

A Neural Network Based Automatic Crop Monitoring Robot for Agriculture

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Abstract—In this work, we present the Neural Network-Based Automatic Crop Monitoring Robot, which is built for assisting farmers to detect plant diseases and monitoring environmental factors in agriculture. This system uses the Raspberry Pi as its hub, with a USB web camera installed to take images for analysis of sign so fillness in tomato-plant leaves. Trained neural networks process those images, distributing them directly back as emails containing pictures depicting diseased leaves and spikes in need of treatment. The robot comes with a DHT11 humidity/temperature sensor so that it can keep conditions optimal for burgeoning plant growth. In order to ensure that the plants grow under the most suitable conditions, we have installed a DHT11 sensor for monitoring temperature and humidity as well as an analog output soil moisture detection unit (connected via ADC to allow for conversion into digital signals). With outside of bounds data from either monitor, an alarm goes off among user environment. The robot is based on a tracked vehicle that uses DC motors and a 12V battery to get around, thanks to this equipment it can move autonomously performing tasks such as weeding or fertilizing (under control of the Raspberry Pi).

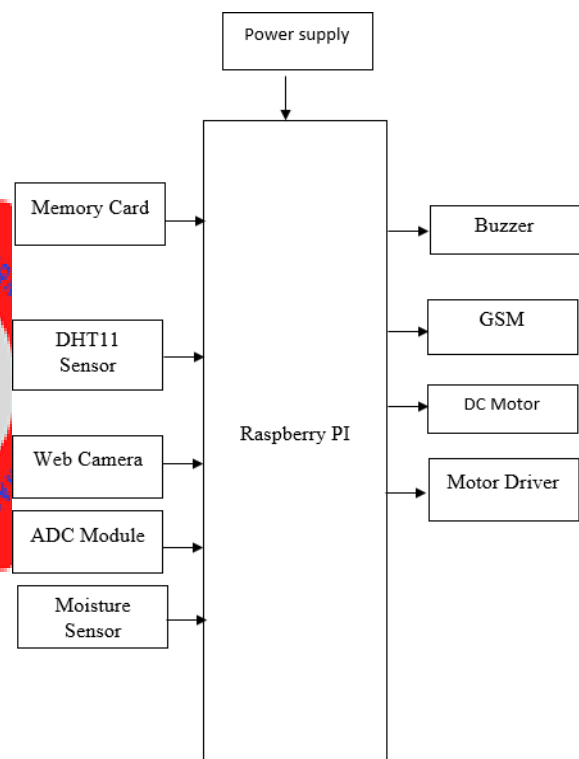


Fig. 1. Block Diagram

I. INTRODUCTION

With the increasing demand for sustainable and efficient agricultural practices, intelligent systems are being developed that can help farmers monitor crops and manage diseases. An example of the latest grassroots radioactive technology is the Neural Network-Based Automatic Crop Monitoring Robot which uses image processing, environmental sensing and autonomous mobility to provide real-time knowledge about plant health. Comprising a USB webcam and a Raspberry Pi, the robot takes pictures of tomato plant leaves, then uses a neural network trained to recognize diseases at an early stage.

With integrated sensors including one DHT11 (temperature and humidity) and a soil moisture detector by means of an ADC module, this mobile, autonomous instrument continually monitors environmental conditions to send alerts through a buzzer in case of anomalies. Furthermore, the system supports communications between farmers by emailing them contaminated leaf images for prompt intervention [1]. [2]. Business model innovation meets cutting-edge technology in this mobile, self-contained solution. It provides a low-cost and effective method for bringing agriculture into the modern age, while at the same time improving production. Fig.1. Block Diagram

real-time sensors and machine-learning abilities to provide an intelligent alternative. Using such a system to travel across farmland fronts gathering data of soil moisture levels, temperature & humidity, current crop areas pests etc. By Valentin H busca. Video, audio and still pictures will be used in the accompanying video series to further illustrate parts of this solution. In contrast to fixed-threshold systems, the neural network is able to observe patterns from the environment, making it possible for the robot to make better-informed decisions regarding irrigation, stress detection, and the early identification of irregularities. The combination of robotics and data-prediction analysis makes the system less dependent on human observation and boosts the accuracy of resource utilization, especially in the utilization of water. This system marks a transition towards automated and intelligent farming, benefiting the automation and intelligence of systems to improve productivity, labor reduction, and optimal crop development. As automation and intelligent systems are increasing in popularity, agriculture is expected to transition towards precision farming. The use of robotics with sensor and machine learning capabilities makes it a promising solution for the efficiency of crop observation.

