Self-Navigating Field Robot for Smart Farming

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Abstract—
Agriculture plays a vital role in the Indian economics. The automation in agriculture is the major regard and the draining issue all across the world. The populace is increasing excessively and with this increase the demand of food. The conventional methods which were used in agriculture were not sufficient enough to accomplish the requirements. To address this issue, we have proposed an Artificial Intelligence Operation Model for Agronomy. This model includes a self-governing robot vehicle that navigates through the agricultural field, which uses QR codes to give directions to the autonomous robots, and it is also capable of capturing images. This model intends to focus on the analysis of application of image processing in agriculture field such as imaging facility, for leaf disease detection. Application of image processing can improve decision making for; classifying the captured image into plant and ground, further identifies the leaf diseases using image processing method. The vehicle is capable of moving in all directions respectively and analyzes the correct path. The imaging model uses Convolution Neural Network classifier. The study of the domain has proved to be authentic and less time consuming when compared to the traditional agricultural methods.

Index Terms — **Agriculture, Robotics, Artificial Intelligence Imaging Model, Convolution Neural Network.**

I. INTRODUCTION

Due to its applicability across a variety of fields, Internet of Things (IoT) technology has gained a lot of interest in recent years. In example, there are many surveillance applications for an IoT-based robot with artificial intelligence. The development of an agricultural nation depends heavily on agriculture. Agricultural practices still rely on methods that were developed hundreds of years ago and don't consider resource conservation. The technology utilized in certain wealthy nations is too expensive and complex to be utilized locally. In order to aid with resource conservation, our initiative aims to provide technology that is affordable, dependable, cost-effective, and simple to use. The three most crucial capabilities of autonomous agricultural robots fall into the areas of navigation, detection, and mapping. The first phase is navigation, which in some situations, such as navigation in orchards, may also rely on detection and mapping.

A precise model to aid in agricultural areas might be created thanks to recent technological advancements. The present strategy is to construct an autonomous robot and create the algorithms necessary to enable mapping and navigation of agricultural fields in real-time. Numerous techniques have been developed over time to let ground robots navigate on their own. The vehicle is designed to move across the farm on its own, and various attachments can be used to carry out a variety of activities, including classifying the acquired image into plants and the surrounding ground and further identifying leaf diseases using image processing techniques. This vehicle is capable of travelling in all directions at the appropriate locations in the farm field by reading the QR codes there.

II. OBJECTIVES

- To understand and implement a self-navigating system with image processing.
- Image processing technologies can conduct object detection accurately, quickly, and non-invasively.
- Convolution Neural Network which can be used to recognize images.
- It can also be used to classify images as plant and ground and to detect leaf disease using CNN.

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III. PROPOSED METHOD

The proposed system uses Raspberry Pi 4 B model which is cost effective and it provides ground-breaking improvements in processing speed, multimedia performance, memory, and connection while maintaining backwards compatibility and similar power consumption, for capturing images the proposed system uses Raspberry Pi 5MP camera module. It is a custom designed camera board that is equipped with a flexible ribbon cable, making it compatible with Raspberry Pi boards. A fixed lens with a 5 megapixel resolution is embedded into the camera board. This 5mp camera module is capable of 1080p video and still images and connects directly to Raspberry pi, which is cost effective and provides less delay than its previous versions.

The proposed system is Autonomous Navigation System for Agricultural Fields. The current approach of this model is to build an autonomous robot and develop an algorithm that enables navigation for agricultural field. The model includes a self-governing robot vehicle that navigates through the agricultural field, which uses QR codes to give directions to the autonomous robots, and it is also capable of capturing images. The model is farmer friendly as it navigates through the entire area. The model uses Convolutional Neural Networks algorithm for image recognition. The vehicle is built autonomously upon which multiple attachments can be made in order to perform multiple tasks such as, classifying the captured image into plant and ground, further identifies the leaf diseases using image processing method. This model research can further be extended to applications like weed detection, fruit grading, harvesting and many more.

IV. METHODOLOGY

1. SYSTEM SPECIFICATIONS

A. RASPBERRY PI 4 MODEL B

- The Raspberry Pi 4 Model B was released in June 2019, and it is the most recent addition to the popular Raspberry Pi computer line. When compared to the previous-generation Raspberry Pi 3 Model B+, it provides ground-breaking improvements in processing speed, multimedia performance, memory, and connection while maintaining backwards compatibility and similar power consumption.
- A high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, hardware video decodes at up to 4Kp60, up to 4GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability are just a few of the highlights (via a separate PoE HAT add-on).
- The board's dual-band wireless LAN and Bluetooth compliance certification is modular, allowing it to be incorporated into end devices with much reduced compliance testing, reducing both cost and time to market.

