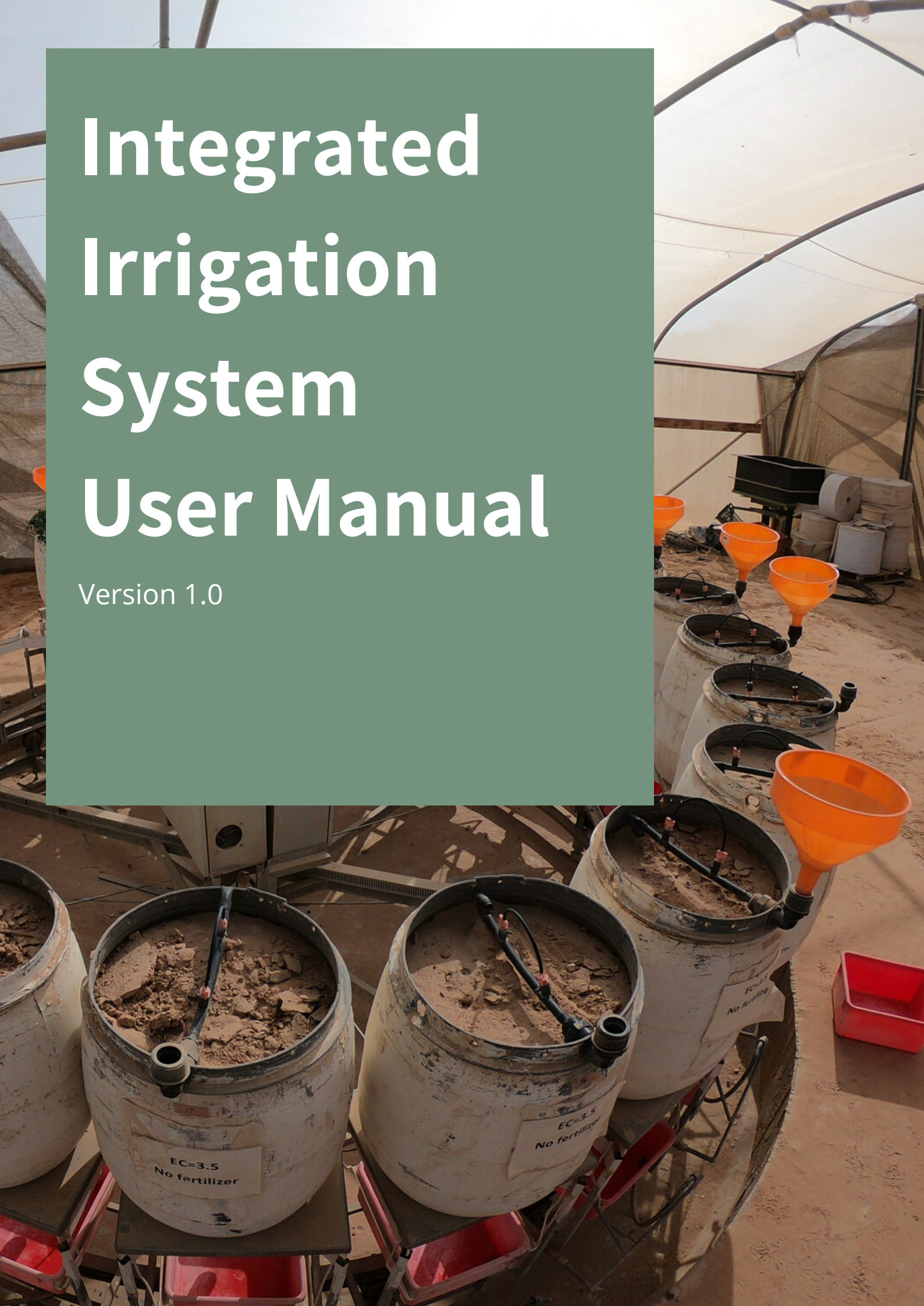
Integrated Irrigation System User Manual

Version 1.0



The Integrated Irrigation System (IIS) is a supplemental automated irrigation system developed by Joseph Cybul, Brendan McClelland, Allison Steeves, and Ella Torregrosa in 2020 as part of Worcester Polytechnic Institute's Interactive Qualifying Project program. The IIS is intended to be used in conjunction with the Southern Arava R&D's Carousel Irrigation System (CIS), which can be used to conduct experiments in its twenty-four planting pots. In lieu of the CIS's original non-functioning irrigation subsystem, the IIS utilizes modern software and hardware components to distribute a preset quality and quantity of irrigation water to each pot. Additionally, the IIS supports a standalone database that can be customized and exported through the IIS user interface (UI) application designed specifically for the CIS.

This manual provides an overview of the IIS parts and their functions, system design, setup procedure, and the IIS UI.

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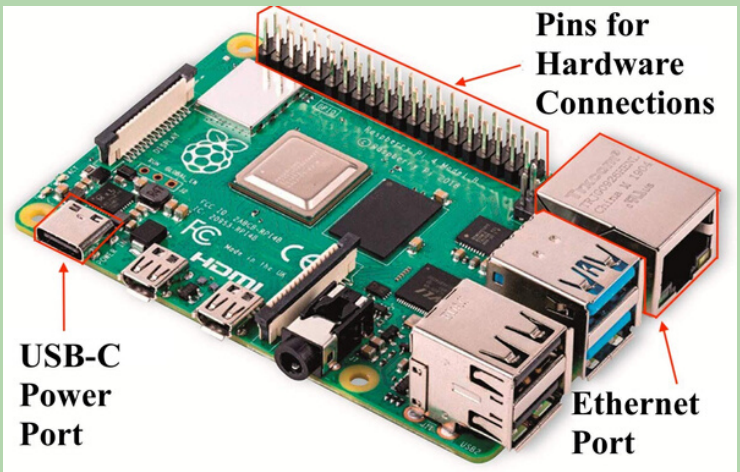
Parts List and Functions

