A Real Time Precision Monitoring and Detection of Rice Plant Diseases by Using Internet of Things (IoT) Based Robotics Approach

Kandula Kushal Sai, P Satyanarayana, Mohammed Ali Hussain , M Suman

Abstract*: Over the past few years, there has been significant interest in designing smart agricultural systems. The use of smart farming techniques can enhance the crop yield, while simultaneously generating more output from the same amount of input. But still, most of the farmers are unaware of the latest technologies and practices. In this paper a novel smart agricultural technology based on Robotics and Internet of Things (IoT) will be designed and implemented for performing various operations on the field. This smart agricultural pest's robot is equipped with various sensors like both data collecting sensors and data transferring sensors and a camera for identifying different environmental diseases and viruses in specific. As on identifying the infected parts in each plant and diseased area in field, we can spread chemicals, pesticides or fertilizers in a specific effected area and to infected parts of plants, in only required quantity. It also includes Micro-Controller and Wi-Fi hardware for executing the whole process. The main features of this novel intelligent smart agricultural pest's robot is that it can execute tasks such as detecting predators and weeds, disease detection, virus identification, predator's detection and scaring birds and animals, sprinkling pesticides & fertilizers, cutting weeds, etc. The entire model is fitted with sensors and a camera to monitor the activities in real time. The proposed model IOT based smart agricultural pest's robot will work in the rice fields, readings will be monitored and stored in cloud and satisfactory results would be observed in application, this system is very much useful for smart agricultural systems.

***Index Terms*: Internet of Things (Iot), Image processing, Multispectral, Pest prediction, Zigbee etc.**

I. INTRODUCTION

Technology has been increasing vastly particularly in the field of irrigation in the past few years. One of the technology that is part of this advancement is Internet of Things (IoT). IoT is connection and communication of devices together in a network over internet. In IoT sensor are used to collect the data and through the controller which acts as gateway the data is sent to the cloud which is used for future analysis. User can access the data through the mobile application provided to him. In this paper, we are going to implement smart irrigation system where farmer do not need to go to the farm for irrigation which is automated, and he can monitor the position of the irrigation through the mobile app that is provided to the agronomist. The sensed data is stored in the cloud for future analysis. Smart irrigation is one of the applications of smart city. Along with IoT Robotic based agriculture is also one of the novel method of agriculture where it does the work of
farmer like collecting weeds, spilling fertilizers to the plants etc. So, combination of both IoT along with the Robotic based agriculture is solution to many problems in the field of agriculture.

About 40% of the produced food is destroyed by Weeds, mildew and pathogens despite of the pesticides, insecticides and other agricultural practices employed [1]. Thus, it is very important to engage pest prediction technology to decrease the food loss. And excessive use of pesticides has adverse effects on the environment with increased production cost and decreased quality [2] - [3]. Thus, their use has to be reduced.

A robot is a machine that can perform some tasks automatically or with guidance. Robotics is generally a combination of computational intelligence and physical machines (motors). Due to their high level of performance and reliability, the robot gets the splendid popularity in our daily life.

The final module which is agrobot which does all the work that farmer does. This agrobot will collect the weeds, collect images of plants which helps in identifying diseases of plants that helps in giving right amount of fertilizers to the plants. Through the camera we can also detect the animals in the field and divert them away from the field. This agrobot can be controlled from anywhere around the globe through the mobile application developed in android studio.

II. DESIGN AND IMPLEMENTATION

This smart agricultural technology based on Robotics and Internet of Things (IoT) will be designed and implemented for performing various operations on the rice field. This smart agricultural pest's robot is equipped with various sensors like both data collecting sensors & data transferring modules and a

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Kandula Kushal Sai, Electronics and Computer Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.
P Satyanarayana, Electronics and Computer Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.
Mohammed Ali Hussain, Electronics and Computer Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.
M Suman, Electronics and Computer Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.

camera for identifying different environmental diseases and viruses in specific. As on identifying the infected parts in each plant and diseased area in field, we can spread chemicals, pesticides or fertilizers in a particular effected area and to infected parts of plants, in only required quantity. It also includes *Raspberry Pie* hardware for executing the whole process. The main features of this novel intelligent smart agricultural pest's robot is that it can execute tasks such as detecting predators and weeds, disease detection, virus identification and scaring birds & animals, sprinkling pesticides & fertilizers, cutting weeds, etc. The entire model is fitted with sensors and a camera to monitor the activities in real time. The proposed model IOT based smart agricultural pest's robot will work in the rice fields, readings will be monitored and stored in cloud and satisfactory results would be observed in application, this system is very much useful for smart agricultural systems.

