EECS 113 Final Project Report - Irrigation System

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Introduction

This project aims to create a more efficient water irrigation method by using a DHT sensor, which detects humidity and temperature, to determine the appropriate irrigation time. By comparing the DHT humidity and temperature data against that of the California Irrigation Management Information System (CIMIS), we can calculate the optimal time to turn on irrigation. An additional feature implemented, the PIR sensor, detects motion within a cone range and will stall an amount of time if the system is irrigating, much like how a real sprinkler would stop watering if it detected a person walking by.

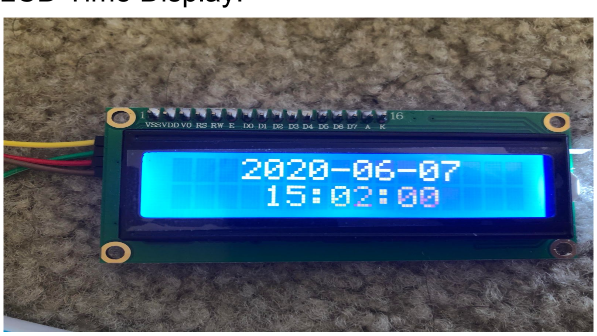
Equipment

- Raspberry Pi 3B+
- DHT-11 (temperature and humidity sensor)
- LCD
- PIR sensor (motion sensor)
- Jumper wires
- Breadboard and GPIO extension board
- 2 LEDs
- 3 10k resistors

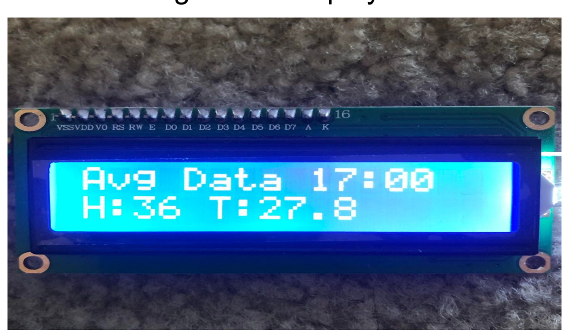
Theoretical Background

PF (plant factor) : 1.0 (lawn)
SF (area of irrigation in square feet) : 200
IE (irrigation efficiency) : 0.75
Water per hour : 1020 gallons/hr
Time to irrigate : water needed (in gallons) / water per hour
Water needed : calculated eto * PF * SF * 0.62 / IE / 24 hours
Calculated eto : Cimis eto * (Cimis humidity / DHT humidity) * (DHT temperature / cimis temperature)

LCD Time Display:



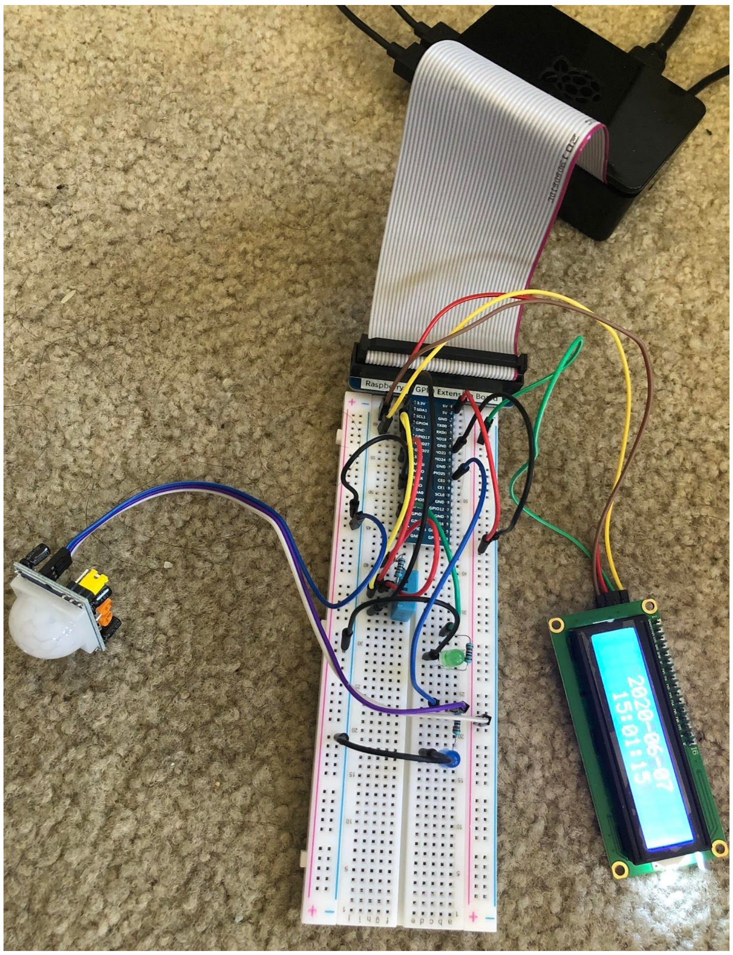
LCD Average Data Display:



