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IoT Based Precision Farming

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Abstract: - This project focuses on leveraging drone images of the pests equipped with advanced sensors for pest detection in crops, combined with methods for image processing to identify diseases. The ultimate goal is to enhance crop health and productivity through timely and targeted pesticide application. Image processing techniques are used to detect signs of diseases and pests in the captured images. The use of machine learning CNN algorithm enhances the system's ability to accurately classify and diagnose crop heath issues. Upon detection of pests, the IOT platform triggers a response mechanism to deploy a precision pesticide spraying system. This ensures targeted and localized treatment, reducing the overall use of pesticides and minimizing environmental impact. This project involves capturing images of pests using a camera, followed by processing these images to extract key features using various image processing techniques. The extracted features are analyzed using algorithms, primarily Convolutional Neural Networks (CNNs), to detect variations in color and other dominant characteristics in the images. By comparing these features across samples, the system can identify pests and plant diseases more efficiently. This approach aims to provide a quicker and more cost-effective solution for pest detection and disease management.

Keywords:- *CNN, IOT, Sprayer Robot, Image Processing, ZigBee Module, Precision.*

I. INTRODUCTION

In recent years, robotics in the agricultural sector, driven by the principles of precision agriculture, has emerged as an innovative and rapidly growing technology. The primary drivers of farming process automation are the reduction of time and energy spent on monotonous farming operations and the enhancement of yield productivity through the application of precision farming principles to each crop on an individual basis. The design of such robots is based on specific approaches and takes into account the agricultural environment in which they will operate. Additionally, a prototype of an autonomous agricultural robot is introduced, specifically designed for tasks like spraying pesticides efficiently and autonomously. Robotic systems have a significant impact across various sectors, including society, organizations, and industries. This research focuses on creating an automated device designed for farm operations, such as pest identification using machine learning [1] and precise pesticide spraying at predetermined distances and depths, incorporating sensors for monitoring humidity and temperature.

This system has two main sections, monitoring station and control station, which are intercommunicated using/aided by the wireless Zigbee or Wi-Fi communication technologies. The control station as well as robotic station possesses the amenities which is soil moisture sensor, ultraviolet sensor, robotic system with motors, ARM microcontroller, and power supply. Next, the sick plants will be categorized, and a camera equipped with Internet of Things technology will be used to take pictures of the afflicted areas of the plants [2]. After that, pre-processing, modification, and grouping are applied to these pictures. The processor then receives these images as input, and using the CNN algorithm, compares the images with the set of tested and pre-trained pests [3].

An automated pesticide sprayer is used to target specific areas of the leaf for pesticide application if the UAV [4] captured image detects signs of damage. This ensures precise and efficient use of pesticides. If not, it will be automatically discarded by the processors, and the spraying robot [5] will move further. This project focuses on making an automated system accessible to farmers for early detection of plant diseases. The system integrates robotics, where a drone captures images, and an onboard processor analyzes them. Once the disease is evaluated, real-time results are sent to the farmer via a Bluetooth HC-05 Android app and displayed on an LCD screen for quick access. The process of disease detection involves several key steps: digital image capture, image pre-processing (including noise removal, color transformation, and histogram equalization), segmentation using the K-means algorithm, feature extraction, and classification using a support vector machine (SVM), a supervised learning algorithm. There are two stages to the processing that is done with these components. Training Phase, often known as the offline phase, is the first processing stage. During this stage, an image analyzer examined a set of input photographs of leaves (both damaged and healthy), and specific features were extracted. Subsequently, the classifier received these attributes as input together with the information identifying whether the image depicts a healthy or diseased leaf. Subsequently, the classifier ascertains the relationship between the retrieved features and the potential conclusion about the existence of the disease [7]. The system is trained as a result.

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II. LITERATURE SURVEY

From Table 1, PAPER-1 refers to The paper discusses the key components of IoT-based smart agriculture systems, such as sensor nodes, communication protocols, data analytics platforms, and control mechanisms. It highlights the importance of each component and their functioning to optimize agricultural practices. Paper 2 refer to the role of OpenCV in analyzing images or video feeds captured from agricultural fields to identify pests or signs of pest infestation. It encompasses a range of image processing techniques, including segmentation, feature extraction, and classification.

Paper-3 refers to the integration of AI technology with UAVs for pest recognition purposes. It discusses the hardware and software components of the AI drone system, including the UAV platform, on board cameras, computational resources, and software algorithms for image analysis. Paper-4 refers to the process of training the deep learning model on the dataset and fine-tuning its parameters to optimize performance. It also presents the results from performance evaluations, including metrics such as accuracy and precision. These papers have respective drawbacks such as connectivity issues, improper detection, outdated technology and also problem in retrieval of the given data.

A. Problems Recognized

From the Literature Survey carried out, several problems were identified in the existing technology of pest detection by drones and spraying methods. They are as follows:

- *Pest Infestation in Crops*

Farmers often face challenges in identifying and monitoring pest infestations in their crops efficiently. Traditional methods of pest detection can be time-consuming and may not provide real- time information.

- *Inefficient Pesticide Use*

Conventional methods of pesticide application may result in over use or under use, leading to increased costs and potential environmental harm. Lack of precision in pesticide application can harm non-target organisms and soil health

- *Manual Monitoring and Treatment.*

Monitoring and treating crops manually are labor-intensive tasks, and the effectiveness of pest management may vary. Timely intervention is crucial, and delays in identifying and addressing pest issues can lead to crop losses.