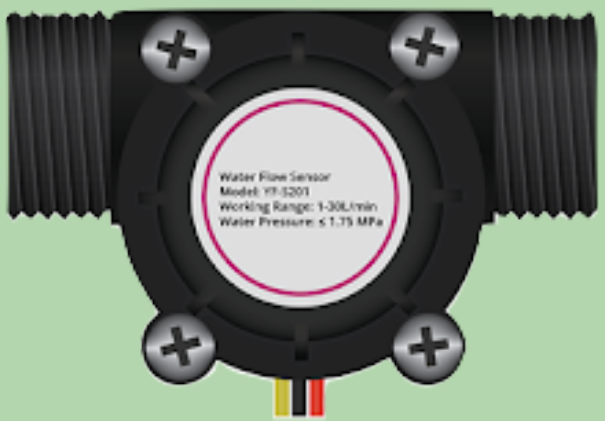


Raspberry Pi

- Micro Computer
- Connects to WiFi through ethernet port
- Sends and receives signals from Flow Rate Sensor, Motorized Driver, and RFID Scanner through pins

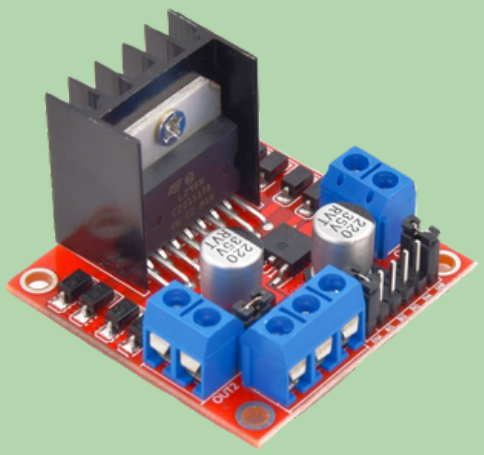
Motorized Ball Valve (MBV)

- Receives signals from the Motor Drivers to open and close
- Internal valve mechanism allows for passage of water
- Operates at 9-24V AC/DC



Flow Rate Sensor (FRS)

- Senses the amount of liquid that has passed through with internal rotating mechanism
- Sends signals to Raspberry Pi to close the MBV when enough water has been transferred
- Can detect 1-60L/min and operates from 3-18V DC



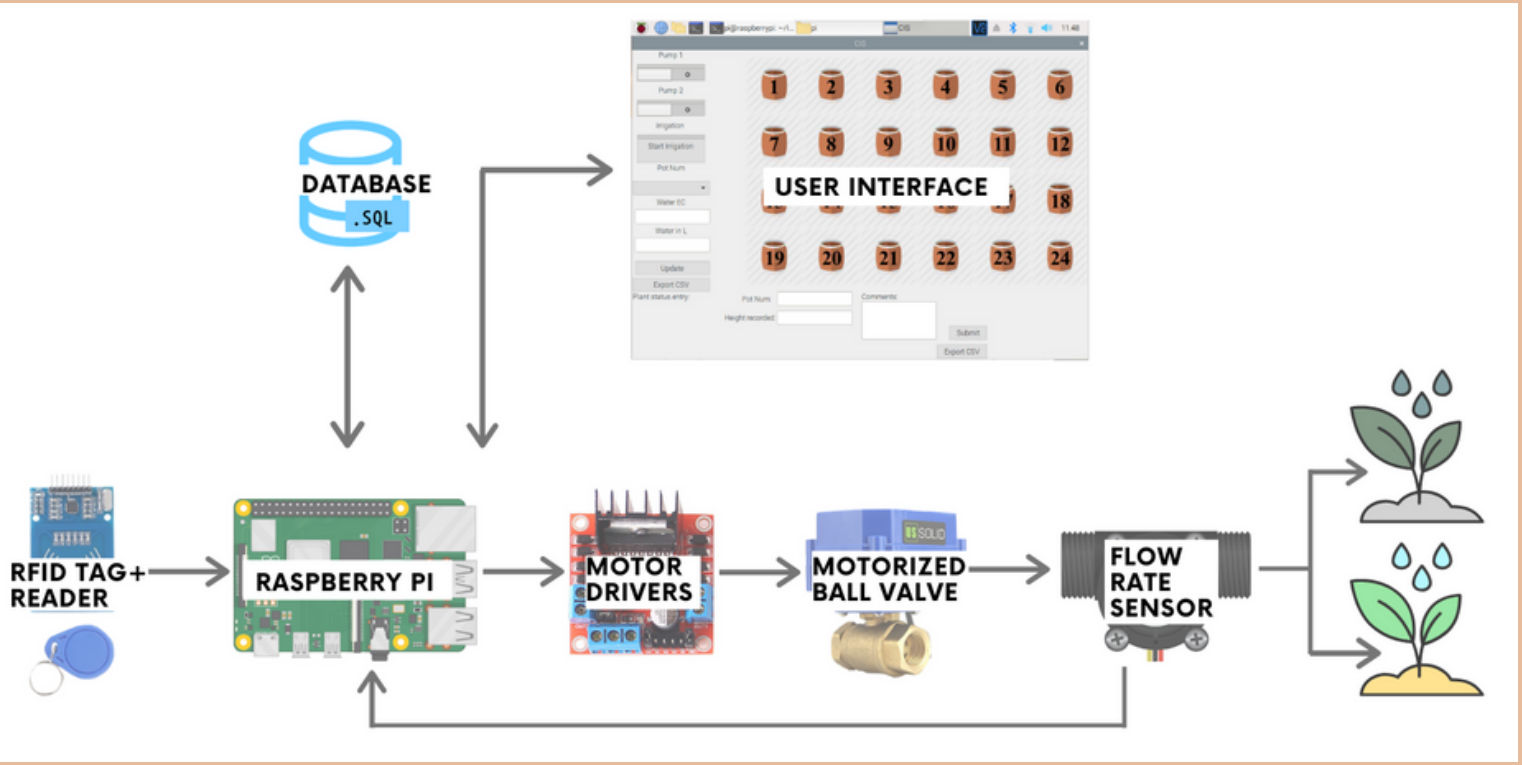
Motor Driver

- Controls speed of MBV
- Controls direction of MBV
- Receives signals from the Raspberry Pi
- Sends open or close signals to MBV
- Operated on 12V external power source

