it is a flexible and user friendly.

D. TensorFlow

Fig. 10 TensorFlow

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The goal of the open-source machine learning platform TensorFlow is to make the development and application of machine learning models easier. Researchers, developers, and businesses utilize it extensively for deep learning, classification, regression, and clustering applications. Tensors are multidimensional arrays that are used to represent data, and TensorFlow lets users create computational graphs made of these arrays. The term "TensorFlow" comes from these graphs that show how data flows through the model.

TensorFlow's versatility in supporting both conventional machine learning algorithms and deep learning techniques is one of its main advantages. It offers both lower-level APIs for fine-grained control and optimization and higher-level APIs for rapid prototyping. Additionally, TensorFlow has distributed computing characteristics that make it possible to train models effectively on several GPUs or TPUs.

VI. METHODOLOGY

The suggested system operates in three main sections:

A. A Dynamic Robot made to move across a field of farms.

An Android smartphone application (blynk) controls the movement of a dynamic robot that was constructed using Arduino, a vehicle kit, DC motors, motor drivers, and batteries. The robot is designed to go throughout the farm and is powered by batteries through a programming board.Selecting the right motor is important since it depends on the amount of force and weight that has to be pushed.The battery is utilized to supply the necessary electricity. Robotic parts are made from car kits.

The usefulness and security of the system are further increased by the integration of sensors like IR (Passive Infrared) sensors. By examining variations in the radiation released by nearby objects, infrared sensors may detect motion. By examining variations in the radiation released by nearby objects, infrared sensors may detect motion. The robotic system detects the presence of objects, people, or animals in its surroundings by utilizing PIR sensors in conjunction with the Arduino microcontroller. This feature improves the system's overall security and safety by allowing the system to be more aware of its surroundings and to promptly notify the farmer through a buzzer.

B. Creation of a model for Machine learning

Several steps were done in order to design and test a machine learning model that can detect pests in agricultural fields in real time. First, pre-trained models from TensorFlow Hub's MobileNetV2 model—which is available in Google Colab—were used to detect pests. The efficiency and efficacy of this model in picture classification tasks led to its selection.
Once the required libraries, including TensorFlow and TensorFlow Hub, were imported into the Python platform of Google Colab, the MobileNetV2 model that had been trained beforehand was loaded and assembled for classification tasks.

The Kaggle source provided the dataset that was utilized for training and comparison. It included pictures of both pest-affected and healthy plant leaves. To support supervised learning, it was made sure the dataset had the proper labels. In order to improve the performance of the model, data preprocessing stages included loading and augmenting training data using a class from TensorFlow. These actions included rotating, shifting, shearing, zooming, and flipping images. Similar to this, a different instance of the class was used to load the validation data.

The trained model was saved for later use, facilitating ease of deployment and reusability for different crops and plants. For testing the model, a separate set of images was used, and predictions were made on whether the leaves were healthy or affected by pests.The dataset used for testing purposes included images of various plants such as tomatoes, potatoes, and black pepper, ensuring a diverse representation of pest types and affected plant species. It's essential that the model can be trained to detect pest diseases of any desired plant by utilizing relevant image datasets.

By following these steps, an efficient machine learning model for real-time pest detection in agricultural fields can be developed and tested. After testing, communication between machine learning model and spraying module. The trained model was stored for later usage, making it easier to deploy and reusable for other plants and crops. A different collection of photos was used to test the model, and assumptions were made about whether the leaves were pest-infested or healthy.Images of a variety of plants, including tomatoes, potatoes, and black pepper, were included in the dataset

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utilized for testing, guaranteeing a varied representation of pest types and impacted plant species. It is imperative that the model may be trained using pertinent image datasets to identify pest illnesses of any targeted plant.

These procedures can be used to construct and test an effective machine learning model for real-time insect identification in agricultural areas. Following testing, the spraying module's and the machine learning model's communication is set up via wifi and communication protocol, the spraying module will spray the pesticide to the affected region if the leaf has a pest disease.

C. Setting up a spraying module

A communication link is created between the machine learning model and the spraying module to start the spraying operation when the model finds bugs on the leaf.To apply pesticides to the plant sections that are impacted, the spraying module and a pesticide sprinkling pump are turned on.To guarantee maximum coverage of the farm, the spraying angle is kept at 180 degrees during the operation. This makes sure that pesticides are applied to plant surfaces uniformly, which targets the pests and reduces the harm they do to the health of the crop.