Table 1: Comparison of Various IEEE Papers

Comparing Factor	PAPER-1	PAPER-2	PAPER-3	PAPER-4
TECHNOLOGY USED	IOT	OpenCV , IOT, 5G - Technology	Cutting Edge Pest Recognition Technology.	Deep learning Artificial Neural Networks
ADVANTAGES	Cost efficiency, Precision agriculture, waste reduction.	Resource Efficiency	Accurate Pest Detection	Real-Time monitoring of the pests
HARDWARE USED	Smart Sensors	Pest Detection by Robot System	Quad - Copter Drones	Unmanned Aerial Vehicle
LIMITATIONS	Connectivity Issues	Ineffective Detection of pests by Aerial Drones	Time Delay in capturing and processing The data.	Retrieval of the data captured.

B. Suggested Solution

Following the difficulties noted in the current system, the following solutions are proposed:

Creation and advancement of an efficient and automatic system to detect diseases in affected plants, by use of image processing of the pests, which minimize the required professional interference and thus reduce the expenditure involved in the spraying the pests using the traditional methods.

The classification software helps in classifying various pests while the hardware consists of a sprayer bot communicated through wireless module.

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This in turn increases efficiency and precision as required, the efficiency in the software is done by the CNN machine learning and precision is done by the nozzle of the sprayer

C. Hardware and Software Components:

The hardware and software requirements are depicted in the Component Diagram of Figure 1.

D. The Project's Hardware Requirements are:

- Arduino Uno
- DC motor
- Water Pump
- Power Supply Module
- Relay
- ZigBee Module
- Embedded c
- Ultrasonic Sensor
- Bluetooth Module
- Soil Moisture Sensor
- Solar Panel
- Battery
- LCD (16*2)
- Motor Drive Circuit

E. The Project's Software Requirements are:

- Arduino IDE
- Tensor Flow
- OpenCV
- Flask
- Python

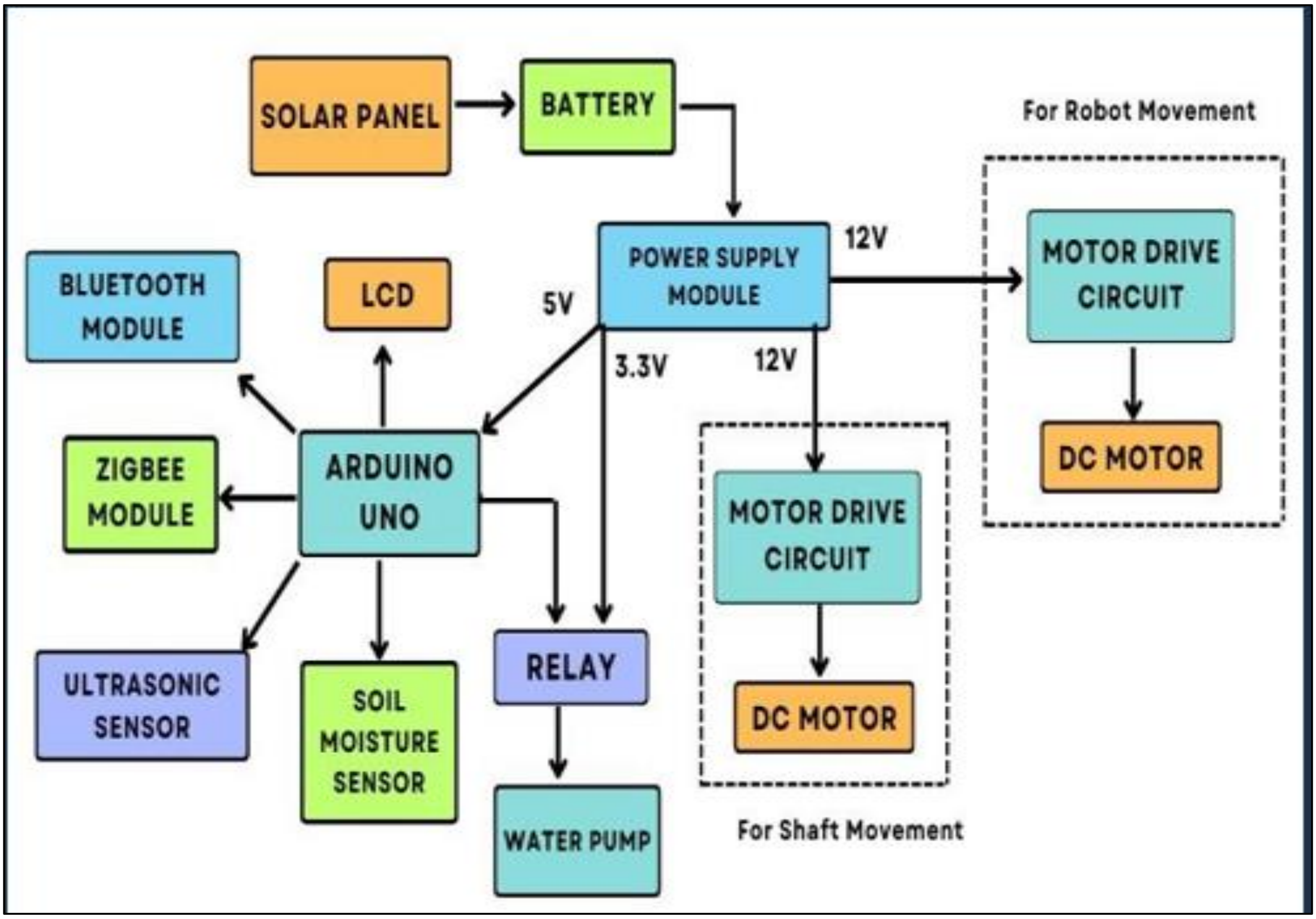

Fig 1: Connection Diagram

III. METHODOLOGY

A. Hardware

➢ *Proposed Methodology:*

The primary goal of this project is to provide precise farming equipment. The hardware component helps to minimize the use of pesticides and aids in precise spraying since it uses a full-cone nozzle, while the software component gives an accurate and precise classification of the pests. The project's block diagram, depicted in Figure 1, is the connection diagram, which includes the different motors and sensors needed for movement and sensing.

