Internet of Things (IoT)-based Precision Irrigation with LoRaWAN Technology Applied to High Tunnel Vegetable Production

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**Introduction**

- Agriculture consumes approximately 80% of water use in the United States.
- As the global population increases, crop production is expected to increase while water resources are increasingly limited.
Introduction

- Conventionally, irrigation based on experiences causes inefficient water usage and crop yield and quality reduction.
- Precision irrigation: Applying only the necessary amount of water directly to the crop
- Lower cost of irrigation water and manpower, and improvement of crop yield and quality
- Based on Evapotranspiration (ET)/crop water stress/soil moisture
- Soil water content: water volume/soil volume
- Soil water potential: capability soil holds water
Introduction

• IoT system
• Uploading sensor data to the Internet.
• Analyzing sensor data and controlling irrigation on the Internet
• Various network types used in IoT-based irrigation: Wi-Fi, Bluetooth, ZigBee, Sigfox, cellular network (GPRS, EDGE, LTE), LoRaWAN

<table>
<thead>
<tr>
<th>Technology</th>
<th>Network type</th>
<th>Frequency</th>
<th>Range</th>
<th>Data rate</th>
<th>Power</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoRaWAN</td>
<td>LPWAN</td>
<td>915 MHz</td>
<td>10 km</td>
<td>0.3-50 kbps</td>
<td>10mW</td>
<td>AES 128 bit</td>
</tr>
<tr>
<td>LTE</td>
<td>GERAN/UTRAN</td>
<td>700-2600 MHz</td>
<td>10 km</td>
<td>0.1-1 Gbps</td>
<td>1 W</td>
<td>3GPP 128-256 bit</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>WLAN</td>
<td>2.4, 3.6, 5 GHz</td>
<td>100 m</td>
<td>6-780 Mbps</td>
<td>1 W</td>
<td>WEP, WPA, WPA2</td>
</tr>
</tbody>
</table>

Source: https://tekzitel.com/what-is-lorawan/
Objectives

• Investigating the applicability of soil water content and soil water potential sensors in the developed irrigation system

• Conducting functionality evaluation on the irrigation system in terms of data communication and irrigation execution
Method: Experimental Setup

- Red cabbage (*Brassica oleracea* cultivar Omero F1)
- T1: Soil water content
- T2: Soil water potential #1 (-30 kPa)
- T3: Soil water potential #2 (-60 kPa)
- T4: Timer
- 3 replicates
- 2 depths (15 cm, 30 cm)
Method: Irrigation system
Method: Sensor system

- 6 soil water content sensors
  TEROS 10, METER Group, Inc., Pullman, WA

- 12 soil water potential sensors
  Watermark 200SS-5, Irrometer company, Inc., Riverside, CA
Method: IoT system

- Sensors
- Valves
- Sensor/Control boxes
- LoRaWAN Gateway
- Server: The Things Network
- Data monitoring
- IoT platform: AllThingsTalk
- Valve control
Method: IoT system
Results: Feasibility of the IoT system

- 300 m between high tunnel and gateway
- 4.3% signal loss
- Control the valve on the IoT platform
- Batteries work for 2 months with a solar panel
- More battery consumption for soil water content sensors because of continuous power supply
Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water potential (T2&T3) day 1-20
Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water potential (T2&T3) 0–24 h on Day 6
Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water content (T1) day 1-15
Conclusion

• The IoT system worked well in general.
• 4.3% signal loss with 300 m distance. Caused by the office wall obstacle, long distance, and gateway performance.
• Enough batteries for two months
• Issues on soil water content sensors
Acknowledgement

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Thank you!

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