B. RASPBERRY PI 5MP CAMERA MODULE

- It is a custom designed camera board that is equipped with a flexible ribbon cable, making it compatible with Raspberry Pi boards. A fixed lens with a 5 megapixel resolution is embedded into the camera board.
- This 5mp camera module is capable of 1080p video and still images and connects directly to Raspberry pi. The module attaches to Raspberry Pi, by way of a 15 pin ribbon cable, to the dedicated 15-pin MIPI Camera Serial Interface (CSI), which has been designed especially for interfacing to the camera.
- This camera board can record films in the 1080p @ 30fps, 720p @ 60fps, and 640x480p 60/90 formats, and it can capture images with a resolution of 2592 x 1944 pixels.

C. L293D MOTOR DRIVERS

- A DC motor can be operated in any direction with the help of this typical Motor Driver IC. A pair of DC motors can be driven by this IC's 16 pins at any time and in any direction. It implies that an L293D IC can manage two DC motors. This IC can also power both quiet and powerful tiny motors.
- The H-bridge theory, which permits electricity to flow in any direction, is the foundation of this L293D IC. We already know that in order for the DC motor to revolve in both directions, the voltage must be altered. An H-bridge circuit based on L293D ICs is therefore perfect for driving a motor. Two H-bridge circuits on a single L293D IC can each independently spin two DC motors. These circuits are frequently used in robotics to operate DC motors due to their compact design.It's a conventional Motor Driver IC that lets you operate a DC motor in any direction. This IC has 16 pins that are used to operate a pair of DC motors in any direction at any time. It means that we can control two DC motors with an L293D IC. This IC can also run small and silent large motors.

2. WORKING OPERATION

Agriculture automation is a major concern and a major topic around the world. Traditional farming methods were unable to meet the demands. To address this problem, we're working on a field robot that can navigate to fields on its own. The robot model is built using a Raspberry Pi 4 B model, Raspberry Pi camera module, L293D motor driver which is connected to two motors which controls the wheels for navigation based on the QR codes and the model is powered using a 12 V power supply, Raspberry Pi board is powered by a power supply less than 5 V. The model is capable of capturing images. The captured image is predicted to be either ground or plant by the trained model. The leaf disease is detected based on the accuracy and loss of the model by plotting a graph of trained data to the test data. QR codes have been used in order to give directions to the autonomous robot. The camera module captures the QR codes in the range of 10 – 30 cm, after scanning the QR codes there is a delay of 2 seconds to make a decision. The results from the model are accumulated and used to determine the vehicle is moving on the correct path or not. If the vehicle is on precise path, then the commands is given to move and stay on the same path. If vehicle is not on the correct path, then the QR code is scanned and the vehicle is moved in the correct path.

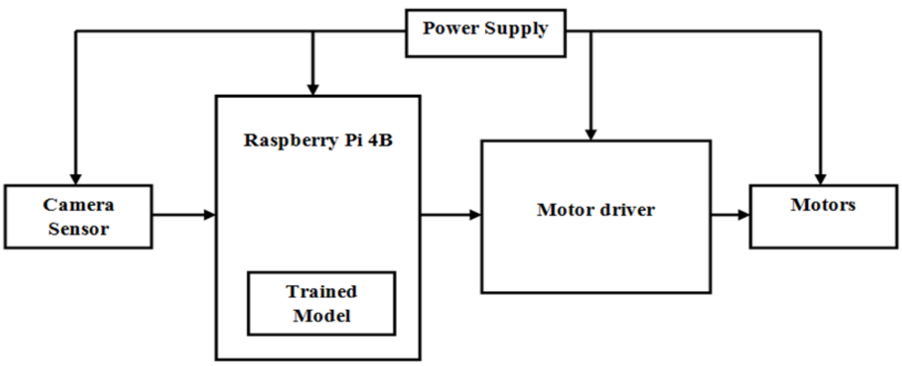

Fig 1. Block Diagram

The Raspberry Pi 4 Model B is a series of small single-board computers. Raspberry Pi boards are microprocessors with their own operating system, and they typically require a minimum voltage of 3-5 volts. In order to process images, a 5MP camera sensor is installed on the Raspberry Pi. The Raspberry Pi board is then linked to the L293D motor driver, which is a basic motor driver integrated chip (IC) that allows us to drive a DC motor in either direction while also controlling its speed. The module is powered by a multi output voltage converter that sends 12 volts to the L293D, which reduces the voltage to 5 volts and then feeds it to the Raspberry Pi to control the motors.