The Arduino Uno controls the DC motors by the motor drive circuit.

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The motor drive circuit is responsible for shaft direction. The below Fig 2 is the practical model implementation where the yellow long vertical pole is the shaft which is responsible for the movement of the pesticide spraying nozzle. The practical model is created which is seen in the connection diagram.

Fig 2: Practical Model

- The sensors and controlling all the motion of the robot is processed and sensed by the microcontroller Arduino UNO.
- The Arduino UNO is connected with the soil moisture sensor and ultrasonic sensor, where the soil moisture sensor is employed to ascertain the percentage of the water content in the soil and the ultra-sonic is employed to ascertain the amount of water present in the pesticide tank.
- The power is supplied to the Arduino UNO through an external rechargeable battery source which has the supply of 12V.
- The battery is the connected with the power module, the power module is utilized in this project since various electronic gadgets require varying voltage values. (for example: Arduino UNO requires 5V, while the dc motor requires 12V).
- The solar panel is connected with the battery, the solar panel produces a good amount of 12V voltage during the sunny day which helps in recharging of the battery.
- A Zener diode is connected between the solar panel and the battery in order to avoid the voltage to flow in reverse direction from battery to solar panel.
- The Lcd screen of 16*2 display is connected to the microcontroller in order to provide the visible output to the user.
- Motor drivers are used to control the DC motors. Because dc motors require a 12V supply, motor drivers are employed. The Arduino board is connected to the motor driver, which enables Arduino to control the dc motor that operates on a 12V supply (the motor drive controller uses an L290D integrated circuit).
- The L290D IC is responsible for power amplification and also helps in bidirectional.
- The Zigbee module is the device used for wireless communication between the robot and the laptop.
- Three DC motors are utilized in the project; two of them are employed to move the robot, while the third one moves the sprayer's shaft. where the sprayer's height can be changed.
- The dc motors are controlled using motor drivers. The motor driver is used because the dc motor requires 12V supply and hence the Arduino board is in turn integrated with motor driver where it helps Arduino to control the dc motor which work in 12V supply (L290DICis used in the motor drive controller).
- The L290DIC is responsible for power amplification and also helps in bidirectional movement of the robot.
- The Bluetooth module is in turn integrated with Arduino uno in order for the movement control of the robot.
- The Bluetooth module helps in wireless control of the robot where it can be controlled by the user's phone

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- The relay is connected with Arduino in order to maintain the control on the water pump, here relay is used to overcome the voltage difference between both the Arduino and the water pump. The pump end is connected with the nozzle for spraying.

B. Software:

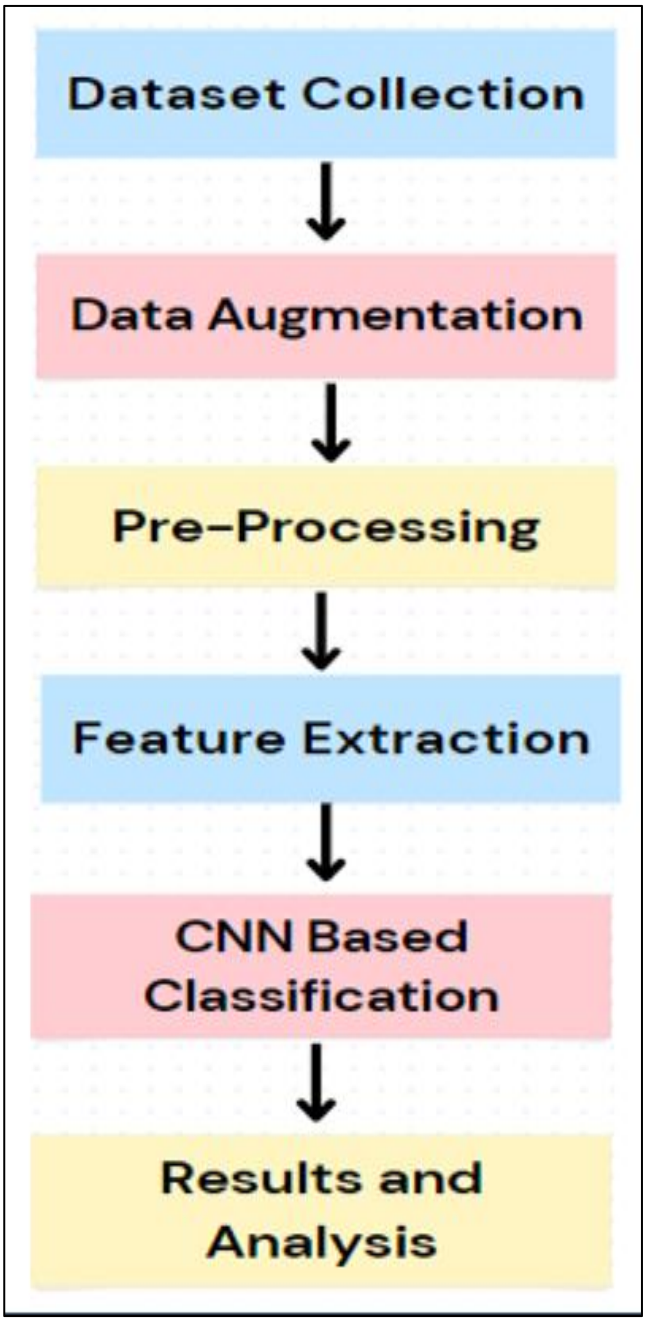

Fig 3: Steps Involved in Image Processing

➢ *Dataset Collection:*

- The dataset is collected by capturing images with a digital camera mounted on a drone, which is connected to a laptop.
- The captured images undergo additional pre-processing.
- The data augmentation is also a part of the dataset collection where the taken set of the images are augmented as per the required resolution by the user

➢ *Image Pre-Processing:*

- The images captured by the camera are pre-processed to enhance their quality.
- Pre-processing steps can include color transformation, noise reduction, histogram equalization, and green masking.
- Color transformation is employed to improve image quality by converting RGB images to grayscale and HSI formats for better clarity.