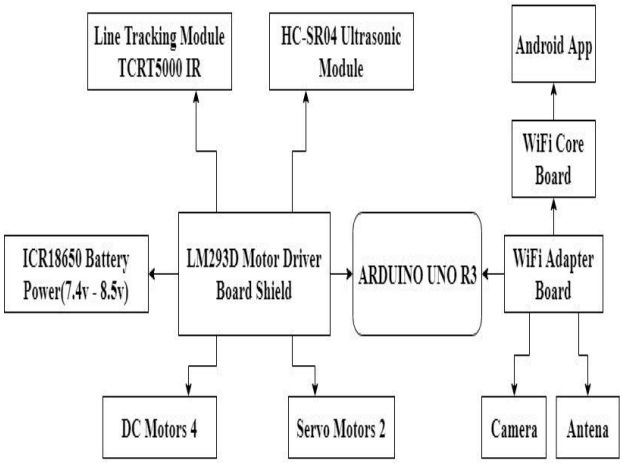

Figure.1. Block Diagram of Robotic IoT Model

Design and Implementation Overview

Figure.2. Design and Implementation Overview of Robotic IoT Model

The first step was to figure out which parameter should be checked for irrigation in the field i.e. identifying different environmental diseases and viruses in specific. As on identifying the infected parts in each plant and diseased area in field, we can spread chemicals, pesticides or fertilizers in a specific effected area and to infected parts of plants, in only required quantity. A wide range research is going on how reduce the chemicalisation of food and to raise the quality & productivity of food, in several research organizations like IRRI, IFPRI and ICRISAT.

The main features of this novel intelligent smart agricultural pest's robot is that it can execute tasks such as detecting predators and weeds, disease detection, virus identification, predator's detection and scaring birds and animals, sprinkling pesticides & fertilizers, cutting weeds, etc. By identifying the specific infected part of plant, area of disease spread, and type of disease, we can analyze and use the correct appropriate chemicals in only sufficient required quantity. So that quality of food can be increased by less chemical usage and production of food, as well as healthy crop yield can be raised. We can save wealth of farmer by implementing these methods.

III. Flow Chart Diagram Representation of Robotic Model

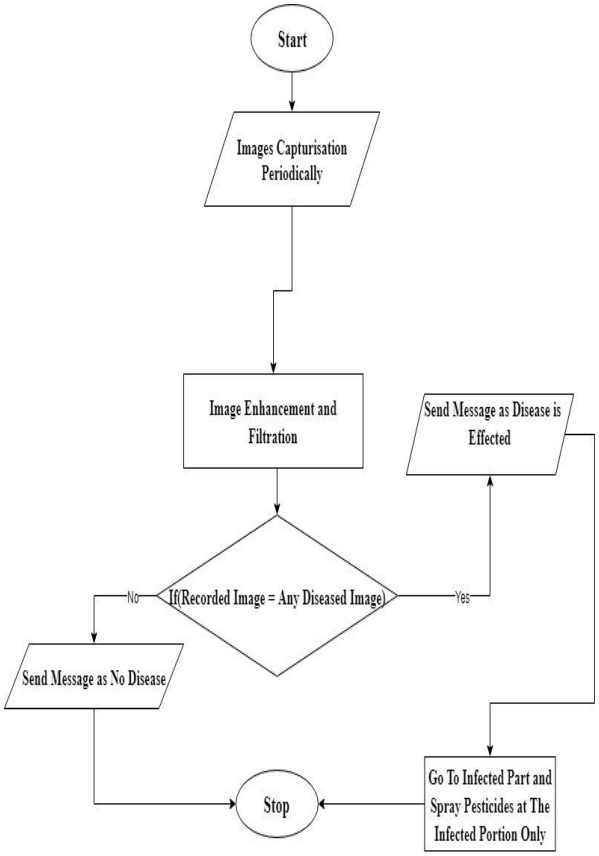

Figure.3. Flow Layered Representation of Robotic IoT Model

Each Module Explanation in Flow Chart:

Image Enhancement and Filtration: This mainly describes about the shape and image behavior. HSV describes about the color and it has 3 matrices hue saturation and value. The hue tells about the color code or color name, saturation is all about level of mixing with white and value gives level of mutation with the black. Due to the noises and other objects having the same color code in the image

some white spots are visible after the threshold limit. Hence these white spots are to be removed to analyze the image. These can be abolished by dilation in addition with erosion with the same structural element.