A neural network-based crop monitoring robot combines

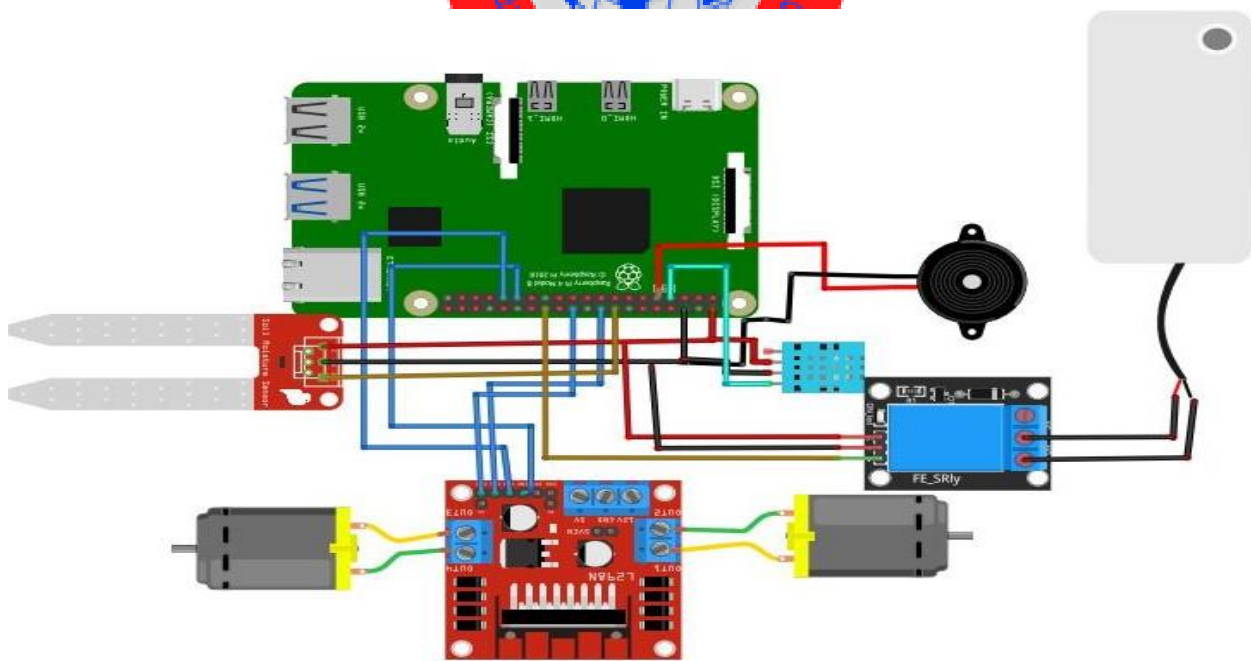


Fig. 2. Connection of Robot

II. BACKGROUND AND RELATED WORK

A. Background

The agriculture sector is undergoing a paradigm shift to improve efficiencies, reduce wastages, and raise the quality standards in the environment of climate change. The manual process of crop monitoring is not in a position to meet the demands being generated due to developments in the agriculture sector [3], [4], [5]. Human observation, being a lengthy process, also causes inaccuracy while assessing the variations in the crop environment and the changes taking place in the environment [6], [7]. With the advancements made in the hardware domain, and the development of low-cost sensors and mobility platforms, the transition from the existing agricultural practices to a more technological and more accurate method for crop monitoring is possible. With the help of the development in the field of neural networks, an extra edge is being added to the technological development, and the possibilities exist for learning from the environment and performing forecasting on the basis of the gathered inputs.