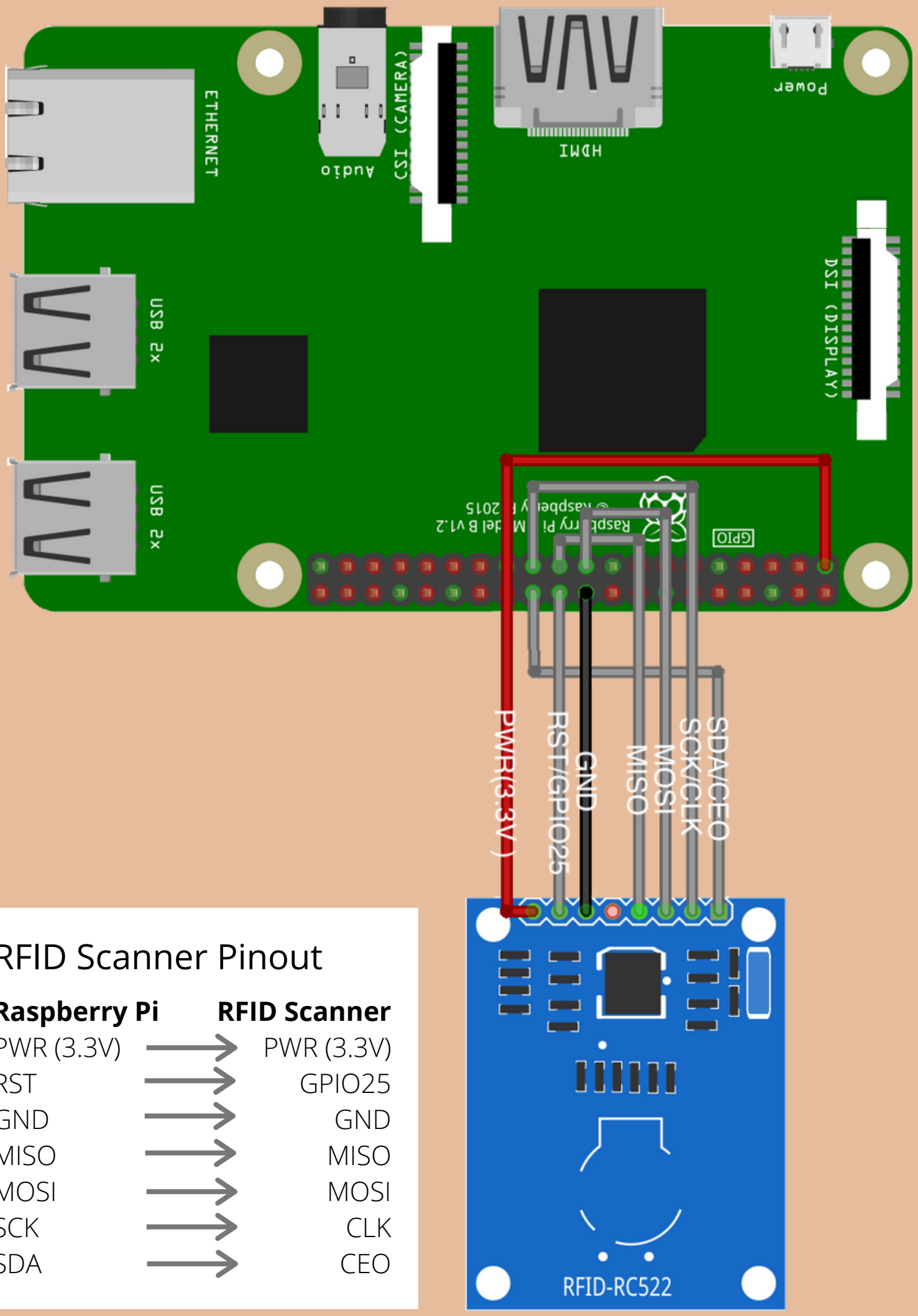
RFID Scanner and Tags

- RFID Scanner receives radio frequency signals transmitted from tags
- RFID Scanner sends signals to Raspberry Pi
- Informs system which pot Is under the irrigation system

System Design



1. Input water EC and volume into user interface, information is stored in the database
2. RFID tag is read by RFID Scanner and pot number is sent to Raspberry Pi
3. Raspberry Pi sends signal to motor drivers to open specific MBV
4. MBV opens and water begins to flow through FRS
5. When correct volume of water is irrigated, FRS sends signal to Raspberry Pi
6. Raspberry Pi sends signal to motor drivers to close MBV