Momentum Calculation: The color intensity can be given by using hessian matrix around a point defined by the n dimensions,

$$Hf\ (x1,x2,x3,\dots xn) = \frac{\partial}{\partial(x1,x2,x3,\dots xn)}\left(Jf(x1,x2,x3,\dots xn)\right)$$

$$= \begin{bmatrix} \frac{\partial^2 f}{\partial x_1^2} & \frac{\partial^2 f}{\partial x_1 \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_1 \partial x_n} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2^2} & \cdots & \frac{\partial^2 f}{\partial x_2 \partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2 \partial x_1} & \cdots & \frac{\partial^2 f}{\partial x_n^2} \end{bmatrix} \quad (1)$$

The pictures are captured by the help of this algorithm and the several colors are spotted on the leaves and different parts of the plant and were collated with the loaded diseased pics and they were contrasted with respect to them and the disease is decided.

GSM Module: After the conformation of the disease the messages are sent to the farmer via messages with captured images through the GSM or GPRS module. Thus, enabling the farmer to have full control over the plant and easy detection of disease before it gets completely infected to the whole field.

IV. Involved Hardware and Technology Explanation

Field Monitoring and Whether Detection: This plays a very dominant role in the quality and the growth of the plants, and must be monitored and to perform this, various component is involved and are explained below

Arduino Uno R3 Module: This module is the heart of the heart of the robot. It is micro-controller acts like gateway interfacing between sensors, camera and cloud. It receives all the sensory data, process it and then transfer to the cloud. The spots on the leaves are detected by this module. Raspberry is cheap, high reliable, cost effective and can be utilized to interface number of sensors, process data, control easily. This is responsible to find the exact position of the infection, send message to the farmer and spray the pesticides.

Figure.4. Arduino Uno R3 Module

Motor Driver Expansion Board: The motor driver board consists of L293D chip. It drives the 4 bi-directional motors with 8-bit individual speed selection. It is also capable of driving two stepper motors. This is compatible to use with Arduino. It has a power button. It is also provided with buzzer which is soldered. It has two connections for 5v Servos connected to the Arduino's dedicated high-resolution dedicated timer. It is interfaced with ultrasonic and line tracking module. All the modules are modified with XH2.54 Ports as to make it much easier and convenient to assemble the bot.

Figure.8. Motor Driver Expansion Board

Line Tracking Module: The TCRT5000 IR sensor on the line follower has a TX and RX inside. If a bright colour surface is detected in front of the sensor, such as a white paper, most of the IR rays will be reflected; if a dark colour like black surface is detected, most of the rays will be absorbed, while only a small amount will be reflected. The RX will output different analog signals according to the intensity of the reflected IR light. This line tracking module is used to detect the lines in its surroundings and transfer the data to the controller. The controller analyses the data and sends a command to control the movement of the wheels.

Figure.5. Line Tracking Sensor Module

Ultrasonic Sensor: This is utilized to check the height of the crop thus describing the growth of the cultivation. The predators like crows, rats are detected by this module and used to take autonomous diversions. The ultrasonic sensor sends the high frequency waves which when hit the crop are reflected back and the sound is analysed. This enables the sensor to calculate the height of the crop based on the time period between the sent and traced back signal. This is not only used to detect the height of the crop but also to detect the pests and sending info to the farmers.

Figure.6. Ultrasonic Sensor Module

WIFI Module: The Wi-Fi module kit has two parts, one module is the core board and the other is the Wi-Fi adapter board. It is used to send control commands to the car that transmits the real-time data i.e. images to the smart phone. It has Wi-Fi antenna. It has system start up light. It Supports USB Camera Interface. It has various working modes like Routing, AP, Relay, Bridging.

Figure.7. WIFI Module

SG90 9g Micro Servo Motor and Pan/Tilt/Zoom: SG90 9g is a tiny and light weight with high output power. This can rotate 90 degrees in both the directions and 180 degrees approximately. This is widely used in the field of fixed wing, helicopter, gliding and manipulator model. The maximum rotation angles of left and right are same. PTZ (Pan/Tilt/Zoom) is a set of equipment used to install and fix the camera module. One set of PTZ contains a PTZ base, 3 pieces PTZ brackets and several accessory screws. Support full rotation. The module is widely applied in the field of fixed wing, helicopter, gliding, small robot, manipulator model.