B. Related Work

Studies in agri-automation technology have observed the development of various levels. These early levels included the implementation of fixed sensors dispersed around the farmland for the purpose of monitoring basic aspects such as moisture content, temperature, and humidity. Although the technology was good, the level had geographically inflexible setup arrangement and hence required a high density of sensors to span the whole farm land [8], [9]. This shortcoming was addressed by the creation of agri-automation technology aspects utilizing the Internet of Things monitor system, which utilized wireless technology for the transmission of data, although the technology still utilized fixed sensors that lacked real-time intelligence. Later came the implementation within the agri-automation technology level requiring autonomous robots within the robotics technology domain [10].

III. PROPOSED METHOD

On this method the incorporation of raspberry Neuromorphic Robot introduction a smart Pi camera served by neural network to detect tomato leaflets fungi, disease prefer relying altogether "Whenever a diseased leaf is detected, the system will automatically send a mail alert with snapshot, so that managers are not compelled to make actual contact with the plants. The robot is a continuously monitor of plant health and ambient temperature, humidity, soil humidity with entire ecological conditions few sensors such as DHT11 and Soil Dun. This mobile machine enhances agricultural efficiency through real-time disease detection, automated alerts and efficient ground coverage without

humans.

IV. ARCHITECTURE

Based on neural networks, the so-called smart crop watcher incorporates sensing, images, decision-making and movement assolid-state systemsintoits architecture. Atthecenter ofthis architecture is a Raspberry Pi acting as chief processor in charge of tracking data for sensors, running the neuralnetwork model and controlling where robots move. The environmental parameters, such as: temperature; humidity; soil moisture content (Main Code name) are typically measured mainlythroughthe DHT11soil-moisture sensor and an ADC module that converts analog signals to digital transmission format. With the USB webcam, the continuous capturing of plant images is done, followed by preprocessing andinputtingintoalightweightneural-networkmodelrunning on the Pi for recognizing the disease symptoms or stress condition. The robot's mobility is provided by a motor driver coupled with two DC motors, each allowing the movement of the robot either forward, backward, or turning. The motors are placed on a sturdy robot platform supported with wheels and dummy shafts.

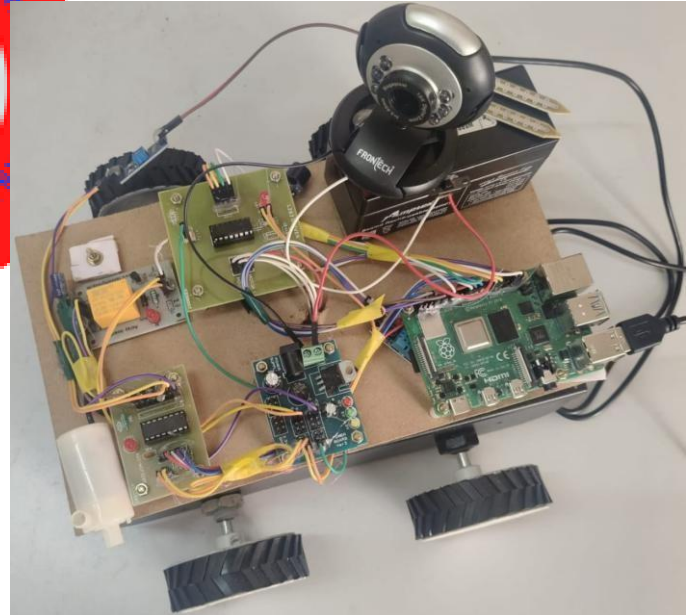


Fig 3: Hardware Set of Robot

V. HARDWARE INTEGRATION

A. Raspberry Pi

The Raspberry Pi is a versatile and compact single-board computer developed by the Raspberry Pi Foundation, designed to promote computer science education and experimentation. It features a range of models with varying performance levels, including multi-

core processors, RAM, and connectivity options such as USB ports, HDMI, and GPIO pins. Its affordability and adaptability make it a popular choice among hobbyists, educators, and developers for prototyping and learning.

B. Web Cam

Web Camera The webcam is a kind of digital camera that can be connected to a computer or other device and used for live transmission of video images via internet link. In the Integrated Vehicle Safety and Security System Using Raspberry Pi work's context, a webcam can be used to give visual surveillance and monitoring of the vehicle environment. This not only increases its safety features but also allows for new security measures.