In addition, the spraying mouth's length can be changed to suit different plant heights and canopy densities. This adaptability enables tailored pesticide application.

VII. Results And Discussion

The writers have carried out tests to assess our robot's performance in a number of areas. The writers specifically assessed the device's capacity to move efficiently, identify pests and apply pesticide, and evaluate battery life. With the help of Wi-Fi connection, the machine learning model would be able to identify pests and instruct the spraying module to only spray pesticides on the regions that are impacted. The scientists looked at two important features of pesticide spraying: the coverage that the actuation setup—which may move in four directions—achieves and the coverage that the sprayer itself achieves. Agricultural robots are still in the experimental stage and encounter difficulties in practical implementation despite developments in robotics. Our research into this found that effective agricultural robots demand not just the development of new technologies but also a supportive infrastructure. The robot in our suggested method is equipped with an intruder detecting system, two DC motors for controlling movement, and a submersible pump for spraying pesticide. It is powered by a 12V battery. Together, these elements make agricultural activities automated and efficient.

An integrated robotic system with complete functionality for real-time insect detection and pesticide application in agricultural fields would be the project's output. PIR sensors, in particular, would be used for motion detection in this system, together with Arduino-based control mechanisms for robotic navigation and spraying activities, and machine learning algorithms for pest detection.Through an Android application, the user can steer the moving robot. The height of the plant can also be used to modify the spraying module.

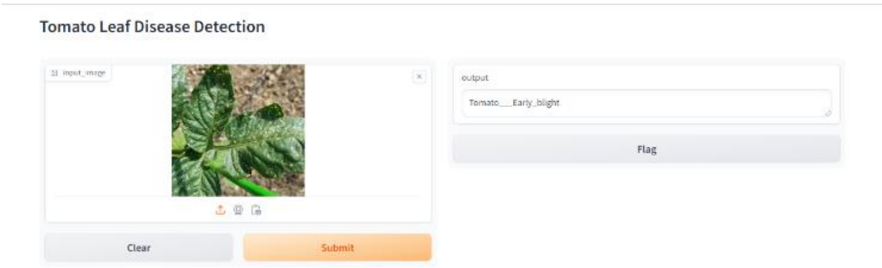

Fig.11 Machine Learning algorithm output and user interface

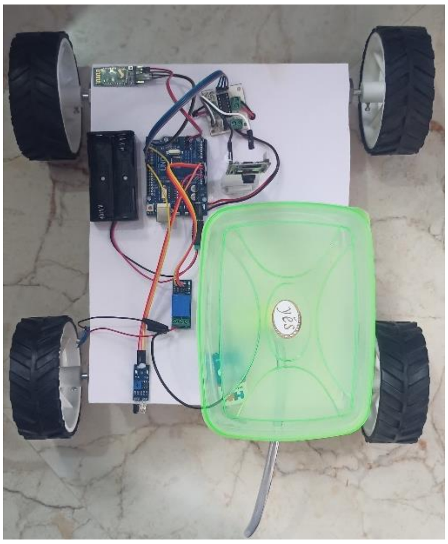

Fig.12 Final Model

VIII. CONCLUSION

An important development in the agricultural industry is the creation of a robot that sprays pesticides and detects plant diseases. The suggested system provides a workable solution to the problems related to conventional pesticide spraying and disease detection by utilizing robotics, IoT, and AI technologies. The Agricultural Pesticide Spraying Robot with integrated Plant Disease Detection's functionality is further enhanced by the inclusion of a PIR sensor, allowing for the real-time detection of intruders in agricultural areas. The authors have proven the efficacy and efficiency of the system in maximizing yields, improving crop health, and optimizing pesticide consumption through rigorous testing and validation. Future improvements might include scalability for large-scale agricultural operations, better machine learning algorithms for multi-class disease identification, and the incorporation of more sensors for soil analysis. In general, this research advances sustainable agricultural methods that guarantee environmental preservation and food security.

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The lab staff's insightful criticism has been crucial in helping us improve our techniques and the caliber of our work. Furthermore, their technical advice has been invaluable in helping us to solve challenging problems and find creative solutions. Our studies and analysis have finally been made easier by the access to specialist resources provided by these labs. helping to accomplish the goals we have set out.

Their dedication to perfection and their readiness to go above and above have made a lasting impression on our project. We take the knowledge and abilities we have gained from their mentoring with us as we proceed. We sincerely thank everyone of the lab workers for their essential contributions to our professional and academic growth.

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