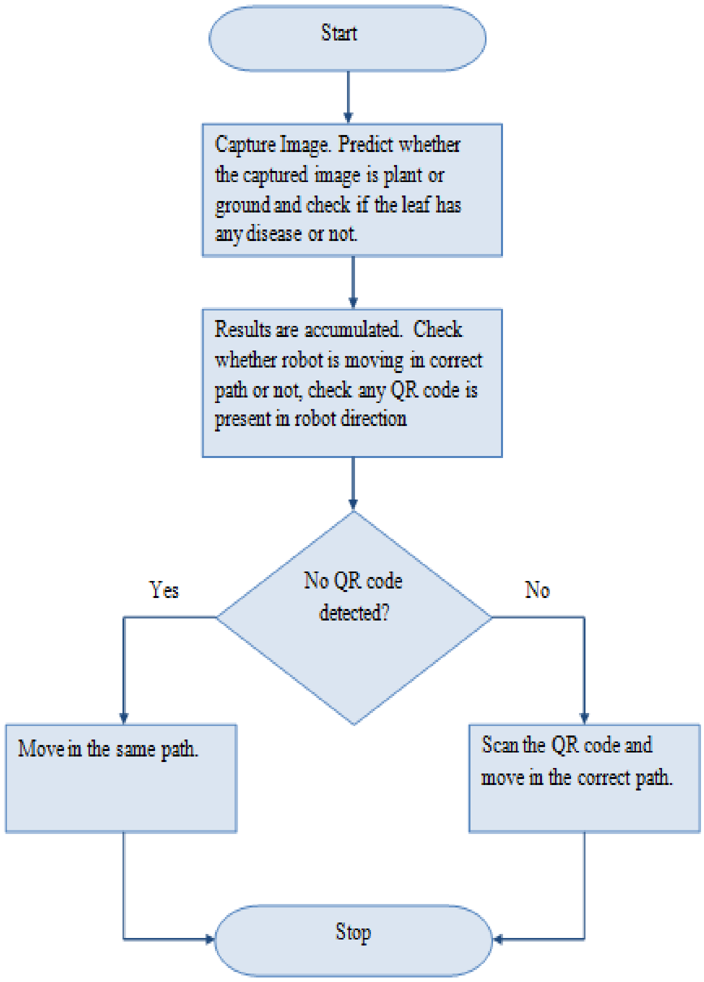

Fig 2. Flow Chart

V. RESULTS AND DISCUSSION

The model includes a self-governing robot vehicle that navigates through the agricultural field, which uses QR codes in order to give directions to the autonomous robots, and it is also capable of capturing images that is classified into ground or plant by the trained model. The camera module captures the QR codes in the range of 10 – 30 cm, after scanning the QR codes there is a delay of 1 - 2 seconds to make a decision.