LCD DHT Data Retrieval:

LCD CIMIS Data Retrieval:

Circuit:



- PIR sensor (leftmost)
- LCD Display (rightmost)
- DHT sensor (blue block on breadboard)
- Yellow LED (irrigation: on = irrigating, off = not irrigating)
- Blue LED (PIR: on = motion detected/turn off irrigation, off = no motion detected)
- Raspberry Pi 3B+ (top)

Code Behind

- Main module/PIR sensor (main.py) :

  Main.py is the main code module that links everything together via import statements. Within the main function, GPIO pins are setup and initialized with their respective locations on the GPIO extension board. Then, a thread to retrieve local data is started to get humidity and temperature readings from the DHT every minute, and averages are calculated every hour. At the same time, a mainloop runs to connect to the Internet and retrieve CIMIS data every hour. The hourly average data from the DHT is then compared with the CIMIS data every hour, and using a provided formula from the lab manual, calculates the optimal irrigation time. Once the irrigation time is calculated, irrigation will be turned on for that duration, indicated by the yellow LED turning on. With the additional feature of the PIR sensor implemented, if any motion is detected within its cone range then the blue LED will turn on to indicate motion detection. If the blue LED turns on, the yellow LED will be turned off, if not off already, indicating that irrigation has stopped. If irrigation was occurring, it will be stalled for 5 seconds as long as motion is still being detected, up to a maximum of 1 minute. When either motion stops or 1 minute has elapsed, irrigation will resume until finished. The cycle will then repeat until 24 hours has elapsed.

- LCD Display (LCD.py, LCDAPI.py, PCF.py) :

  LCD.py is the code for the LCD display that shows the time and data whenever either local or CIMIS data has been retrieved. The functions within that file are responsible for displaying CIMIS, average, and local data, as well as any messages.

  LCDAPI.py is the code for initializing, clearing, and displaying text on the LCD display. It has API from the freenove_ultimate_starter_kit link provided, and is responsible for the actual implementation of getting text to display and cursor to move. The data from LCD.py is what gets displayed by the LCDAPI.

  PCF.py is the code for interfacing with the I2C. The functions within this file work with the LCDAPI in order to get text to display and the cursor to move. Without all three files, messages would not be able to reach the right address and nothing would be displayed.

- DHT sensor (DHT.py) :

  DHT.py is the code for the DHT-11 sensor that detects temperature and humidity.It has API from the freenove_ultimate_starter_kit link provided within the lab manual and the functions within it are used by main.py to retrieve local temperature and humidity readings every minute.

- CIMIS data retrieval (CIMIS.py) :

  CIMIS.py is the code for retrieving CIMIS data from online for Irvine, CA (station 75). The functions within this file get the data (hour, humidity, temperature, and Eto) from the website every hour so that the local data from DHT can be compared to it to calculate optimal irrigation time.