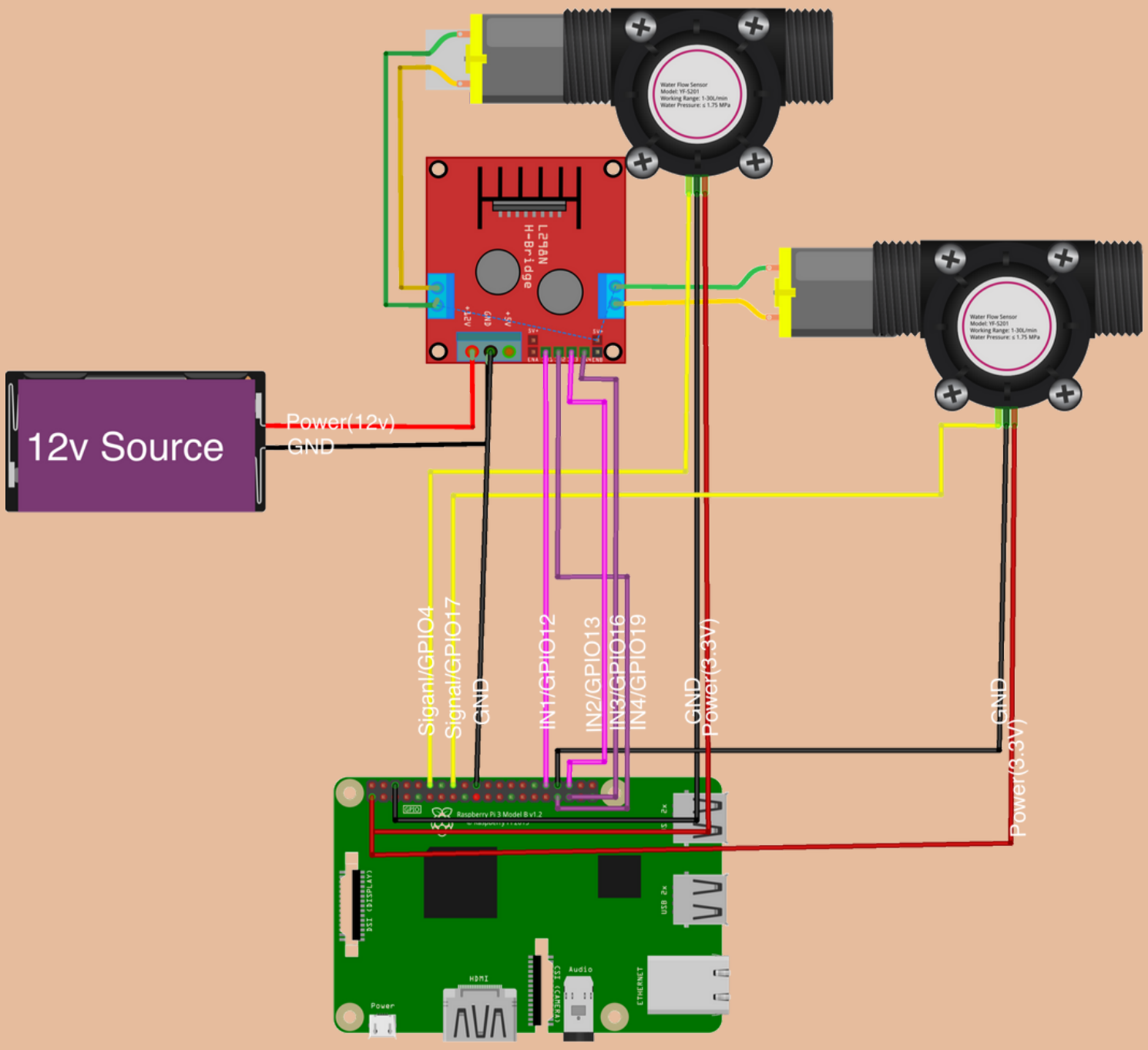


RFID Scanner Pinout

Raspberry Pi		RFID Scanner
PWR (3.3V)	→	PWR (3.3V)
RST	→	GPIO25
GND	→	GND
MISO	→	MISO
MOSI	→	MOSI
SCK	→	CLK
SDA	→	CE0

MBV and FRS Pinout

Raspberry Pi		Motor Driver & FRS
PWR (3.3V)	→	PWR (3.3V)
GND	→	GND
GPIO4	→	FRS1
GPIO17	→	FRS2
GPIO12	→	IN1
GPIO13	→	IN2
GPIO16	→	IN3
GPIO19	→	IN4



Setup Procedure

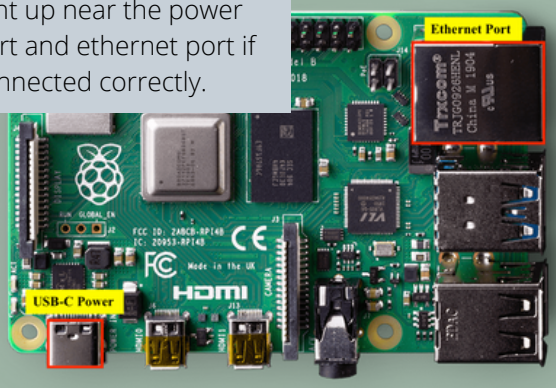
Raspberry Pi
Username: pi
Password: iqp2020

Turning on the Raspberry Pi

1.Plug Raspberry Pi into a power source through the USB-C power port and connect to WiFi through ethernet port.

1

Red and Green LEDs will light up near the power port and ethernet port if connected correctly.



Accessing the IIS UI

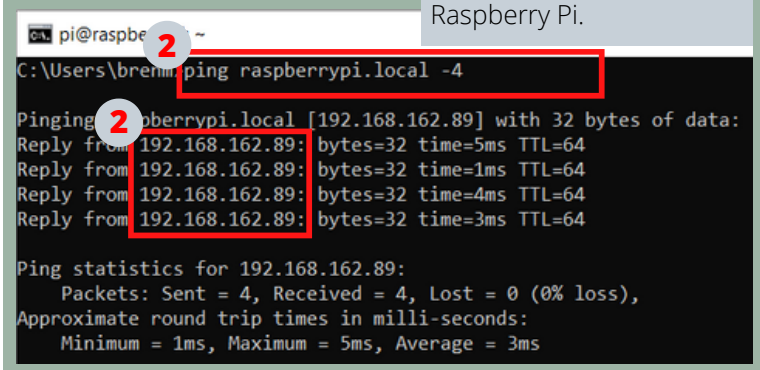
To use the IIS UI, you will need to access the Raspberry Pi, either through a remote desktop or a dedicated monitor. If you have a dedicated monitor, skip to step 9.