➢ *Feature Extraction:*

- An image has several key features, primarily color, texture, and shape. In this context, three main features are considered: the color histogram, texture representing color patterns, and the shape and texture characteristics of the object.

➢ *Classification Using CNN:*

- In this module, the images are classified using a Convolutional Neural Network (CNN) classifier.
- To assess the relevant elements and identify distinguishing characteristics for crack identification, a number of features are combined.

➢ *Results and Analysis:*

- The outcomes are far more effective than those of the earlier models and come from a suitable training of the CNN model.
- The study shows the kinds of pests that are found, and the model's effectiveness is gauged by how well it can detect the pests.

➢ *Software Applications*

- *Arduino IDE:*

The Arduino IDE software is used to program the hardware components of the project which include the coding for the sensors, movement of the sprayer bot and also the shaft movement of the sprayer.

The software is programmed using embedded C, where the Arduino IDE is the main interface for the hardware and the user, the user can program his required needs in the hardware by Arduino IDE.

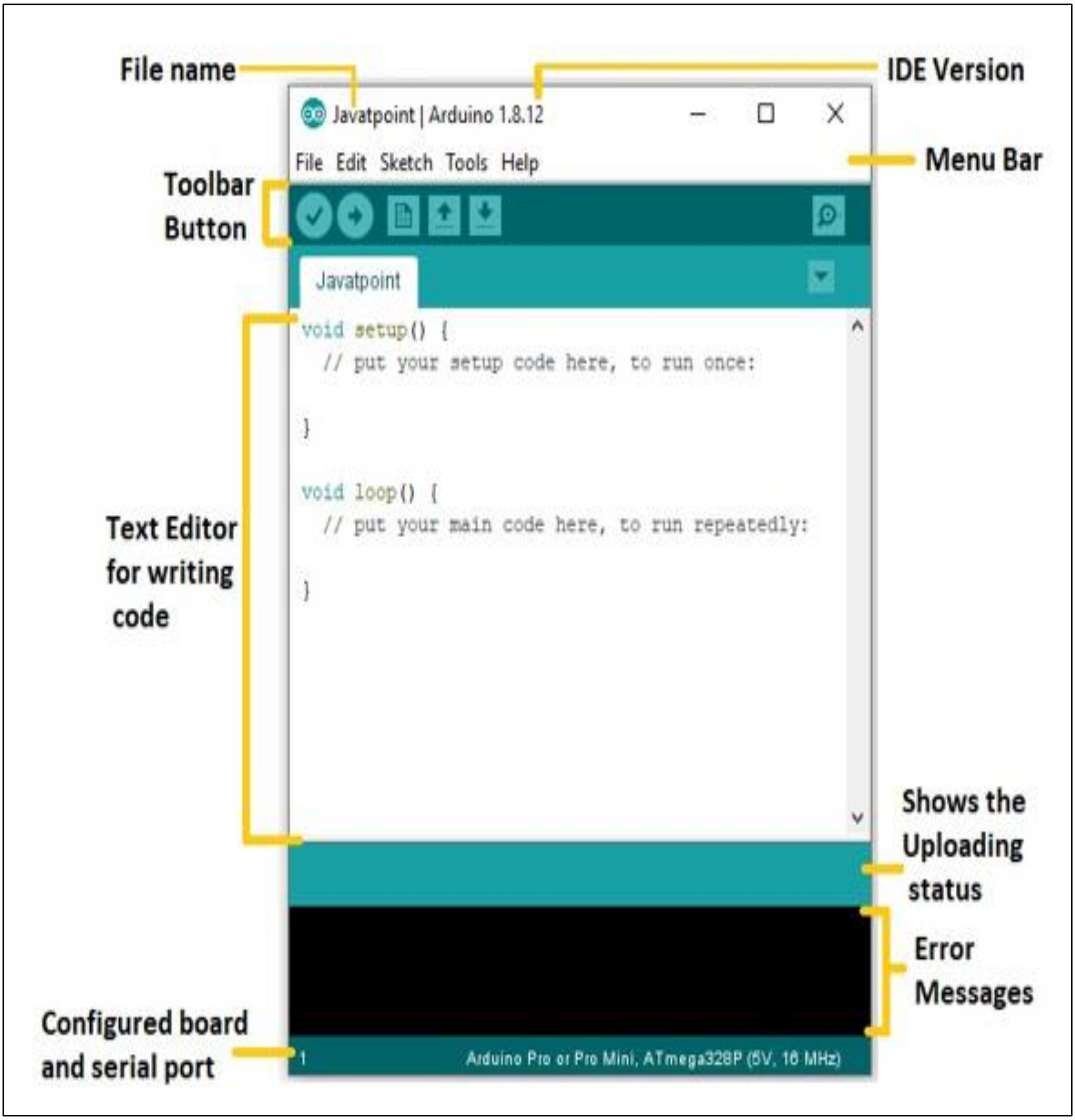

Fig 4: Arduino IDE Software Sketch Screen

- *Tensor Flow:*

✓ TensorFlow is a free and open-source software library designed for artificial intelligence and machine learning. Although it can be used for a variety of tasks, its primary emphasis is on training and inference with deep neural networks.

