Demo Abstract: An Internet of Plants System for Micro Gardens

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ABSTRACT

The promising paradigm of the Internet of Things (IoT) has rapidly proliferated in a number of domains, e.g., energy monitoring, transportation, smart cities, healthcare, and the like. Leveraging on the same, in this paper, we proposed an Internet of Plants system to remotely monitor soil moisture level and automate watering control for the plants. The envisaged system not only facilitates in over watering or under watering of the plants but also provides data collection for the gardeners to understand the key features pertinent to healthy growth of plants. Such kind of system also encourages more people to grow their small-scale organic gardens in urban areas, thereby, increasing greenery in modern cities.

CCS CONCEPTS

• **Computer systems organization** → *System on a chip*; *Firmware*; *Embedded software*; *Real-time system architecture*;

1 INTRODUCTION

Over the past few years, with a rapid advancement in the promising paradigm of the Internet of Things (IoT) [1], scientists in both academia and industry have started exploring the possibilities of deploying sensors on the plants in a bid to track their physical and environmental needs and any associated drastic imbalances. This notion is often referred to as the Internet of Plants (IoP), wherein a unified ubiquitous network facilitates in efficaciously monitoring the said challenging needs and imbalances, thereby, enhancing productivity and mitigating global food shortages and water scarcity.

This pioneering technology is traditionally based on the notion of IoT, wherein different IoT objects are capable of sensing and communicating with other objects in their immediate ambience to abstract useful contextual information which could be intelligently analyzed for varied applications and services [2]. Key emerging trends such as cloud computing, the rapid availability of low-cost botanical sensors, and seamless ubiquitous connectivity are some of the driving factors behind the rapid proliferation of such technologies. Plants deployed with the botanical sensors are often referred to as cyber plants, and these botanical sensors not only assist in monitoring the crops' quality but also facilitate in tracking various environmental factors such as temperature, absolute humidity, soil and air quality, wind speed, and solar intensity.

Soil moisture is one of the indispensable factors behind a plant's life. In [3], the authors envisaged an innovative soil moisture sensor design that could be employed to identify moisture level from four vertical soil depths. In [4], the authors proposed the automation of drip irrigation system via a mobile phone to capture the soil image and for measuring the wetness level of the soil surface. Smart irrigation systems help optimize the water utilization in farming fields. Accordingly, the authors in [5] employed machine learning models to predict irrigation requirements of the farming fields for water conservation purposes. However, most of these use-cases pertain to large-scale farming fields, and therefore, in this paper, we propose an IoP solution for small-scale urban gardens.

The main contributions of our research project include (a) proposing of an easy-to-implement, robust, and efficacious IoP solution for small-scale urban gardens providing real-time and reliable data sets for the research community, particularly for plant biologists, and (b) offering a peace of mind to the gardeners for remotely controlling their plants irrigation systems.

2 PROPOSED INTERNET OF PLANTS SYSTEM

In this section, we demonstrate smart irrigation devices, data collection and storage, and our dashboard application for monitoring the soil moisture level of the plants. The overview of the envisaged IoP system is depicted in Figure 1.

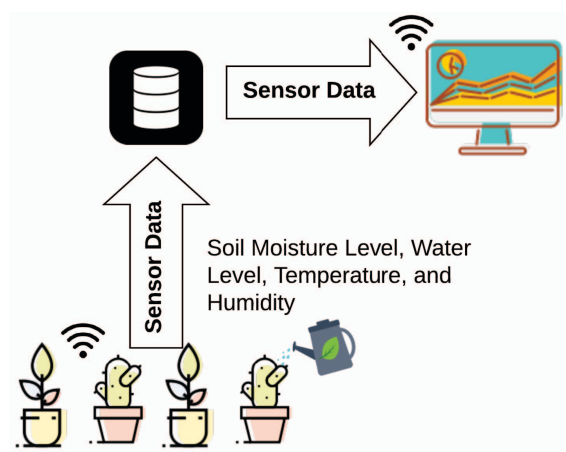

Figure 1: An Overview of the Internet of Plants System

2.1 Hardware Design

The primary idea behind our approach is to track each single plant as an IoT object via a microcontroller, specifically ESP32 (see Figure 2 (A)). In our IoP ecosystem, we used Arduino soil moisture sensors covered with immersion gold to prevent oxidation (see Figure 2 (B)). The sensors measure the resistance to ascertain the soil moisture level, i.e., the soil with more water (less resistance or high moisture level) conducts electricity easier in contrast to the dry soil (more

978-1-7281-5497-8/20/$31.00 ©2020 IEEE
DOI 10.1109/IPSN48710.2020.000-9

resistance or low moisture level). Moreover, a liquid level sensor is also attached to the outer surface of a non-metallic water container to trigger the water flow once the water level in the container falls below a specific threshold. Both soil moisture sensors and liquid level sensor are connected and controlled by ESP32 to communicate with the server.

