Case Study: An Academic Building Monitoring Sensor Network

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***Abstract*—In this paper, Sparkfun FIO V3 combined with Xbee were used to monitor Breakiron 164. Multiple sensors were deployed in Breakiron 164, including door switch, solar cell, temperature and humidity sensor, motion sensor, thermistor, RED LED and buzzer, to monitor the environment. In this paper, we will discuss how each sensor is interfaced with the Arduino and analyze data collected in a twenty-four hour period.**

Keywords*—*SparkFun Fio V3, Xbee, Environmental Monitor, Sensor, BreakIron 164.

I. Introduction

Correctly operating an arduino with sensors on it required time and multiple sources of information. Many of these sources were great resources and occasionally provided code. However, as we found out, sometimes this code was not quite right for our specific sensors. After we got all of the sensors working, they were deployed in breakiron 164 from Friday, February 20th at 9 pm, until Sunday, February 22nd at 2 pm. The sensors observed and on a fixed interval sent data back to an xbee radio that was running through python. This python program simple saved the values returned by the sensor to a text file and put a timestamp on each reading.

II. Method

In this section, we will discuss each sensor we used in this project, and analyze data collected from them.

A. Door Switch

The door sensor is a magnetic contact switch. The sensor is a reed switch, which is normally open, but when the magnet is less than 13mm away the reed switch closes.[1] This type of sensor can be used to detect when a door opens and closes. The type of door switch we used was from. [1] We used this sensor to monitor when the door to a classroom opens and closes. The magnet was placed on the door and the reed switch was on the doorframe. The switch is connected to ground and to a digital pin, which reads the signal from the switch. A 10K resistor pulls the switch up to 3.3 V of power. The radio sends data to the base station every 1000 milliseconds. If the door is open, a 1 is sent. Otherwise a 0 is sent, indicating that the door is shut. The door sensor successfully sent data to the base station during the 24-hour period. At the beginning of the 24-hour period, there are more 1?s sent to the base station because we were testing the sensor. After this, there are mainly 0?s as we ran the experiment on a Saturday and not many people entered the classroom. Overall, the door sensor worked and successfully sent data to the base station.

B. RGB LED

The RGB LED is a full color led lamp with uniform light output. It is composed of three colors: hyper red, blue and green. It has four pins, and they are red cathode, common anode, green cathode and blue cathode, from left to right. This RGB LED can operate under 3.3v, the standard output from Sparkfun Fio V3, and the anode is connected to the GND (ground) pin of Sparkfun Fio V3.[6] Each pin should have power supply, and they should be connected to the analog channel of Fio V3; therefore, the red cathode is connected to D6, the green cathode to D9 and blue cathode to D10. To limit current flowing through the RGB LED, the cathodes are connected to 1k ohm resistors and then connected to the Sparkfun Fio V3. The RGB LED is connected to the solar cell, indicating if the solar cell receiving light energy or not. If the sensor value from solar cell is under 350, the light will be red; otherwise, the light will be green.

C. Solar Cell

The solar cell can be used as either sensor or energy source. In this project we used it to sensor daylight. To avoid interior light, we built a shield using black paper, blocking nearly all the lights from room. The solar cell should be operated under 3.3v and 5.1mA, so it is directly connected to the Sparkfun Fio V3.[7] The red cathode is connected to A4, an analog output on Fio V3, and the black anode is connect to GND (ground). The solar cell will send the sensor value every 3 seconds, and it will send the real sensor values to the base station. At night, the sensor value is around 10, and the sensor value starts to increase at around 6:30 A.M., right before sunrise. The sensor value reaches the highest point at 11:30 A.M., when the sunlight is the strongest. It then starts to decrease at 6:00 P.M., right after sunset. The shield worked perfectly to block light from inside, and the sensor value matches to the daylight outside.

D. Honeywell

The Honeywell humidity and temperature sensor is wired to Sparkfun Fio v3 according to the datasheet. Two 2.2 k resistors, one 0.11 uf and one 0.22 uf capacitors were used to build the circuit. Using I2C serial communication protocol, both data and clock were fed back into Fio v3. Using the wire library and HIB libraries provided on course website, we successfully sensored the humidity and temperature in Breakiron room 164. We set the sampling interval to be 500 ms, which means 2 datapoint every second. It appeared to be way more data than we needed but the sensor survived from the high pressure sampling. In total, more than 290k data points were collected during the sampling period, from 9 P.M. to around 2 P.M. two days later. We converted our data into humidity percentage and celsius degree for easier human reading. Thanks to Bucknell's advanced building temperature controlling system, 164's temperature has been extremely consistent between 21.5 degree to 23 degree over the night and day. However, the humidity usually stay around 5 10 percent during the night but jump up to 15 percent during the day time. We think it is mostly because of the luminosity of the room.