C. DHT11 Sensor:

DHT11 Sensor The temperature and humidity being able to be measured using a digital sensor that is very widely adapted, the DHT11 sensor is a good example. It uses a thermistor for temperature and an integrated humidity sensor to give dependable and precise readings. It is used not only in weather stations, HVAC systems and other fields, but also in environmental monitoring. Due to the way that it handles 0- 50°C temperatures as well as 20-80% relative humidity, DHT11 can meet a variety of basic functions in climate monitoring. Floor mops. Self-powered. Small and with a large measurement range, DHT11 is very practical for measurement.

D. ADC MCP3008:

MCP3008 ADC the MCP3008 is a 10-bit, 8-channel analog-to-digital converter (ADC). It communicates with Arduino and Raspberry Pi using the Serial Peripheral Interface (SPI) protocol. This converts data from sensors into digital form with 10 bits of resolution, accurate to within voltages represented by A/D results.

E. Soil Moisture Sensor:

The soil moisture sensor is an instrument that measures the water content in soil. Usually it is achieved by probe sensing ohm difference between dry and wet performances or mechanically detecting continuously changing electric parameters such as capacitive sensing, impedance sensor current value this needs only touch type fast response, like time domain reflectometer is using now. Soil moisture sensors are

widely used in agriculture, gardening and environmental monitoring.

F. Buzzer:

A buzzer is an electric sound-producing device. The activeness of a buzzer to produce sounds is created by passing electricity through this device. It is mainly composed of a coil connected to a magnet with a diaphragm to produce sound or another suitable device capable of handling this operation. There is swift movement back and forth once connected to electricity with a resultant high-speed sound production. The sound produced by a buzzer can also be depicted to go from blues song to high chord based on sound-wave productions created using different frequencies and because each and every element has some dead time.

G. Motor Driven:

It is the motor drive represented by electronic circuits designed for controlling the speed, direction, and motion by supplying voltage & current for the operation of the motor. This is because most microcontrollers do not have the capability to drive the motor unless through the use of motor drivers. The motor drivers make use of transistors, MOSFETs, or H bridge circuits to control the motor for effective motor movements. They are normally used in controlling the AC motor in robots, PLDs, or any other microcontroller-based embedded device. Some of the motor ICs used are L293D, L298N, and TB6612FNG.

H. DC Motor:

DC Motor is an electrical machine that converts direct current (DC) into mechanical energy through the combination of magnetic fields and current carrying conductors--so-called because to distinguish it from AC machines such as almost universally used during its first century is inaccurate since field persistence in practice terms always requires some kind of "field" and this type simply derives strength from expressly associated magnetic electromotive force. Key parts include the rotor, stator, commutator, and brushes. When current passes through the coils of a motor.