✓ Developed by the Google Brain team for internal use in Google's manufacturing and research, TensorFlow was first released in 2015 under the Apache License 2.0. An enhanced version, TensorFlow 2.0, was released by Google in September 2019.

✓ TensorFlow supports a variety of programming languages, including Python, JavaScript, C++, and Java, making it versatile for a broad spectrum of applications across different industries.

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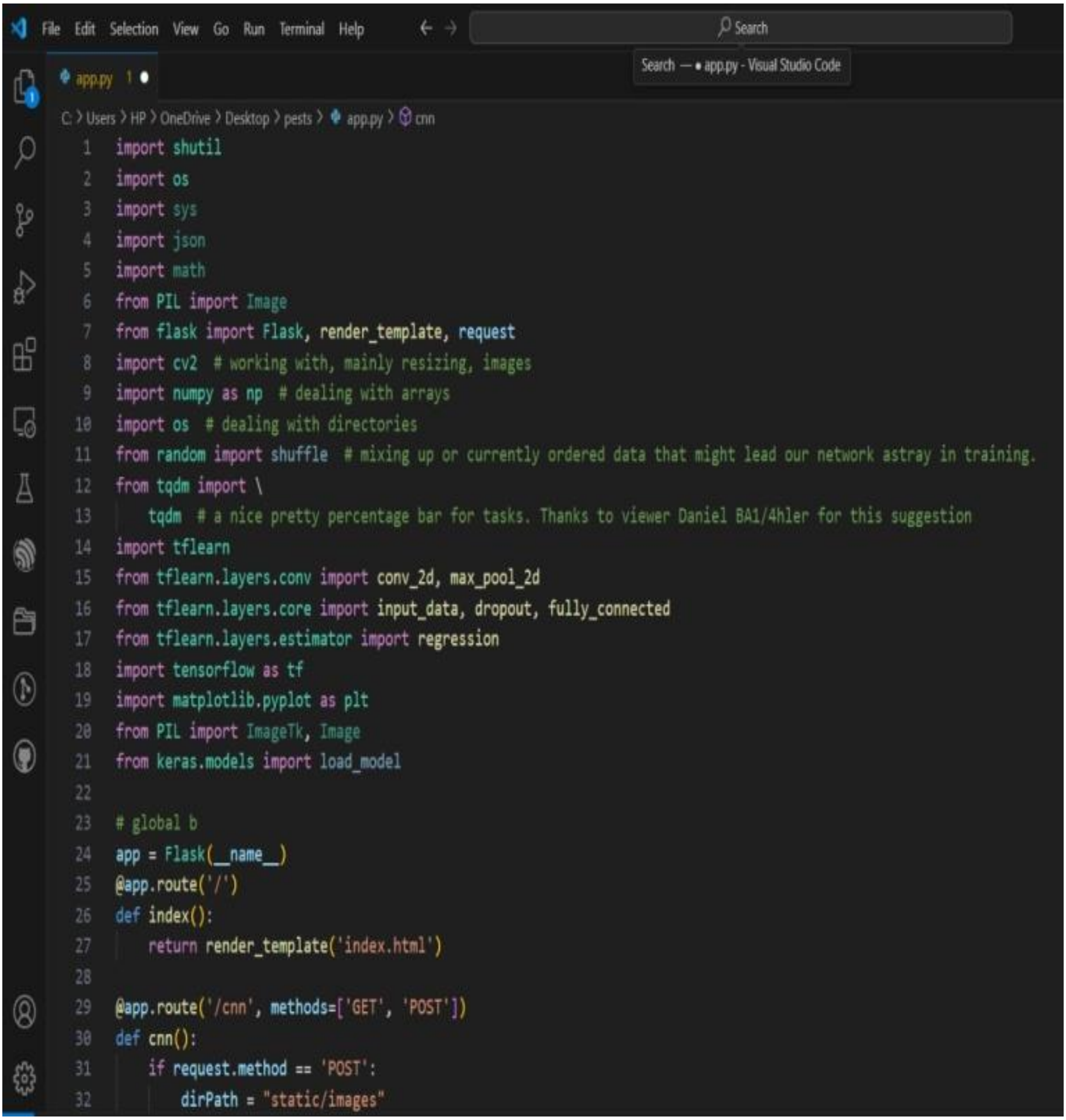


```python
import shutil
import os
import sys
import json
import math
from PIL import Image
from flask import Flask, render_template, request
import cv2  # working with, mainly resizing, images
import numpy as np  # dealing with arrays
import os  # dealing with directories
from random import shuffle  # mixing up or currently ordered data that might lead our network astray in training.
from tqdm import \
    tqdm  # a nice pretty percentage bar for tasks. Thanks to viewer Daniel BA1/4hler for this suggestion
import tflearn
from tflearn.layers.conv import conv_2d, max_pool_2d
from tflearn.layers.core import input_data, dropout, fully_connected
from tflearn.layers.estimator import regression
import tensorflow as tf
import matplotlib.pyplot as plt
from PIL import ImageTk, Image
from keras.models import load_model

# global b
app = Flask(__name__)
@app.route('/')
def index():
    return render_template('index.html')

@app.route('/cnn', methods=['GET', 'POST'])
def cnn():
    if request.method == 'POST':
        dirPath = "static/images"
```

Fig 5: Tensor Flow Program Snippet

The Fig 5 shows the python code for the machine learning CNN where we can see that many libraries are imported as required.

- *OpenCV:*

✓ Programming functions for real-time computer vision are predominantly available in the OpenCV (Open-Source Computer Vision Library), which was originally developed by Intel and later supported by Itseez (a company later acquired by Intel) and Willow Garage.

✓ The cross-platform library is distributed as free and open-source software under the Apache License 2. OpenCV has included GPU acceleration for real-time operations since 2011.