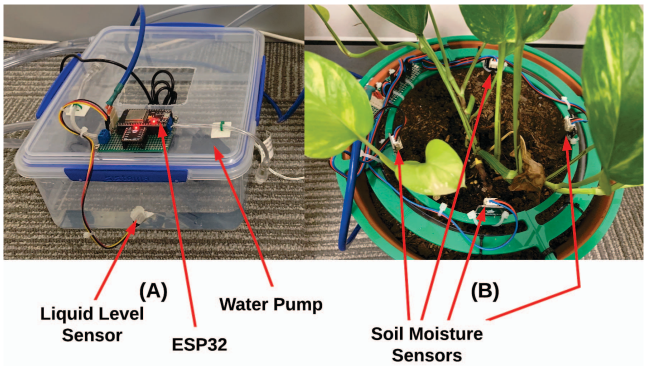

Figure 2: The Proposed Internet of Plants System

2.2 Software Development

The firmware of our envisaged IoP prototype is programmed in C++. There are three primary functions of our firmware: network connectivity, reading and sending of data to the platform, and an automatic watering system. The IoP platform is built based on one of the most popular open source IoT platforms, Thingsboard. The system analyzes the data in an intelligent manner and automatically turns on the water pump once the soil moisture level is low. It is also capable of showing notifications to the end-users when the water level in the water tank falls below a specific threshold.

3 DATA ANALYSIS

In this section, we demonstrate the data acquisition process and summarize our key insights discovered from the data analysis.

3.1 Data Acquisition

The IoP system comprises four soil sensors to record soil moisture level in four soil areas of a plant pot, as depicted in Figure 2, along with one temperature sensor and one humidity sensor for the ambient environment. Data is displayed via our dashboard[1] and stored in PostgreSQL database in real time. For the sake of this experiment, we collected 11.98 million records of soil moisture data from 12/09/2019 to 30/11/2019 for performing our analysis.

A univariate time series analysis was performed to investigate the trends in the soil ecosystem over time. The timestamp is rounded to the nearest 0.1 second to resolve the discrepancy issues when recording data via different sensors. We computed the median from four soil moisture levels being recorded at the same timestamp and discarded the timestamps at which any of the four sensors did not retrieved data to avoid inconsistencies in computing of the median.

[1]http://tiny.cc/iottestbed

3.2 Data Exploration

We have applied moving median in a time window of one minute to smoothen the soil moisture levels and eliminate any short-term fluctuations. According to Figure 3, the highest number of outliers were observed on Fridays. We argue that our scheduled watering activity on every Friday leads to an uneven distribution of water on different soil areas of the plant pot. Nevertheless, the median soil moisture levels start becoming stable in the preceding days with little or almost no outliers in the data distribution.

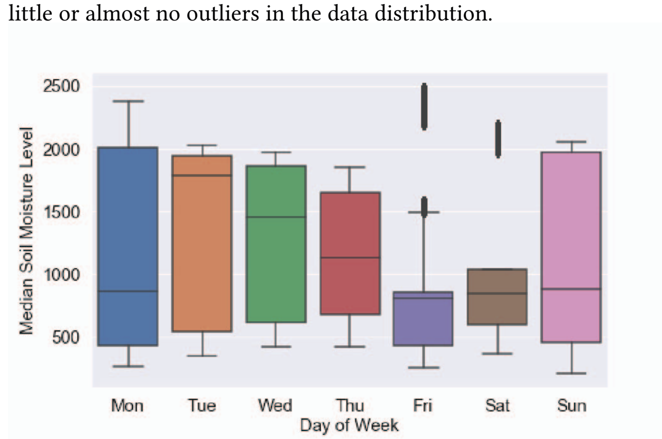

Figure 3: A Boxplot of the Smoothed Soil Moisture Levels

4 CONCLUSION

In the near future, we intend to focus on exploring IoP's data acquisition process to extract some more useful features pertinent to healthy growth of the plants. We further aim to investigate the co-relationship between soil moisture levels and other environmental factors, i.e., temperature, humidity, and light intensity, thereby, developing better soil moisture forecasting models.

ACKNOWLEDGEMENT

The authors sincerely acknowledges the generous support of the Australian Research Council's Linkage Infrastructure, Equipment, and Facilities Project entitled, *A Large-Scale Distributed Experimental Facility for the Internet of Things (No. ARC LE180100158).*

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