2. Find the IP address of the Raspberry Pi by opening a command prompt/ Windows Power Shell and running the following command:

```
>ping raspberrypi.local -4
```

2

If you use the ping command, you should see this on your screen. The number displayed here is the IP Address of the Raspberry Pi.



Copy or write down the IP Address that is returned, use **ctrl+c** to stop pinging.

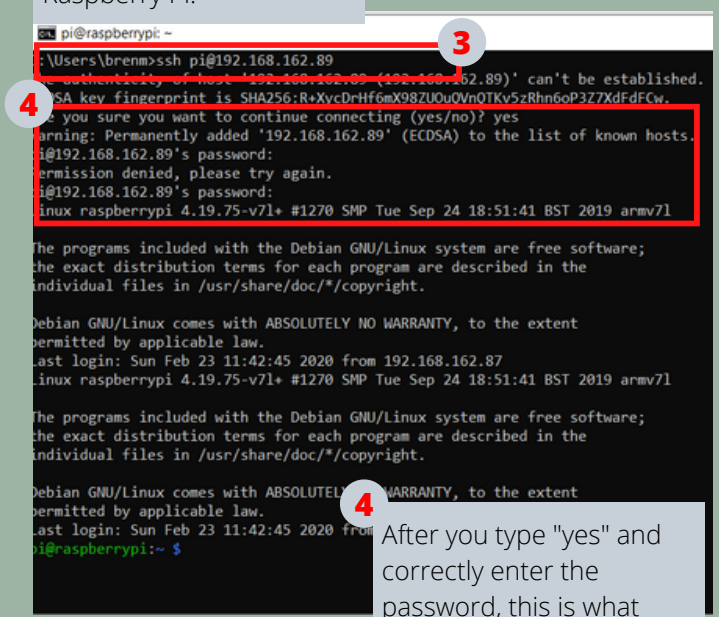
3. Type the following command into your command line prompt/ power shell to connect to the Raspberry Pi:

```
>ssh pi@XXX.XXX.XXX.XX
```

Where the "X's" are replaced with the IP Address.

3

This is how the command line should look when you input the IP address of the Raspberry Pi.



4

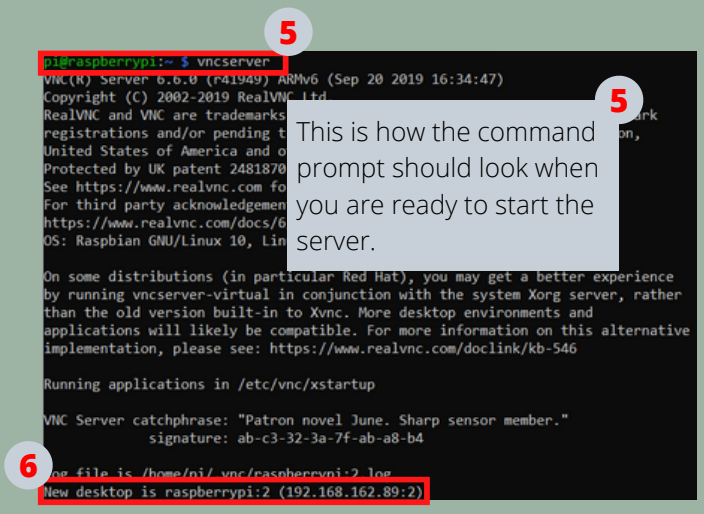
After you type "yes" and correctly enter the password, this is what your command line will look like.

4. Type "yes" to continue connecting. When asked for a password, type iqp2020.

Once you are logged in, your command prompt/ power shell should now start with pi@raspberrypi.

5. Type in the following command to start the server:

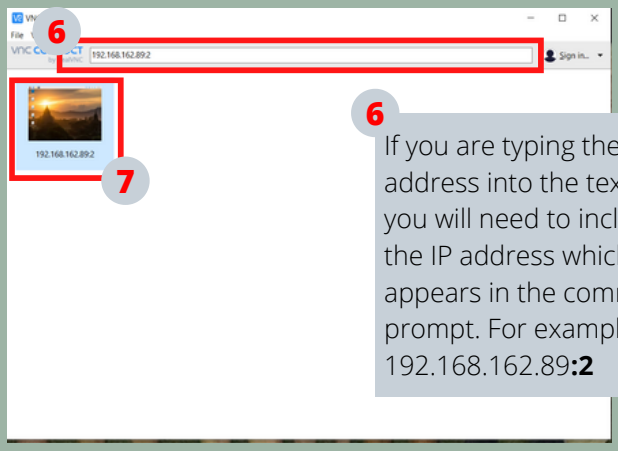
```
>vncserver
```



Using a Remote Desktop

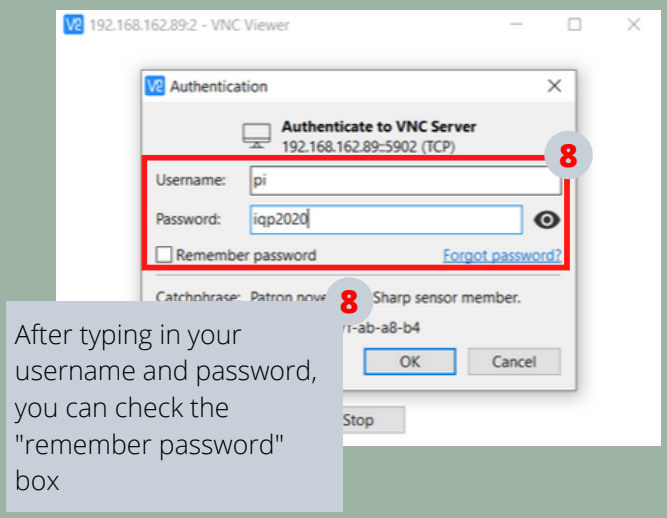
6. Open VNC Viewer App on your Windows desktop (see Quick Tips for information on downloading VNC Viewer).