➢ *Among the Application Areas of OpenCV are:*

- Toolkits for 2D and 3D features
- Assessment of egomotion
- System for facial recognition

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The Fig 6 shows the code snippet for the required OpenCV, this shows how the real time application of the program is run, the smaller code snippet shows how the OpenCV is implemented.

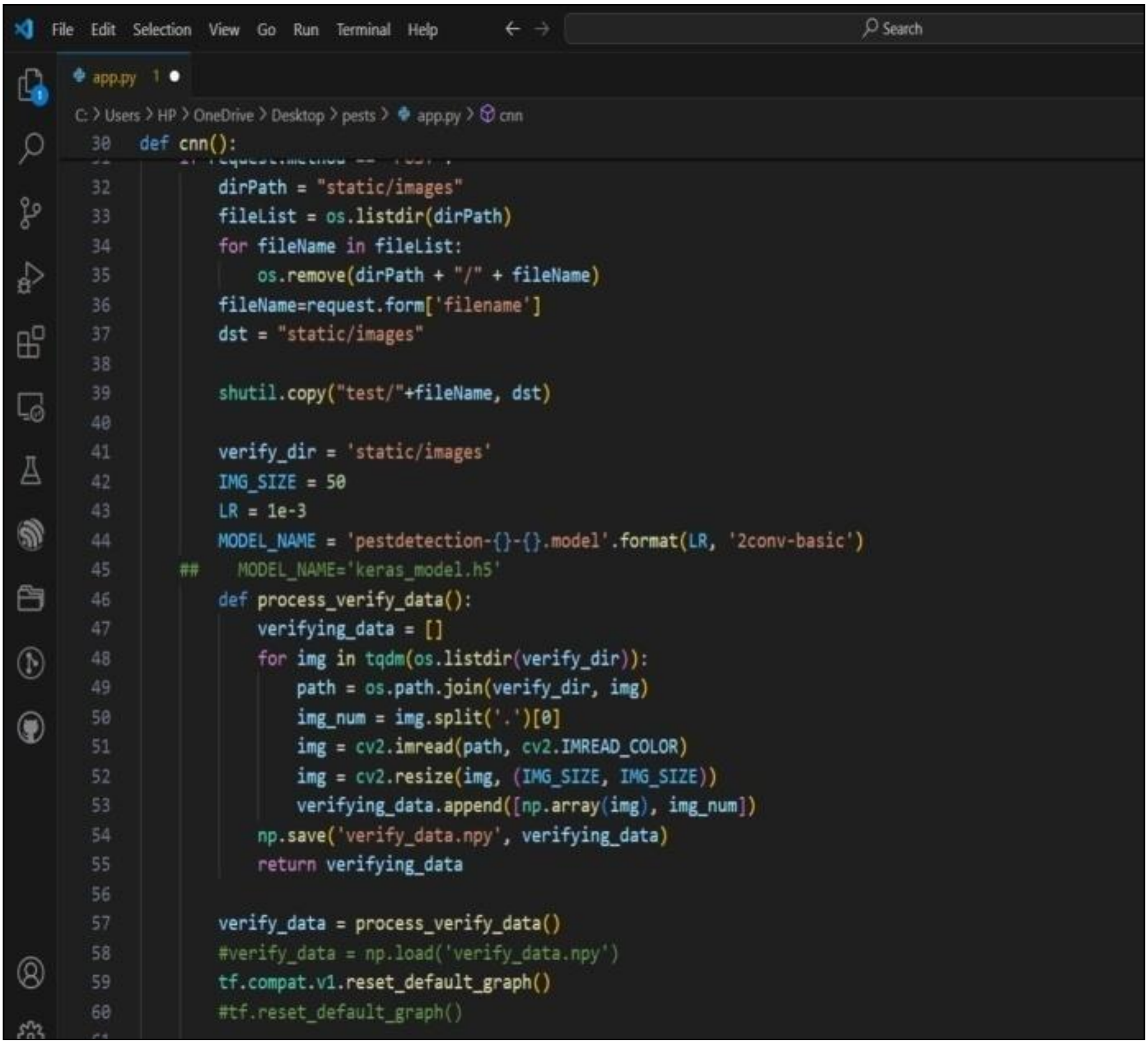

Fig 6: OpenCV Program Snippet

- *Flask:*

✓ Flask is a Python-based micro web framework known for its minimalistic design, as it doesn't require any specific libraries or tools to function.
✓ Lacking built-in features like form validation or database abstraction layers, Flask relies on third-party libraries to provide common functionalities, though it supports extensions to add capabilities as if they were native to Flask.
✓ Extensions in Flask support various functions including open authentication protocols, object-relational mappers, form validation, file upload processing, and utilities for shared frameworks.

- *The Flask Features Include:*

✓ Debugging and development server
✓ Uses Jinja templating
✓ Offers comprehensive assistance for unit testing.
✓ RESTful request dispatching.
✓ assistance with safe cookies
✓ the Fig 7 gives us the code snippet of the web driven application built in Flask for the project.