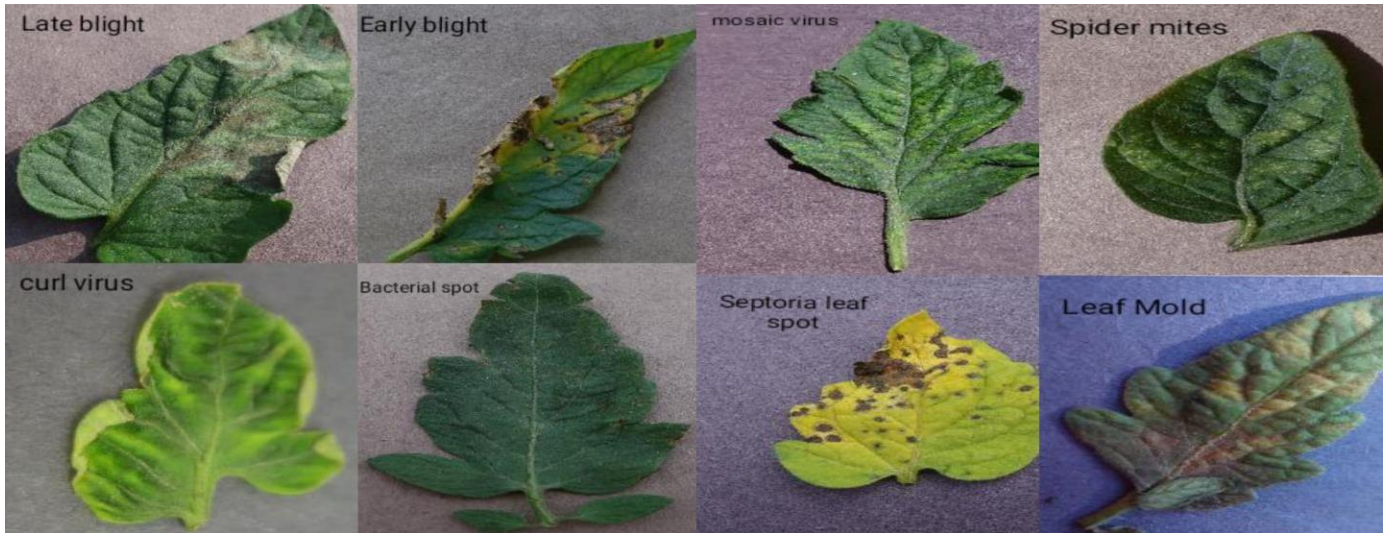


Fig 4: Insect Damaged Leaves

VI. IMPLEMENTATION AND USE CASES

The Implementation and Usage section of our work assists us in understanding the performance of the system when implemented in real-world scenarios. Our crop monitoring robot can be implemented with the help of a Raspberry Pi connected to sensors for gathering environmental inputs, taking pictures of the crops with the help of a USB camera connected to the Raspberry Pi and a light weight neural network algorithm for detecting diseases or stress on the crops. This is done with the help of a motor driver for autonomous control in the field and a 12v battery for the entire system setup with a buzzer for notifications when abnormal inputs are detected.

A. Simulation

The robot comprises a Raspberry Pi, which acts as the main controlling unit for the entire sensor reading, image analysis, actuation of the motors, and the computation for the neural networks. The DHT11 sensor and the soil moisture sensor measure environmental parameters such as soil moisture, temperature, and humidity, from which the analog outputs are digitized by the ADC module. On the other hand, the USB camera captures images of the crops at a scheduled time or during motion in between rows of the farms. The captured images are preprocessed and utilized by a simplified neural network model developed and executed by the Raspberry Pi using Tensor Flow or any other AI library. The model interprets the captured images by outlining the potential diseases and signs of stress of the crops based on input by sensors and model predictions, and the robot moves accordingly to change the pattern of movement through the motor driver. The robot is designed to run with the help of a 12V battery

so that it works properly in outdoor conditions, has regulated supply lines of 5V, and protects the Raspberry Pi along with other sensitive components. The robot platform is designed in such a way that it holds all the modules using DC motors, which ensures the movement of the entire platform conveniently on wheels in the farmland. The buzzer indicates all the abnormalities the robot detects with the help of a neural network implemented within it.

B. Use Case Exploration

The robot can be applied in several practical agricultural situations, making it a valuable tool for modern farms. It supports early detection of plant diseases by analyzing captured images through the onboard neural network, allowing timely intervention. Soil-moisture monitoring helps optimize irrigation schedules and avoid water wastage. Temperature and humidity data offer insight into micro-climate conditions that influence plant growth and pest activity. The robot's autonomous movement enables continuous scouting without requiring human presence, making field monitoring more consistent and less labour intensive. The system logs all observations, creating useful historical records for crop-health analysis and decision-making. It can also serve as an educational or research platform for precision-agriculture studies, helping students and researchers explore plant detection, sensing, and robotics.