If the desktop does not already appear in your VNC window, type the IP Address from the command prompt/ power shell Into the textbox In the VNC window and press enter.



7. Click on the mini screen which appears in your VNC connect window.

8. Enter the username: pi and password: iqp2020.



You should see a desktop with a sunset over mountains and buildings.

Opening the IIS UI

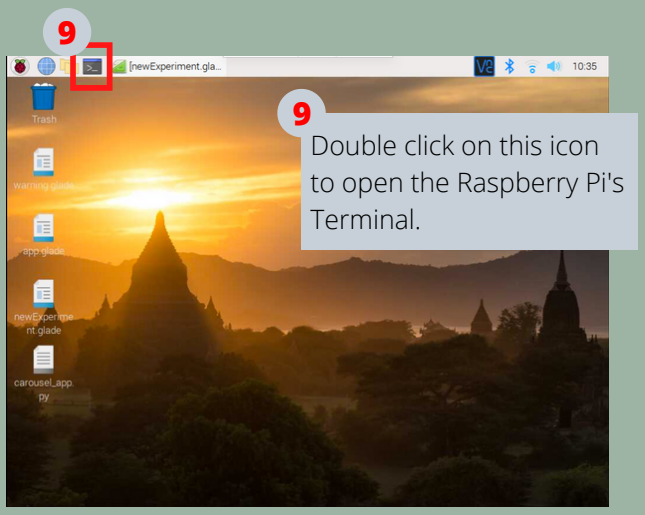
9. On the desktop, open a new command line terminal.

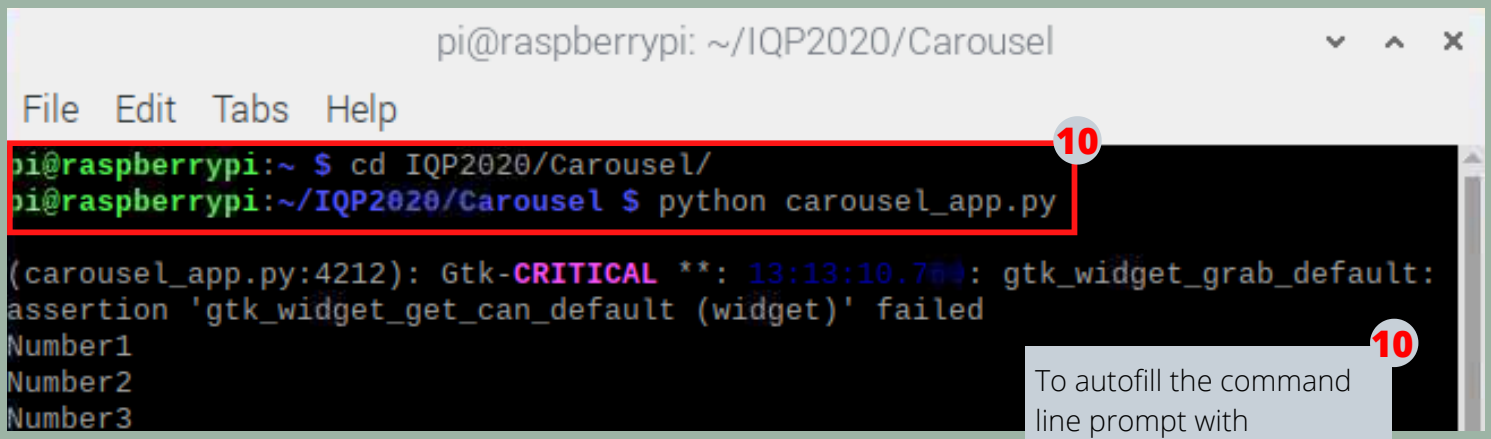
10. Type the following commands to open IIS UI:

```
>cd IQP2020/Carousel
```