E. Piezo Buzzer

The Piezo Buzzer can play certain tone if programmed. It can be powered under 3.3v by Sparkfun Fio V3. [8] The cathode is connected to a 1K ohm resistor and then connected to the analog input to Sparkfun Fio V3. The anode is directed connected to GND (ground). The buzzer worked with door switch. If the door switch is open, the buzzer will play sound. Otherwise, it will stay quite.

F. Thermistor

The thermistor is a type of resistor in a waterproof cap whose resistance varies significantly with temperature. Its function is to measure the temperature of its surroundings, and can be placed in any sort of environment. The word is a combination of thermal and resistor.[2] The thermistor connects an analog pin to 3.3 V of power and 10K resistor pulls the whole thing to ground. From the voltage recorded from the analog pin, we can determine the resistance of the thermistor at that moment in time. Then, using the Steinhart-Hart thermistor equation, we can determine the temperature in Kelvin.[3] We used the thermistor seen in. [4] The thermistor we set up converts the temperature to Fahrenheit before sending the data to the base station. We taped the thermistor to the window in the classroom to get a comparison of the temperature by the window to the room temperature, which is 70 degrees Fahrenheit. This value was recorded during a test of the thermistor. We found that the temperature right at the window was about 55 degrees Fahrenheit. The thermistor successfully sent data to the base station during the 24-hour period. Every 1000 milliseconds, the radio would send the temperature in Fahrenheit of the window at that time. Overall, the thermistor worked and was able to send data to the base station.

G. Motion Sensor

The motion sensor is an infrared sensor for the purpose of detecting the presence and movement of living things. The motion sensor that we deployed was a HC-SR501.[5] The sensor itself automatically collects data under settings manually set on the sensor itself. These settings are set physically before deployment and cannot be changed remotely. When the sensor detects motion, it outputs a logical high which we capture using the arduino board. These are sent over an xbee radio to the base station approximately every 1/10 of a second. The motion sensored worked and collected data for the whole 24-hour. We examined the data in 1 hour periods and noticed that the standard deviation of each hour was just sly of 1.2% of the average of each hour. Thus, even though the sensor was collecting data, the data has no meaning as the sensor could not differentiate between the presence and absence of people. The easiest comparison is between the hour when set-up was occurring and the hour between 4 and 5AM. The busy hour has marginally less hits than the ghost hour, confirming that the sensor was not actually sensing motion. We suspect that the activity of the idling computers is triggering the sensor continuously.

H. Base Station

The base station is relatively simple compared to the rest of the components. An xbee radio is connected to a Linux system and interfaced with python. A callback function is provided that writes values to a separate text file for each sensor. It determines which text file to write to and how to interpret the data by an int stored in the first position of the data received. This int specifies which sensor the data was sent from and is in the range of 1 to 5.

III. Conclusion

Overall interfacing with the sensors, monitoring the environment, and communicating with the base station went very well. The few problems that occurred were easily fixed and we now have an accurate reading of what breakiron 164 was like over the weekend.

Appendix A
Data and Code

All the code and data can be found on GitLab: git@gitlab.bucknell.edu:cr025/sensorproject.git

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REFERENCES

[1] http://www.adafruit.com/product/375

[2] http://en.wikipedia.org/wiki/Thermistor#Steinhart.E2.80.93Hart_equation

[3] http://www.eidusa.com/Electronics_Kits_TEMP_THERMISTOR_1.htm

[4] http://www.digikey.com/product-search/en?x=0&y=0&lang=en&site=us&keywords=BC2654-ND

[5] http://www.mpja.com/download/31227sc.pdf

[6] http://www.kingbrightusa.com/images/catalog/SPEC/WP154A4SUREQBFZGW.pdf

[7] http://media.digikey.com/pdf/Data%20Sheets/Sanyo%20Energy/Amorphous_Br.pdf

[8] http://www.princetronics.com/supermariothemesong/