- Detecting early plant diseases through neural-network image analysis.
- Monitoring soil-moisture levels to support efficient

- Irrigation planning.
- Recording temperature and humidity trends to understand micro-climate effects.
- Performing autonomous patrols across fields for continuous crop inspection.
- Reducing manual labour by automating routine monitoring tasks.
- Providing real-time alerts when plants show signs of stress or infection
- Storing historical field data to track crop-health changes over time.
- Supporting agricultural research with a mobile sensing
- And imaging platform.
- Helping farmers optimize fertilizer and pesticide usage based on early detections.
- Improving overall productivity by enabling timely and data-driven decisions



	Predicted Class			
	Healthy Crop	Diseased Crop	Weeds	Bare Soil
Actual Class	320 (95%)	10 (3%)	5 (3%)	3 (1%)
Diseased Crop	280 (90%)	15 (5%)	8 (3%)	7 (2%)
Weeds	310 (93%)	8 (2%)	290 (5%)	6 (1%)
Bare Soil	260 (92%)	7 (3%)	5 (2%)	225 (90%)

Accuracy: 92.5%
 Precision: 91%
 Recall: 90.5%

■ Correct Prediction
 ■ Incorrect Prediction

Fig.5. Confusion matrix



Fig 6: Leaves damaged by insects

VII. SOFTWARE INTEGRATION

The software developed and used by the robot also generates a variety of meaningful outputs that aid the evaluation of the health and conditions of the crop being grown. Using the images taken by the camera mounted on the robot, the software developed using a neural network approach generates a result indicating whether the plant is healthy or whether it is affected by a crop disease and stress reaction. The sensor values indicating the levels of soil moisture, soil temperature, and humidity are reflected in real-time by the software using the Python program developed and stored as a record for future evaluation by saving it as a log file. The software developed generates other outputs indicating the movement status of the robot, including changes in directions and the progress of patrolling the fields, hence assisting the evaluation of the robot's performance while performing the task of field observation and patrolling the fields. The software developed generates other crucial outputs of all images processed and sensor data saved as files documented using the memory card for future record evaluation by the customer or client to evaluate the entire history of the fields observed by the robot software developed for the specified task and mission assignment by the farmer or researcher requesting the robot's assistance.

A. Data Pre-processing

Data Pre-processing is done in this phase of the work for ensuring that images and sensor data, as acquired by the robot, are clean and amenable for analysis. Images from the camera are normalized and sized to meet the input requirements of the neural network. The images are further checked for clarity, and the blurred images are removed. Simple adjustments in brightness and contrast ensure that the images are uniform despite changing lighting conditions in the field. Data from the DHT11

sensor and the soil- moisture sensor are filtered using simple filters to smoothen the effects and avoid spurious peaks. Sensor data is also time-stamped to ensure that the acquired data is accurate and correctly captures the conditions in the field.

B. Model Training and Analysis

In this phase of the work, the neural network methodology used in the crop monitoring robot learns from a set of images of the crops when healthy and when they are infected with different diseases, using a dataset of crop images for both healthy and diseased states. Preprocessing of the images is done through resizing and normalizing the images, along with augmentations like rotation, flipping, and adjusting the brightness of the images to make the system more robust in the real-world setting. The objectives are achieved by using a lightweight convolutional neural network methodology, such as the MobileNet or Efficient Net-Lite methodology, which is trained using a labeled dataset with unique health states for a set of images.

The robot captures real-time images of the crop field, sending these images to a Python-based processing system. These images need to be preprocessed by resizing, normalizing, and reducing noise in the images for them to act appropriately in the analysis through a neural network system. These pre-processed images are then passed on to the trained system, and based on the result given by the system, the crop is classified as healthy, diseased, or stressed. Alongside this, the environmental readings of temperature, humidity, and soil moisture have been taken through sensors and then combined with the results for better identification of the state of the crop, after which it produces a decision like alerts and actions accordingly.