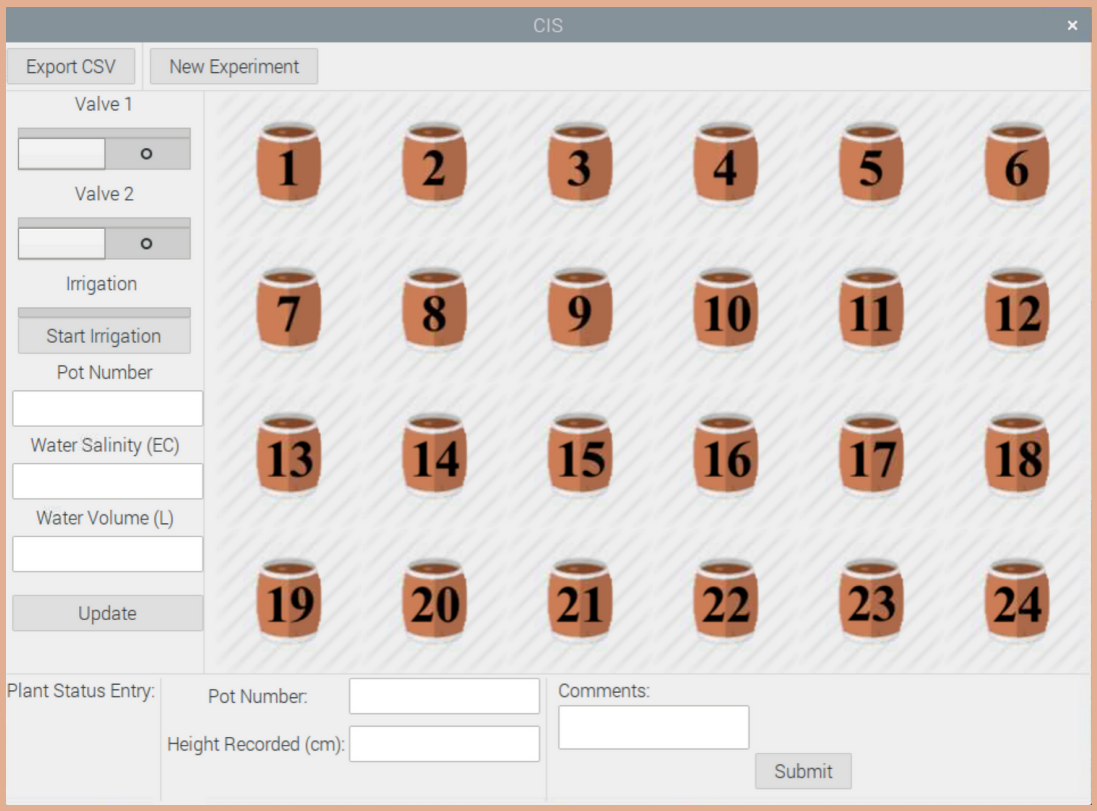
```
>python carousel_app.py
```

You should see the application open. From here, you can view information about the current state of the pots, update the database with new information, or download your data in a CSV format.





The IIS UI



The IIS is controlled using the IIS UI, a user interface application installed on the Raspberry Pi, which is connected to a MySQL database that runs locally on the Raspberry Pi. Through this application, users have access to a variety of the IIS's functions.

Through the IIS UI application, the user can perform four main functions:

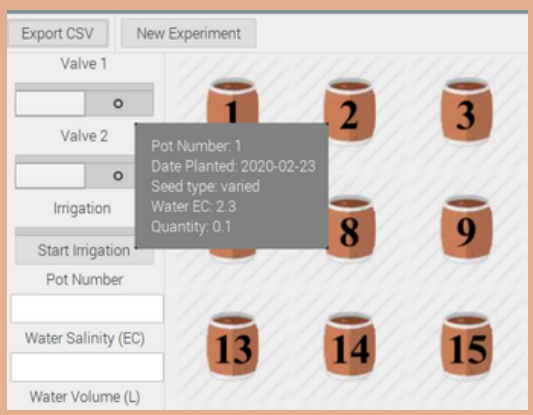
- Access Pot Summaries
- Manually Control Ball Valves
- Update Irrigation Parameters and Start Irrigation
- Manage Database

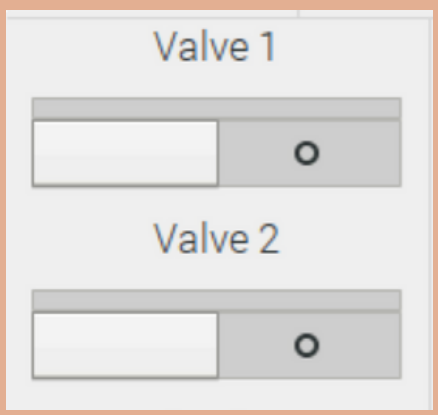
Access Pot Summaries

In the upper right quadrant of the IIS UI is a 6x4 grid of pot icons. Each numbered icon corresponds to the pot and RFID tag set of the same number on the CIS. Hover over a given pot icon to show details about the crop in that pot:

Date of Planting
Type of Seed
Current Volume and EC of Water
Most Recent Data Entry

This summary is automatically updated whenever the pot's seed type, planting and germination dates, or irrigation parameters are reset, as well as when data is entered into the "Plant Status Entry" menu.





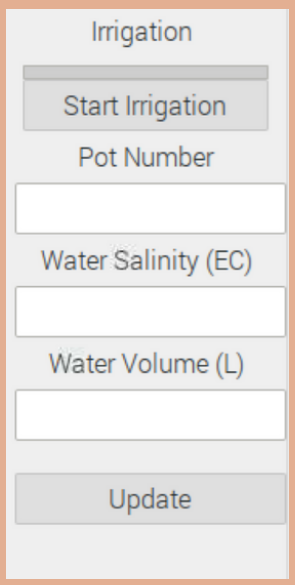
Manually Control Ball Valves

In the upper left section of the IIS UI are two switches labeled "Valve 1" and "Valve 2," which allow for manual control of the MBVs on the irrigation structure.

By default when the automated system is not running, the valves are closed—indicated by the switch set in the left position.

Clicking on the switch will move it to the right position and manually open the valve. There is a delay of five seconds for the ball valves to fully open and close.

You cannot manually open the ball valves after you have started the irrigation cycle.



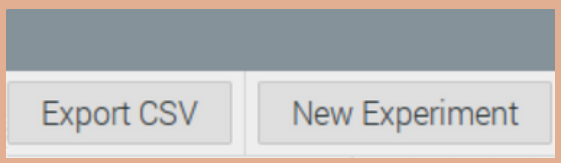
Update Parameters and Start Irrigation

Below the ball valve switches are buttons and input boxes that allow you to start the automated irrigation schedule and update water parameters for each pot.

The "Start Irrigation" button begins the approximately 30-minute cycle of scanning RFID tags and distributing the correct quality and volume of water to each scanned pot.

The pot number input box lets you choose any of the 24 pots that you would like to adjust the water parameters for.

Once a pot is selected, you can adjust water EC and water volume levels to your desired values. Pressing the "Update" button finalizes the given values so that the selected pot is irrigated based on those parameters when the automated system is in use.



Manage Database

STARTING A NEW EXPERIMENT

To start a new experiment, click on the "New Experiment" button in the upper left. Click "Continue" on the prompt to download any existing data from the prior experiment as a CSV file and then input new experiment parameters for each pot. For each pot—indicated in the upper left—input the following fields.

