[TBD: NAME OF TOOL]

TBD: A tool to study microclimates in an orchard

By

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1 Introduction

In this report I give details of an online tool called [TBD: NAME OF TOOL], an interactive website that collects real time data from Small Brook Farm in Devon. The tool aims to give farmers accessible, specific climate data to help reveal the existence of microclimates over a small area and inform their decision making.

Three sensor clusters were distributed at three points in the farm. Each cluster was powered by a raspberry pico and then a variety of sensors were added to these. Data is then sent in real time back to a backend server which processes the information and allowed for real time data to be presented to farm workers via a website.

Part I

Background

2 Microclimates

2.1 Microclimates in agriculture

A microclimate is generally understood as a set of distinct climatic conditions within a small, localised area [1]. The maximum size of a microclimate is debated, but the World Meteorological Organisation (WMO) regards it as occupying an area of anywhere from less than one metre across to several hundred metres [2]. In practice, microclimates can occur in spaces such as gardens, valleys, caves, or fields. Even human-made structures can generate their own microclimates; for example, tall buildings can create *street valleys* that reduce wind flow and lead to the formation of localised pockets of warmer air, which can also trap higher concentrations of pollution from vehicle emissions [3]. Vegetation plays a critical role in influencing microclimates. The addition of trees to an urban environment can reduce air temperature by as much as 2.8 °C [4].

This localised climatic variation, characteristic of microclimates, is therefore significant in agriculture. The climate that crops are exposed has an enormous impact on overall agricultural yields. Indeed, farmers have modified the microclimate of crop fields for millennia, a clear example of this being the use of fencing to reduce soil erosion and damage to edible plants [5]. Therefore, the relationship between microclimates and agriculture has been the subject of extensive research - particularly as climate change introduces new threats to food security.

2.2 Microclimates in apple orchards

3 *Internet of Things*

3.1 LoRa and LoRaWAN

Long range systems are a way of transmitting data over much longer distances than Wi-Fi allows. LoRa has a range 4000 times greater than Wi-Fi.

3.2 Implementation of LoRa Communication

In this project, I deployed a low-power, long-range (LoRa) wireless network to connect a distributed set of environmental sensors across an apple orchard. The primary goal was to establish a reliable Internet-of-Things (IoT) weather station capable of transmitting temperature, humidity, soil moisture, and wind speed data over distances of up to [insert number of km] without the need for external infrastructure such as with mobile data.

Measurements were sent as compact JSON payloads. We achieved a balance of data rate (insert data rate) and sensitivity (insert sensitivity), ensuring packet delivery even over hilly terrain.

On the gateway side, a [insert final device used] served as a base station. It received raw payloads and forwarded them over MQTT to a cloud server for storage and visualization. Field tests were conducted showing a maximum range of [final range achieved].

3.3 Early prototyping

For early prototyping, We chose two Challenger RP2040 LoRa modules. These are simple Raspberry Pico based devices with a low powered antenna. With these modules I developed an early script that allowed for the sending of JSON packets containing all the necessary measurements.

These modules served only as a proof of concept as my own testing of range for these only reported about 100m distance before significant packet loss and corruption occurred.

Part II

Hardware development

4 Overview of hardware

5 Design

5.1 Nodes

5.1.1 Components

The first step in the design process was selecting hardware components that could operate autonomously without mains power. This required devices that were highly power-efficient, while also capable of transmitting small data packets via LoRa. An equally important consideration was ensuring the final devices could be fully weatherproofed to protect the sensitive electronics from water ingress and environmental damage.

Challenger RP2040 LoRa

The iLabs Challenger RP2040 LoRa is an embedded computer that uses the Raspberry Pi RP2040 chip that was released in 2021. The RP2040 itself is a low-cost and power-efficient processor with ample power to perform the data encoding and transmission in my use case. Additionally, the chip is extremely popular with over 10 million units being produced in the first two years of release [6]. This popularity means there is ample documentation for developing with this processor and is compatible with circuit python which was my preferred language for development on the nodes.

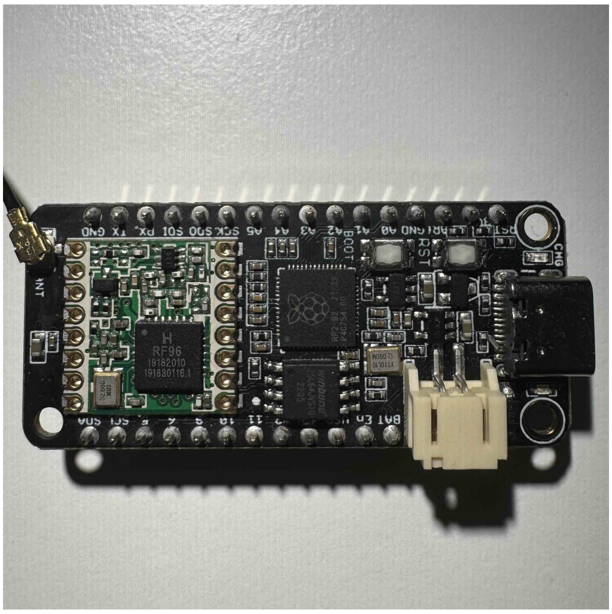

Figure 1: iLabs Challenger RP2040 used in the project. Note the RP2040 chip centre and RF96 LoRa module to the left.

The challenger board itself is based on the Adafruit feather form factor

Antennae

Sensor selection

Temperature and humidity sensor

Soil moisture sensor

Wind speed sensor

Powering the node

Weather proofing

5.1.2 Repeater

5.2 Gateway

5.3 LoRa settings

5.3.1 Compliance with regulatory limits on radio power

6 Development and testing

7 Deployment in the field

Part III

Software development

8 Software design

Part IV

Evaluation

References

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