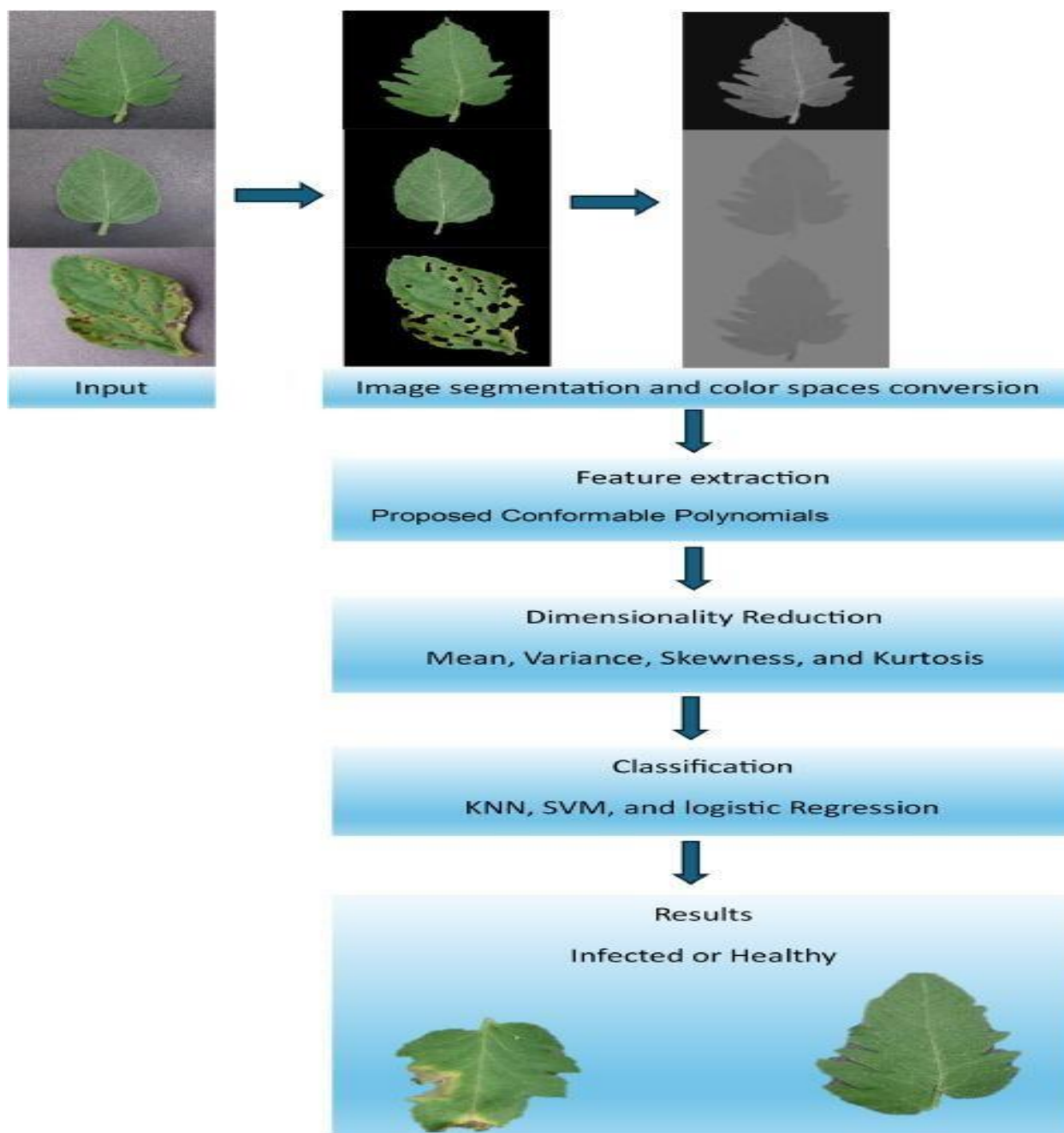


Fig 7: Image Processing

VIII. CONCLUSION AND FUTURE WORK

The suggested solution for the Neural Network-Based Automatic Crop Monitoring Robot work is economical and effective for real-time crop and environmental condition analysis in agriculture. Farmer can make decisions with ease thanks to the proposed work's use of

deep learning for disease identification in addition to temperature, humidity, and soil sensing. The robotic approach used in the proposed work improves accessibility to the fields. The buzzer notification system is also utilized in the suggested solution.

This intelligent agriculture system is envisioned to become one of the major ways to improve crop yield, reduce crop losses due to diseases, and contribute to the creation of more value-added precision agriculture technologies. Future improvements of the crop-monitoring robot may be made by advanced computer vision techniques in detection, deep learning model development for better forecasting, and autonomous path planning for better coverage. Additionally, technology for aerial observation through drone technology and renewable energy sources in the form of solar panels might lead to sustainable deployment in agriculture.

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