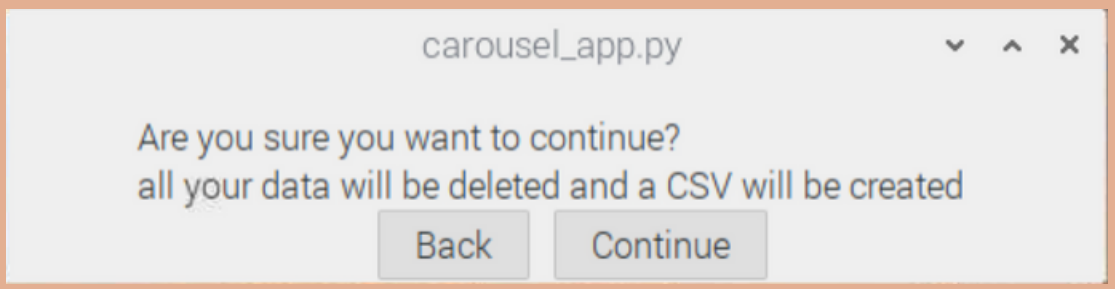
Seed Type: Accepts any input under a 200-character limit.

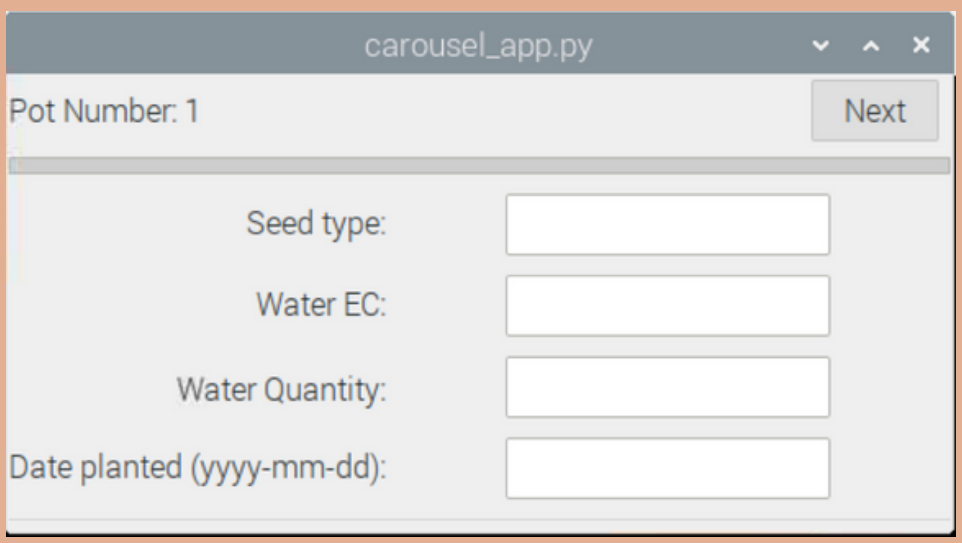
*If the pot input prompt is closed before parameters are entered for all 24 pots, the data for each entered pot will be saved, but you will have to start a new experiment to input the seed type and date planted parameters of the other pots.

Water EC: Input the number that represents the EC of the water you want that pot to receive. Currently, the system only supports inputs of 2.3 (corresponding to the "Valve 1" switch) and 0 (corresponding to the "Valve 2" switch). This parameter can be updated later without starting a new experiment.

Water Volume: Input the number that represents the volume of water, in liters, you would like the specified pot to receive during automatic irrigation (e.g., "0.5" for 500mL). This parameter can be updated later without starting a new experiment.

Date Planted: Input in the form of yyyy-mm-dd. E.g., if a seed was planted on March 6th, 2020, type as 2020-03-06.



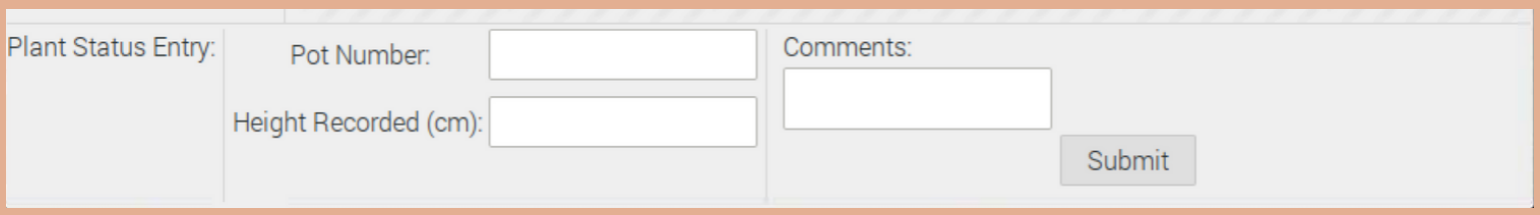


RECORDING DATA

The bottom section of the UI allows you to record the crop height and write any other comments for a given pot to the database. In the input boxes you can enter the desired pot number and height of crops measured in that pot, as well as any other comments you might have about a certain pot.

The “Pot Number” and “Height Recorded” boxes only accept numbers as an input (e.g., “4”), while the “Comments” box accepts anything as an input under a 200-character limit.

The “Submit” button to the right of these boxes stores this information in the database with a timestamp—taking the current date and time from the Raspberry Pi—and then clears the boxes of any text for subsequent entries.



DOWNLOADING EXPERIMENT DATA

The “Export CSV” button in the upper left takes the information from the database and exports it as a CSV file. This file is automatically downloaded to the computer and can be found at the following file pathway:

home/pi/IQP2020/Carousel/CSV

If you would like to analyze the data using a program on a different computer system, you can transfer your files using a USB-A flash in the ports highlighted to the left.