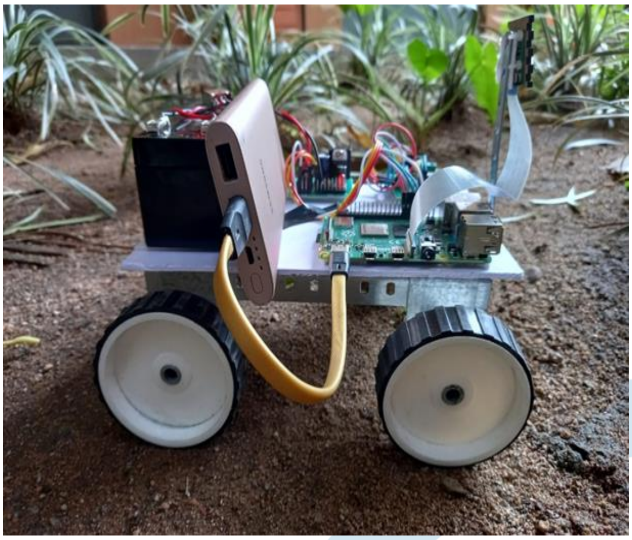

Fig 3. Model Side View

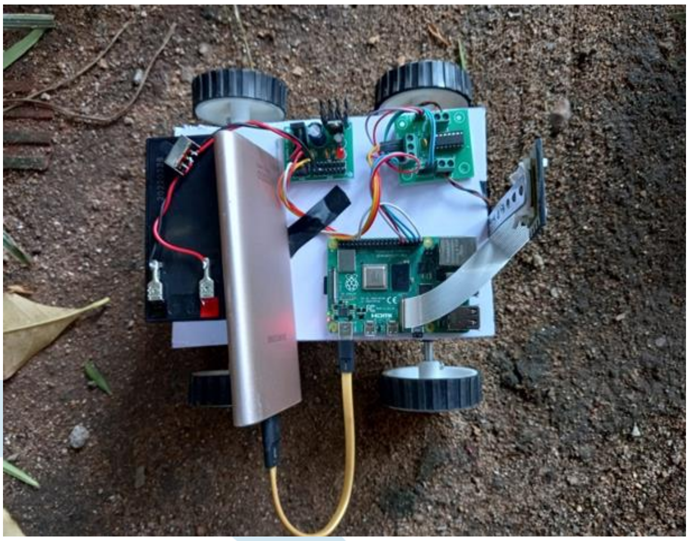

Fig 4. Model Top View

The above figure shows the model side and top view. The model consists of a Raspberry Pi 4B model, Raspberry Pi 5 MP camera module (stationary), four wheels, power supply and two DC motors.

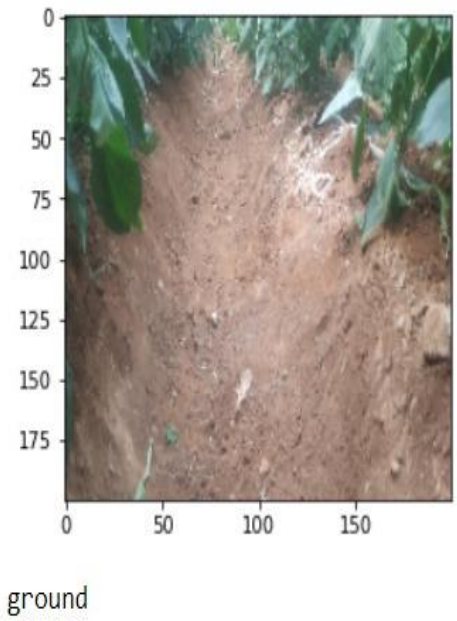

Fig 5. Image Classified as Ground

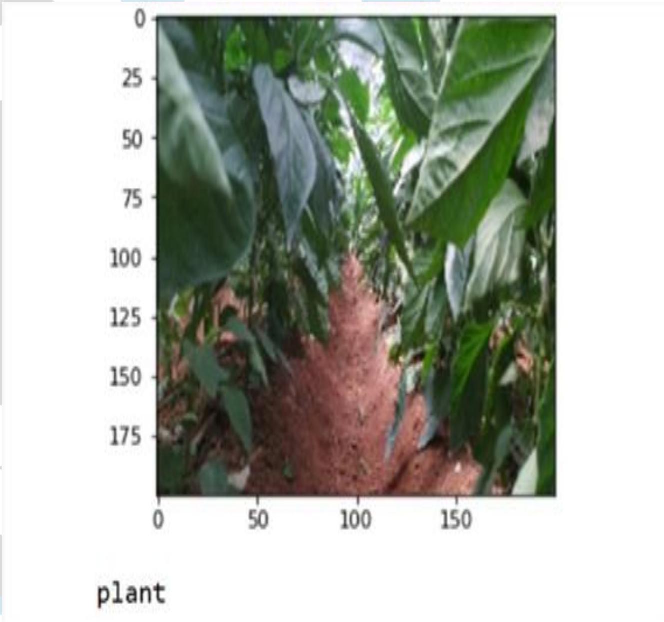

Fig 6. Image Classified as Plant

The above figure shows the classification of images as ground and plant where the ML model is first trained using the training dataset which is divided into two classes that is as ground and plant then the model is tested using testing dataset.

