RESEARCH PAPER ON PLANT STRESS DETECTION

[1]Mrs.M.A. Paralikar,[2]Ayush Anil Gudhekar,[3]Dhruv Pritam Thorat,
[4]Shivam Mohan Kotkar,[5]Shubham Sandip Sabale

[1]Sr.Lecturer,[2]Diploma Student,[3]Diploma Student,[4]Diploma Student,[5]Diploma Student
[1]Department of Information Technology,
[1]Pimpri Chinchwad Polytechnic College, Pune, India

***Abstract*:** This paper presents the design and implementation of "Plant Stress Detection," also known as Plant-Station a IoT-enabled plant health monitoring system. Using the ESP32 microcontroller, the system mixes bio-impedance analysis with traditional environmental sensing to evaluate plant states. The device features software architecture that handles real-time sensor data collection, machine learning model, and a responsive web based dashboard for remote monitoring. Data is visualized locally on a display and logged to an SD card for storage. This paper details the hardware , the bio-impedance measurement algorithm, and the software stack that enables robust, standalone plant monitoring.

Keywords: Internet of Things, Bio-impedance, ESP32, Precision Agriculture, Embedded Systems.

I.Introduction

The joining of Internet of Things technologies and agriculture has led to the development of Precision Agriculture, where data driven decisions optimize crop yield and health. While traditional systems focus only on external environmental factors such as temperature and soil moisture, there is a rising need for methods to measure the internal physiological status of plants.

This research paper introduces Plant-Station, a solution designed to monitor plant health through multiple ways. Unlike standard monitors that only track soil wetness, this system includes a custom bio-impedance measurement circuit.

The system is built upon the Espressif Systems platform. It functions not only as a data logger but as a standalone web server, allowing users to view real-time data and historical graphs via a smartphone or computer without requiring Internet.

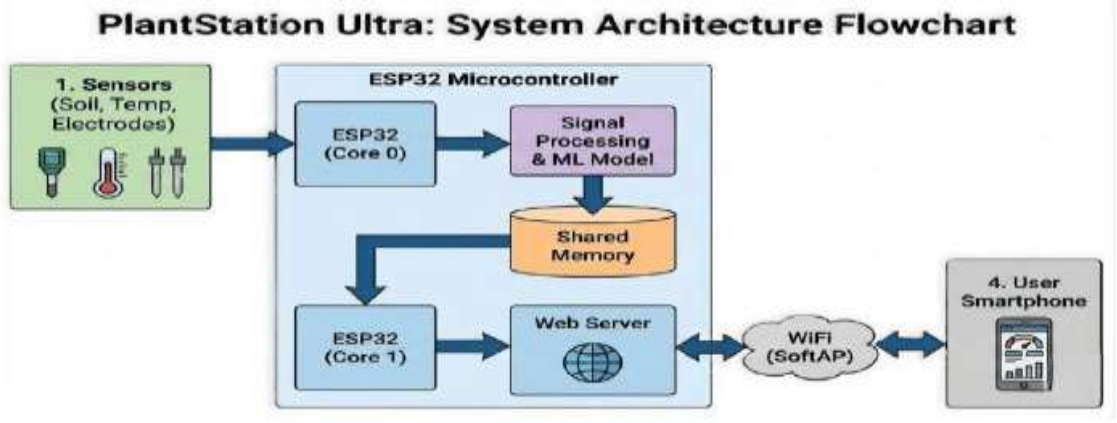
II. Need of the Study

While traditional systems focus greater on external environmental factors such as temperature and soil moisture, there is a growing limitation in these metrics: they measure the environment, not the plant itself. A plant can be in moist soil but still suffer from root rot, nutrient deficiency, or disease, which external sensors may miss.

There is a critical need for non-invasive methods to measure the internal physiological status of plants. This study addresses this gap by incorporating Bio-Impedance Analysis. By measuring the opposition of plant tissue to an alternating electric current, we can understand ion concentration. The Plant Station was developed to perform this complex analysis, providing an immediate Healthy or Stressed classification that simple moisture sensors cannot provide.

III. Research Methodology

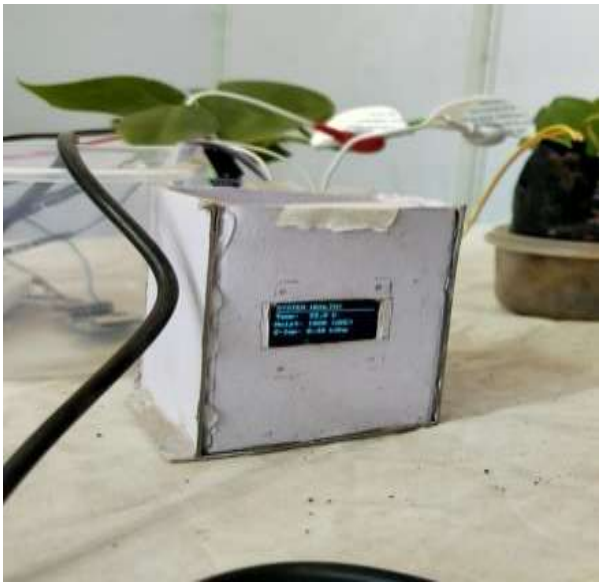
- Flow Chart:-



A. Hardware Architecture

The core processing unit is the Espressif Systems 32 microcontroller also known as DevKit1. The hardware consists of four primary subsystems:

- Bio-Impedance Circuit: A signal generation loop using the DevKit1's Digital-to-Analog Converter to generate sine waves and an Analog-to-Digital Converter to measure the response through plant tissue.
- Environmental Sensors: A digital sensor measures temperature, while a capacitive soil moisture sensor provides analog readings.
- Local Interface: A display provides immediate visual feedback and Light-emitting diodes provide at a glance information.
- Data Storage: A SD card stores the data in an CVS file.



B. Software Architecture & Free Real Time Operating System

The software is written in C language and utilizes Free Real Time Operating System to manage multiple tasks on the processor:

- Core 0 (Sensor Task): It manages sensor task function, which reads the altering current values, calculates impedance, and runs the local ML model.
- Core 1 (Network Task): It manages the Access Point, the Multicast Domain Name System responder, and the Web Server.

IV. Results and Discussion

A. Web Dashboard Performance: The system effectively hosts a dashboard over its access point. The dashboard features real-time graphs for Impedance and Moisture.

B. Data Logging and Reliability: Testing confirmed the system's ability to handle multiple operations at a single time. The data collection function operates under a isolation, ensuring that file writes do not crash with sensor reads. The Voting Buffer logic successfully smoothed out sensor noise, providing stable classifications displayed on the screen, Web Interface and the Lightemitting diodes.

V. Acknowledgment

The authors would like to acknowledge the valuable references that supported this research.
The authors acknowledge the following contributions to background research and reference material:

- Espressif Systems, "ESP32 Technical Reference Manual," 2023.
- FreeRTOS Real Time Kernel, "Mastering the FreeRTOS Real Time Kernel," 2016.