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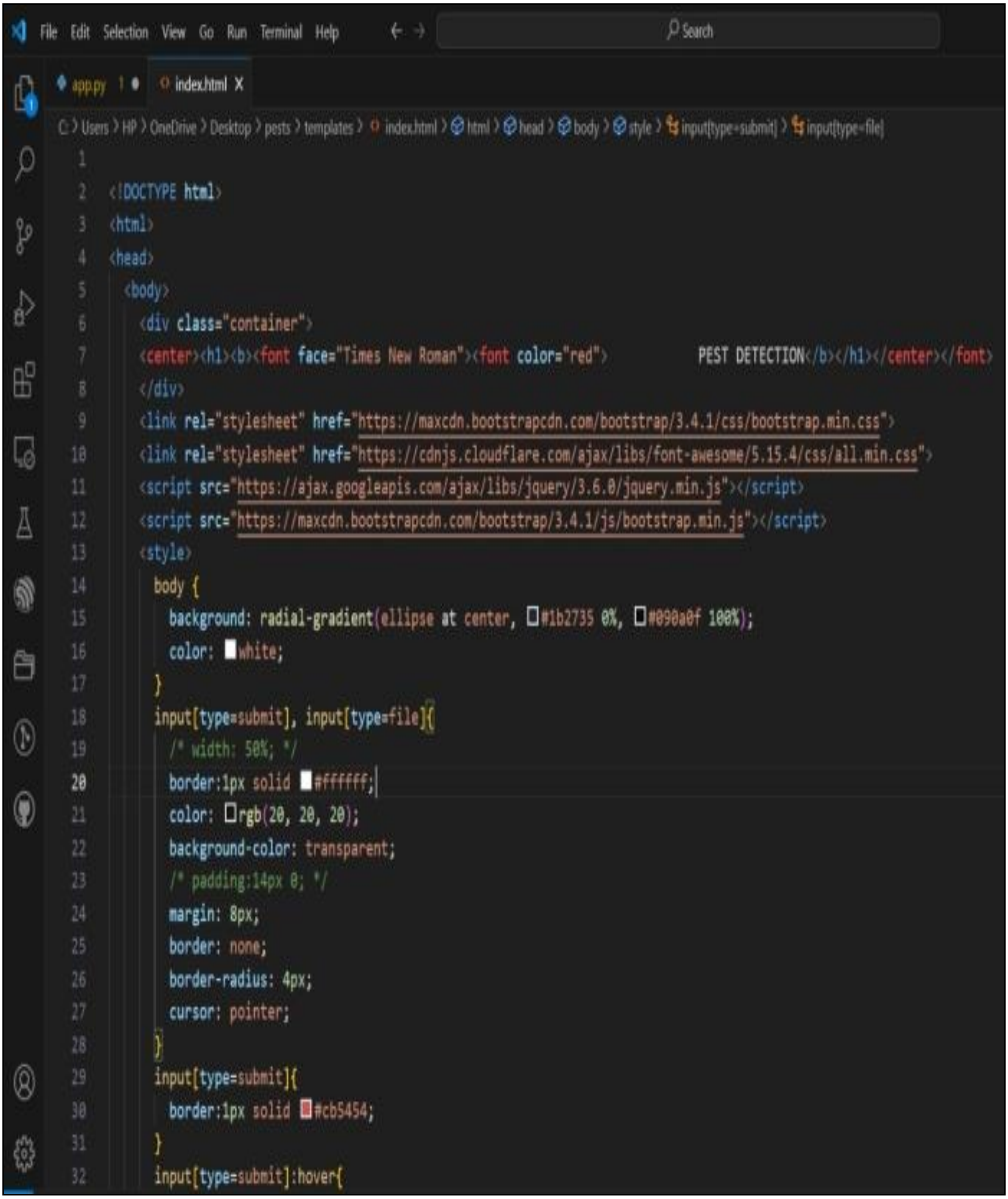

Fig 7: Code Snippet for Web Application of Flask

➢ *Flow Chart*

A flow chart depicting the stages involved in IOT Based Precision Farming is illustrated in Fig 8. This Flowchart gives a detailed explanation of the working of the model.