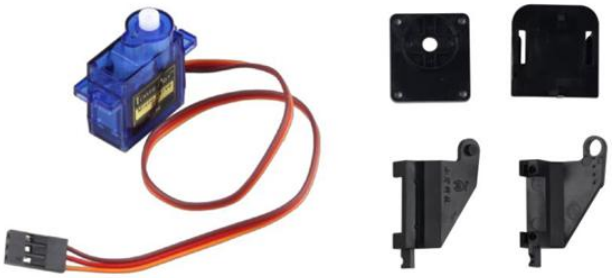

Figure.8. Moisture Sensor Module

Multispectral Camera: This module is employed to identify the diseases, predators and tacking the path. These are used to take the photographs of the plants and store them in the DCM format which is gray scale images. These images are compared to diseased crop images and based on the intensity of the colour they are classified and thus plays an important role in the disease detection. These are cheap, simple, accurate and have many applications. Main key function of this camera is to identify the what is the type of disease occurred, in which part of plant it got effected and how much area does the disease spread. So that we can suggest the farmer about what is the pesticide needed, how much quantity of pesticide is required and where to spread the pesticide in specifically.

Figure.9. Multispectral Camera Module

ThingSpeak Cloud Platform: ThingSpeak is an open-source IoT application and API used for storing and retrieving of data, of the things which are using HTTP protocol over the Internet or via LAN. ThingSpeaks enables us to create applications like sensor logging, tracking of locations, and networking of things socially with status updating facility.The

ThingSpeak is a cloud and web service which provides apps and facilitates us for analysing and visualizing our data in MATLAB, and to act on the data. Sensory data can have transferred to ThingSpeak through several gateway interfacing devices like Arduino, Raspberry Pi, BeagleBone Black, NodeMCU, and other hardware.

V. TASKS PERFORMED BY THE ROBOT

The robot was designed to perform all the tasks done by the farmer like field Monitoring (Soil, Plants, Predators, Insects, Birds, Rats, Snakes, etc.) and Weather Monitoring, Spreading of Fertilizers and Manures, Plant Monitoring, Predators Detection, Weeds Detection, Obstacle Detection. This can be done easily by the utilization of the different sensors.A continuous Plant Monitoring is done autonomously and all the data will be sent through wireless communicating modules like WIFI, Bluetooth, Zigbee, GSM, etc. Predators Detection is done by camera. and the taken pics are send to the raspberry pi and then related tasks are done by robot accordingly. Obstacle Detection task is performed by Ultra-Sonic sensor. Weeds Detection is also done by the camera by the periodic transmitting of the crop pictures, image processing and comparing them with other diseased images. The data or information received from the different sensors is controlled by the controller unit when passed through the A/D converter. It consists of network of field sensor unit and radio transmitters to transmit the I.R, pH, water level, temperature and human intrusion data for data transmission. This data is stored in a server and sends messages to the farmers. Message Sending Module unit has GSM module to transmit data from the sever to the farmer using a public mobile network. It consists of a GSM or GPRS long with a micro controller unit. The sensed data is received, classified/processed and registered in the transmission unit. The sensed data is sent to the farmers via SMS along with the necessary action that have to be applied periodically and can be easily altered with respect to the need using a computer.

VI. EXPERIMENTAL RESULTS

The robotic smart agricultural technology is equipped with various sensors that includes both data collecting sensors like Moisture sensor, Electrical Conductivity sensor, pH sensor for measuring different agricultural parameters; ultrasonic sensor and camera for manual and autonomous controlling of robot; and data transferring sensors like Wi-Fi-module and helical antenna to transmit the information about the field to farmers; and to perform actions in the field accordingly. The environmental parameters like temperature and humidity are also detected with the help of DHT, in the location where crop is situated in. It also includes Raspberry Pi microprocessor and other hardware components like motor driver board, stepper motors, DC motors and camera for performing various actions around the crop field.

Figure.10. Autonomous Smart Agrobot Preview

Figure.11. Autonomous Smart Agrobot

Fifure.12. Autonomous Smart Agrobot Whole Setup

Xanthomonas Oryzae Pv (ZOO) is one of the most common diseases seen in the rice crop right from its seeding state. Along with these diseases like Rhizoctaniasolani, Helminthosporium Oryzae, etc. are seen during different stages of the cultivation. The symptoms are periodically monitored using image processing and pesticides are sprayed only at the

infected portions using HSV module. These are totally bacterial type infected diseases.

Figure.13. Xanthomonas Oryzae Pv (ZOO) Disease in Rice Crop

Figure.14. Rhizoctaniasolani Disease in Rice Crop

Figure.14. Helminthosporium Oryzae Disease in Rice Crop

VII. CONCLUSION

This system is designed for the collection of the data(images) periodically of a large field and the analysis of the images is done with respect to the position. Therefore, enabling the farmers to act at a specified area. The image sensing technology in collaboration with multi spectral imaging increases the field horizons. And the transfer of the whole data as messages through GSM module enables the farmer to have full control over the field and can take decisions easily increasing productivity with increased quality.

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