Results

Sample Output (first hour):

```
Program started at 09:57:01
[09:57:01][Main thread] Starting thread to fetch data
[09:57:04][Data thread] DHT data #1: Temp = 27.3 Humidity = 35
[09:58:06][Data thread] DHT data #2: Temp = 27.4 Humidity = 39
[09:59:04][Data thread] DHT data #3: Temp = 27.4 Humidity = 39
[10:00:03][Data thread] DHT data #4: Temp = 27.4 Humidity = 39
[10:01:04][Data thread] DHT data #5: Temp = 27.4 Humidity = 35
[10:02:03][Data thread] DHT data #6: Temp = 27.3 Humidity = 39
[10:03:06][Data thread] DHT data #7: Temp = 27.4 Humidity = 39
[10:04:03][Data thread] DHT data #8: Temp = 27.3 Humidity = 39
[10:05:04][Data thread] DHT data #9: Temp = 27.4 Humidity = 39
[10:06:03][Data thread] DHT data #10: Temp = 27.4 Humidity = 39
[10:07:03][Data thread] DHT data #11: Temp = 27.4 Humidity = 39
[10:08:04][Data thread] DHT data #12: Temp = 27.4 Humidity = 35
[10:09:04][Data thread] DHT data #13: Temp = 27.4 Humidity = 35
[10:10:04][Data thread] DHT data #14: Temp = 27.4 Humidity = 35
[10:11:03][Data thread] DHT data #15: Temp = 27.4 Humidity = 39
[10:12:04][Data thread] DHT data #16: Temp = 27.4 Humidity = 35
[10:13:03][Data thread] DHT data #17: Temp = 27.4 Humidity = 39
[10:14:05][Data thread] DHT data #18: Temp = 27.4 Humidity = 39
[10:15:08][Data thread] DHT data #19: Temp = 27.4 Humidity = 39
[10:16:03][Data thread] DHT data #20: Temp = 27.4 Humidity = 39
[10:17:04][Data thread] DHT data #21: Temp = 27.4 Humidity = 39
[10:18:07][Data thread] DHT data #22: Temp = 27.4 Humidity = 35
[10:19:06][Data thread] DHT data #23: Temp = 27.4 Humidity = 35
[10:20:03][Data thread] DHT data #24: Temp = 27.4 Humidity = 39
[10:21:03][Data thread] DHT data #25: Temp = 27.3 Humidity = 39
[10:22:05][Data thread] DHT data #26: Temp = 27.4 Humidity = 39
[10:23:03][Data thread] DHT data #27: Temp = 27.4 Humidity = 39
[10:24:04][Data thread] DHT data #28: Temp = 27.4 Humidity = 39
[10:25:04][Data thread] DHT data #29: Temp = 27.3 Humidity = 39
[10:26:05][Data thread] DHT data #30: Temp = 27.4 Humidity = 35
[10:27:05][Data thread] DHT data #31: Temp = 27.4 Humidity = 40
[10:28:04][Data thread] DHT data #32: Temp = 27.4 Humidity = 40
[10:29:04][Data thread] DHT data #33: Temp = 27.4 Humidity = 40
[10:30:04][Data thread] DHT data #34: Temp = 27.5 Humidity = 40
[10:31:06][Data thread] DHT data #35: Temp = 27.5 Humidity = 36
[10:32:06][Data thread] DHT data #36: Temp = 27.5 Humidity = 40
[10:33:04][Data thread] DHT data #37: Temp = 27.5 Humidity = 40
[10:34:04][Data thread] DHT data #38: Temp = 27.5 Humidity = 39
[10:35:05][Data thread] DHT data #39: Temp = 27.6 Humidity = 40
[10:36:04][Data thread] DHT data #40: Temp = 27.5 Humidity = 40
[10:37:06][Data thread] DHT data #41: Temp = 27.6 Humidity = 36
[10:38:06][Data thread] DHT data #42: Temp = 27.7 Humidity = 39
[10:39:04][Data thread] DHT data #43: Temp = 27.7 Humidity = 39
[10:40:05][Data thread] DHT data #44: Temp = 27.7 Humidity = 40
[10:41:05][Data thread] DHT data #45: Temp = 27.7 Humidity = 35
[10:42:06][Data thread] DHT data #46: Temp = 27.8 Humidity = 39
[10:43:04][Data thread] DHT data #47: Temp = 27.8 Humidity = 39
[10:44:05][Data thread] DHT data #48: Temp = 27.8 Humidity = 39
[10:45:05][Data thread] DHT data #49: Temp = 27.8 Humidity = 39
[10:46:07][Data thread] DHT data #50: Temp = 27.8 Humidity = 39
[10:47:04][Data thread] DHT data #51: Temp = 27.7 Humidity = 39
[10:48:04][Data thread] DHT data #52: Temp = 27.7 Humidity = 39
```