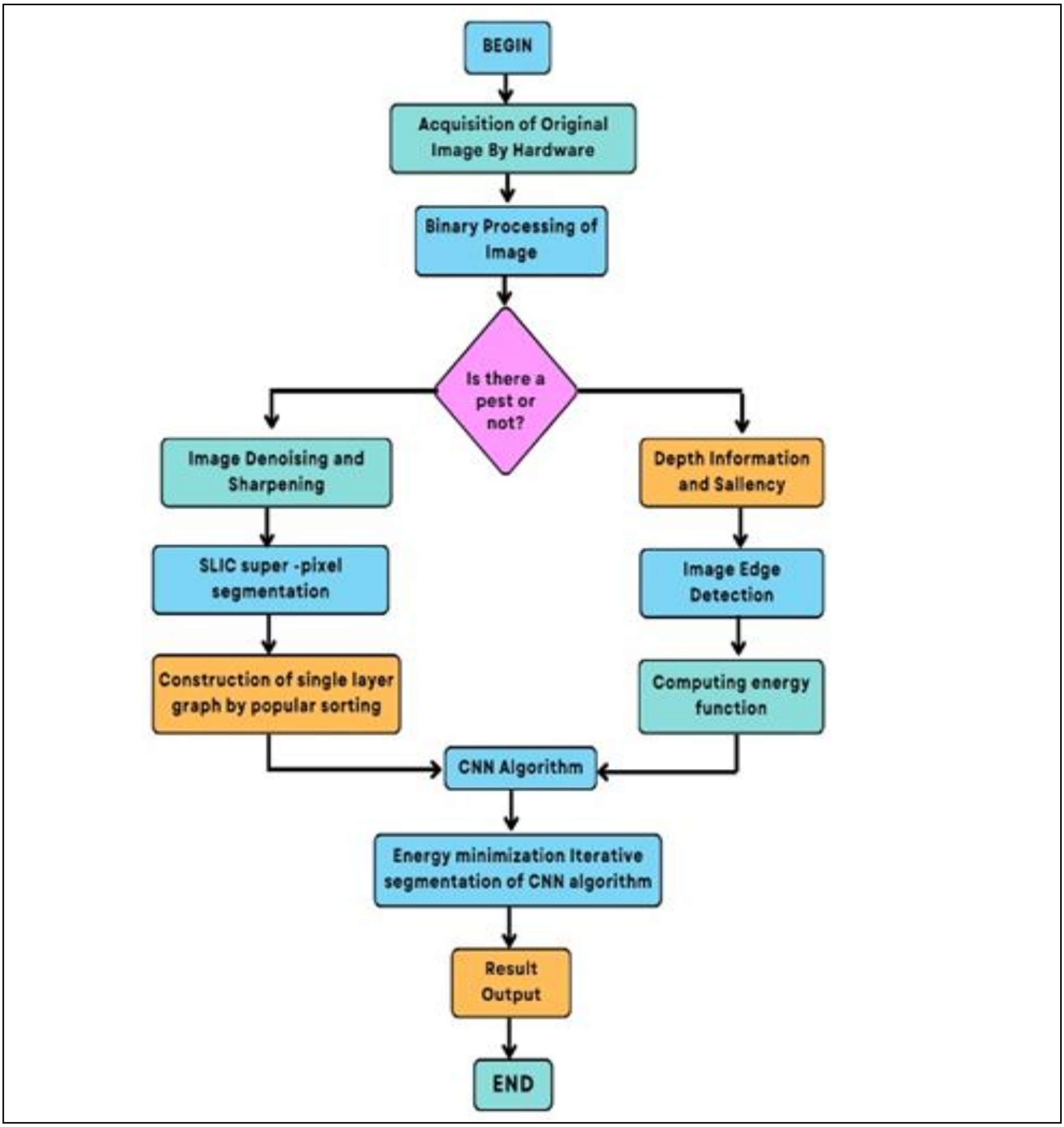

Fig 8: Flow Chart of the Process of IOT Based Precision Farming

IV. RESULTS

Figure 9(a) depicts the software page of the project. The place where the pests images are inserted for testing and Fig 9(b) depicts the output of the given image along with the precision required while Fig 9(c) depicts the sprayer level with the help of ultrasonic sensor where it tells the tank level also Fig 9(d) tells the pesticide detection and Fig 9(e) tells the soil moisture level with the help of sensor.

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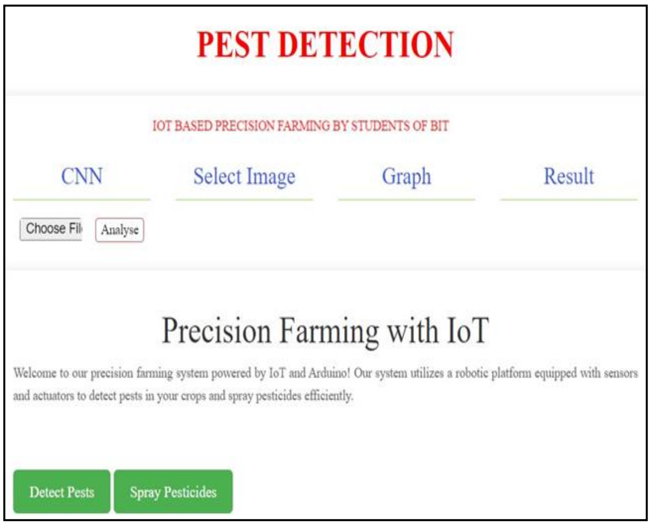

Fig 9(a): Web Application Page

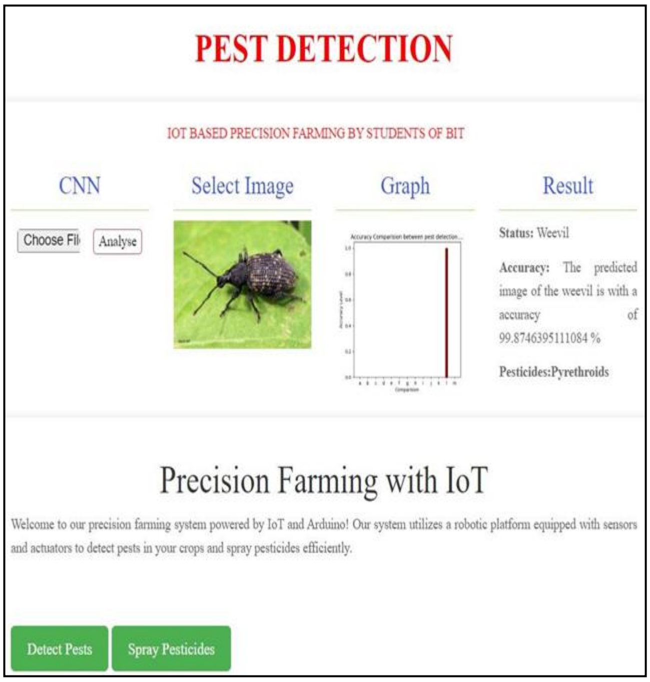

Fig 9(b): Software Result in Classification

Fig 9(c): Shows the Sprayer Tank Level

Fig 9(d): Shows Pest Detected by Hardware

Fig 9(e): Shows the Soil Moisture Level

In this model the IOT Based Precision Farming is done by both hardware and software methods. The software parts and their results are depicted in Fig 9(a) and Fig 9(b) where it identifies and classifies the pests while the rest of the figure 9(c),9(d) and 9(e) depicts the hardware results the hardware model is shown below in Fig 9(f).

Fig 9(f): The Hardware Practical Model

V. CONCLUSION

The prototype is non-invasive, low-cost and user-friendly.

- This prototype may be substantially less expensive than the goods that are sold commercially. The prototype's efficacy and efficiency result in improved power control and little energy loss.
- This self-powered device uses solar power and is connected tothe central gateway using the communication protocol.
- The experiment effectively illustrates how precision agriculture and image processing may revolutionize pest detection and management. by applying pesticides precisely and intervening early.
- The automated and data-driven method encourages environmental sustainability in addition to improving efficiency and cost-effectiveness.

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