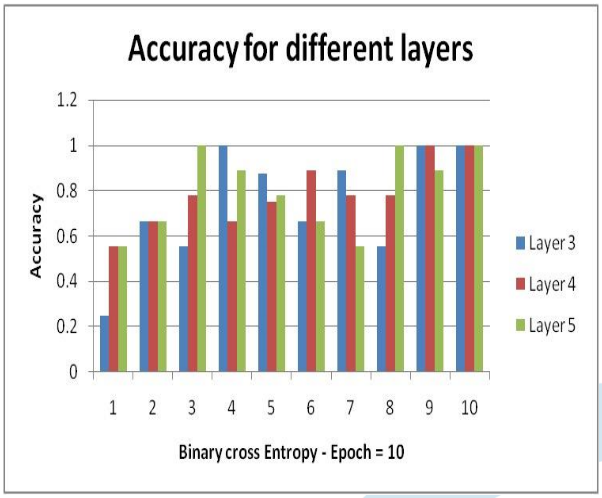

Fig 7. Accuracy for different layers

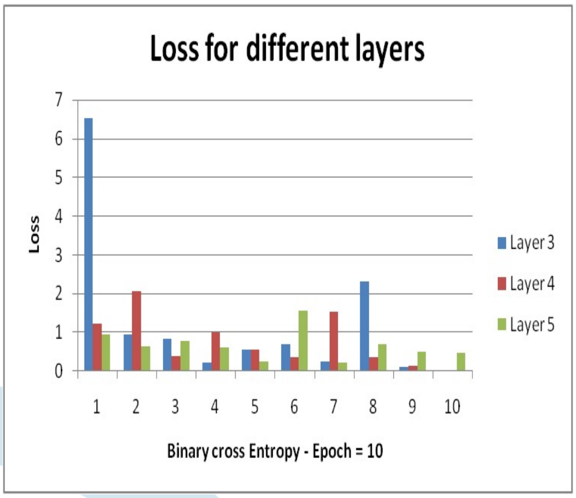

Fig 8. Loss for different layers

The above Fig 7. Determines the model accuracy for the machine learning model developed. The x-axis represents the binary cross entropy with 10 epochs respectively, the y axis represents the accuracy ranging from 0 to 1.
The above Fig 8. Determines the model loss for the ML model. The x-axis represents the binary cross entropy with 10 epochs respectively, the y-axis represents the loss occurred while training the model.
Accuracy can be improved by training the model using more datasets.

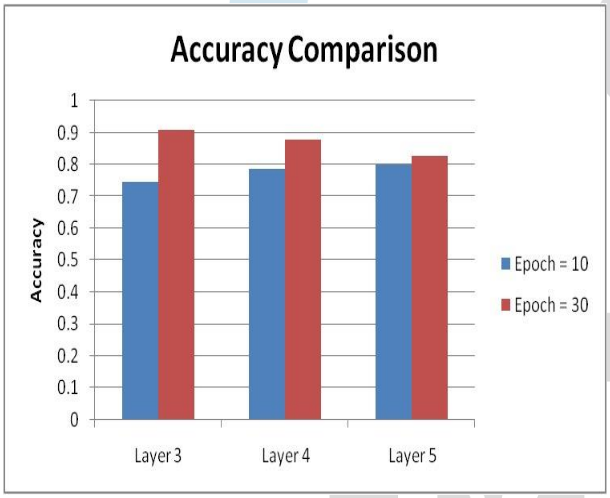

Fig 9. Accuracy Comparison

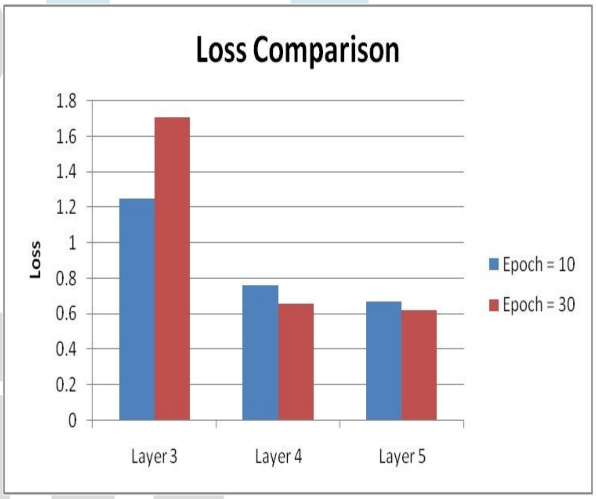

Fig 10. Loss Comparison

The above Fig 9. Determines the model accuracy comparison for the Machine Learning model. The y-axis represents the accuracy ranging from 0 to 1. The x-axis represents the layers defining the accuracy for 10 and 30 epochs.
The above Fig 10. Determines the model loss comparison for the Machine Learning model. The y-axis represents the loss that occurred. The x-axis represents the layers defining the loss for 10 and 30 epochs.

VI. CONCLUSION AND FUTURE SCOPE

A self-navigating system with an image processing application is making it possible to monitor things easily. Smart farming improves and increases agricultural production in order to contribute to reducing the food demand gap. The purpose of this project is to implement a robot that navigates through the crops by capturing the images using a camera module. The model can be used for Real-Time Mapping by adding a GPS module. The model can be extended for various applications like weed detection, fruit harvesting.

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