[10:49:09][Data thread] DHT data #53: Temp = 27.8 Humidity = 39
[10:50:06][Data thread] DHT data #54: Temp = 27.8 Humidity = 35
[10:51:06][Data thread] DHT data #55: Temp = 27.8 Humidity = 35
[10:52:06][Data thread] DHT data #56: Temp = 27.8 Humidity = 39
[10:53:05][Data thread] DHT data #57: Temp = 27.8 Humidity = 39
[10:54:05][Data thread] DHT data #58: Temp = 27.8 Humidity = 39
[10:55:06][Data thread] DHT data #59: Temp = 27.9 Humidity = 35
[10:56:06][Data thread] DHT data #60: Temp = 27.9 Humidity = 39
[10:56:06][Data thread] Computing hourly local averages...
Avg Temp = 27.5 Avg Humidity = 38
Local temperature averages:
[None, None, None, None, None, None, None, None, None, 27.528333333333318, None, None, None, None, None, None, None, None, None, None, None, None, None, None]
Local humidity averages:
[None, None, None, None, None, None, None, None, None, 38.18333333333333, None, None, None, None, None, None, None, None, None, None, None, None, None, None]
[10:57:01][Main thread] Getting CIMIS data for time 9:00
[10:57:02][Main thread] Cimis data for 9:00 is:
Humidity = 30 Temperature = 26.3 Eto = 0.54
[10:57:02][Main thread] Local data for 9:00, Avg Temp = 27.53 Avg Humidity = 38
[10:57:02][Main thread] Turning on irrigation for 10.797341927378929 seconds...
[10:57:11][Data thread] DHT data #1: Temp = 28.0 Humidity = 39
[10:57:11][Main thread] Motion detected. Stalling irrigation for 5 seconds
[10:57:16][Main thread] Motion detected. Stalling irrigation for 5 seconds
[10:57:22][Main thread] Motion detected. Stalling irrigation for 5 seconds
[10:57:27][Main thread] Motion detected. Stalling irrigation for 5 seconds
[10:57:33][Main thread] Irrigation done for hour 9:00. Turning off irrigation.
[10:58:12][Data thread] DHT data #2: Temp = 28.0 Humidity = 39

24-hour-Log:
*Temperature is taken in Celsius (C), Irrigation Time is taken in seconds (s)

Time	DHT temperature	DHT humidity	CIMIS temperature	CIMIS humidity	Eto	Irrigation Time
09:00	27.528	38.183	26.3	30	0.54	10.797
10:00	27.912	38.5	28.6	28	0.68	11.735
11:00	28.720	37.383	29.8	30	0.79	14.855
12:00	29.203	40.717	30.9	27	0.87	13.257
13:00	29.470	41.05	31.3	22	0.89	10.919
14:00	29.920	39.683	31.6	18	0.84	8.771
15:00	31.052	38.817	31.6	18	0.75	8.309
16:00	31.188	40.167	31.5	15	0.6	5.394
17:00	31.355	42.85	30.6	18	0.42	4.395
18:00	30.512	45.5	27.8	32	0.25	4.692

19:00	29.898	43.467	24.8	51	0.07	2.407
20:00	29.702	44	21.5	71	0	0
21:00	29.172	45.25	19.8	78	0	0
22:00	26.992	51.467	18.4	84	0	0
23:00	23.118	65.25	17.9	88	0	0
00:00	24.515	58.5	17.9	89	0	0
01:00	25.310	53.133	17.6	88	0	0
02:00	24.992	52.466	17.5	85	0	0
03:00	24.567	53.717	17.1	84	0.01	0.546
04:00	23.997	55	15.9	87	0	0
05:00	24.000	54.483	14.9	90	0	0
06:00	23.682	54.267	15.4	85	0.02	1.171
07:00	24.397	55.05	15.2	89	0.11	6.94
08:00	25.945	48.583	16.8	80	0.29	17.931

*Total Irrigation Time: 122.12 seconds

Conclusion

By using a DHT-11 sensor to get local temperature and humidity, we can compare the statistical data to that retrieved from the CIMIS website for California Irrigation Management Information System to calculate the optimal irrigation time, given certain specifications from the lab manual. Based on a multitude of factors, a formula was derived to calculate the optimal irrigation time. The following parameters were used: plant factor (PF) of 1.0 for a lawn, area of irrigation in square feet (SF) of 200, irrigation efficiency (IE) of 0.75, water per hour rate of 1020 gallons per hour, and a timespan of 24 hours. From the data gathered over 24 hours, the resulting irrigation time for a day was calculated to be 122.12 seconds.

While the irrigation time may vary from what is ideal, this was the time that my project resulted in. On every hour, the system would automatically irrigate for the calculated time, unless motion was detected in which it would then stall and continue. A major factor that may have impacted the accuracy of the experiment results is that I took the local measurements indoors, whereas the CIMIS data is based on outdoors data, suggesting a wide range in temperatures.