CS Capstone Technology Review

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HyperRail App

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Abstract

This report explores the hardware portion of the HyperRail project, looking at possible hardware alternatives that could be used. Specifically, the report looks at hardware boards that could be used for the environmental sensor package base as well as different types of environmental sensors and hardware communication methods.

CONTENTS

1 Introduction

The technology review examines three components of the HyperRail project. For each component, three alternatives are explored for possible use in the project and each alternative will be evaluated based on their specifications.

2 Problem Description

The HyperRail is a small railway where an automated environmental sensor package can traverse along the railway through a space and collect information. Using the HyperRail application, the sensor package's settings can be customized and monitored. The application currently allows the user to specify the speed of the package, current length of the rail, and the size of the spool used for the motors. It also monitors the position of the sensor package and updates the position display in real-time. However, the application requires a direct connection to the sensor package, limiting the HyperRail's use.

3 Piece 1: Hardware Board

3.1 Overview of Criteria

The hardware board is the heart of the HyperRail environmental sensor package. The board is connected to all the sensors and is connected to the HyperRail application, allowing the board to communicate with the application. In addition to receiving commands from the application, the board will also send the package's current location and data collected from the sensors to the application for the user to see in real-time.

3.2 Adafruit Feather M0 Basic Proto

This is the hardware board that is currently selected for the HyperRail project. The board itself is small and lightweight, being 5.08 x 2.29 centimeters big and weighing 4.6 grams total. It has a total of 20 general purpose input and output (GPIO) pins as well as 6 analog inputs and 1 analog output. This allows a multitude of sensors to be connected without the use of an external board for additional connections. Despite the small size, it also has a built-in rechargeable battery that makes it useful for portable projects. An external power source, such as a battery, can be provided to continually charge the internal battery, but it is not required. The Feather M0 has 256 kilobytes (KB) of flash memory and 32 KB of random access memory (RAM), but no electrically erasable programmable read-only memory (EEPROM). In addition to a direct serial connection, the board has several variations that enable communication with other devices through a Bluetooth or Wi-Fi connection. [1]

3.3 Arduino MKR WiFi 1010

The Arduino MKR WiFi 1010 is the largest of the three alternatives, being 6.15 x 2.5 centimeters in size. It has fewer pins than the other two boards with 8 digital I/O pins, 7 analog input pins, and 1 analog output pin. This board has an internal lithium-polymer battery powering the board and can also be powered by an external source. Similar to the Adafruit board, it also has 256 KB of flash memory, 32 KB of static RAM, and no EEPROM. However, the MKR WiFi board can communicate with other devices through a direct or Wi-Fi connection and is cheaper than the Wi-Fi equivalent of the Adafruit Feather M0 board, meaning it will be easier for the board to interact with a web interface. [2]

3.4 Arduino Micro

The Arduino Micro board is the smallest board of the three alternatives, being 4.8 x 1.77 centimeters big. The Arduino Micro also has 20 GPIO pins as the Adafruit Feather M0, but it does not have an internal battery, meaning the board requires an external power source. Because of its small and simple design, it can be easily placed on a breadboard to help with prototyping. The Arduino Micro has less memory than the other two boards, with 32 KB of memory, 2.5 KB of SRAM, and 1 KB of EEPROM. However, the board can only communicate with other devices only through a wireless or direct serial connection. [3]

4 PIECE 2: HARDWARE COMMUNICATION METHODS

4.1 Overview of Criteria

Hardware communication determines how the HyperRail environmental package will interact with the user. It determines how the package will receive configuration settings and commands from the user and how the package will send environmental data back to the user.

4.2 Wired Communication

Wired communication is the process of sending data over a wired communication channel. Typically with wired connections, the devices simply send bits sequentially through the cable. Data can also be simultaneous sent in both directions, to and from the board or devices, through the data plus and data minus wires. However, because the devices are directly connected to each other, the range is limited based on the length of the cable. For the HyperRail project, this direct cable connection may inhibit the HyperRail's use as it limits the environmental package's range and possibly its usability. The package would have to be connected to a computer at all times in order to send the data collected to the user. Depending on the HyperRail's physical setup, the long cables may be infeasible or too costly as the cable can get caught on objects or entities in the surrounding environment. However, for contained environments with a relatively short and linear rail, a cable connection could be useful for quickly transferring the data collected to the user.

4.3 Wi-Fi Communication

Wi-Fi communication is the process of sending data through the internet. Information is sent from one device to another using a router, which reads the information packet and routes it to an appropriate destination, either another router if the target device is further away or the target device itself. Limitations to this type of communication is that it requires a stable internet connection. If the connection drops, data loss could occur and the HyperRail system would be offline, with the severity of both depending on the duration of the connection drop. However, because the proposed solution is to create a web application for the HyperRail, Wi-Fi communication would make it easier for the environmental sensor package to interact directly with the web application as it can send data directly to the web server for it to be available to the user.

4.4 Bluetooth Communication

Bluetooth is another form of wireless communication that uses low-power radio wave. Bluetooth uses weak radio signals which limits its communication range, but it reduces the chances of external interference with other Bluetooth devices. In the case of the HyperRail, the communication range becomes more important as the size of the railway increases, but for small HyperRail systems, the reliable and safe connection could be very useful especially in cluttered areas. It also avoids interference with other Bluetooth devices by rapidly changing its frequency. However, Bluetooth does not need a direct line of sight between the communication devices, so it can be useful in areas with many obstacles. [4]

5 PIECE 3: HARDWARE SENSORS

The main purpose of the HyperRail is to make environmental data collection simpler. Therefore, environmental sensors are essential to the project so data collection can be automated, making environmental monitoring easier.

5.1 TMP36 - Temperature Sensor

Monitoring temperatures is vital in agriculture as certain crops or products require a certain temperature range for an optimal result. Also, as global warming becomes more prominent, monitoring temperatures becomes more important. The TMP36 temperature sensor is very small and cheap, costing $1.50 each. It is easy to setup, only having three pins: power, ground, and voltage out. The sensor outputs a voltage depending on the temperature it detects at a ratio of 10mV per 1°C and the sensor operates between -40°C and 125°C. At around 25°C, the temperature reading is with within 1°C of the true temperature, but near the ends of the operating range, the reading accuracy drops to being within 2°C of the true temperature. The temperature of most environments should be within this sensor's operating range, making this sensor useful for the HyperRail. [5]

5.2 MG-811 CO2 Gas Sensor Module

Because global warming is caused by carbon dioxide (CO2) trapping heat in the Earth's atmosphere, monitoring CO2 levels becomes more important. The MG-811 sensor module is small and it seems a little pricey at around $52.95, but it is relatively cheap compared to other CO2 sensor modules. The module has a sensor jack and 4 pins which allow for simple and fast setup. The sensor itself can detect CO2 levels from between 350-10000 parts per million (ppm), which makes it very versatile, and outputs a voltage between 30 and 50mV depending on the CO2 level. The sensor's design allows it to essentially ignore other gases in the environment as well as the temperature and humidity. [6]

5.3 DFR0027 - Ambient Light Sensor

Monitoring light level can be important for greenhouses as plants can require varying amounts of light to grow properly. The DFR0027 light sensor is also small and cheap, being 2.2 x 3 cm in size and costing $2.60. Like the temperature sensor, it is easy to setup as it only has three pins. The sensor can detect light levels from 1 to 6000 illuminance (lux) with a response time of 15 microseconds, so it can detect abrupt changes in light levels. Although the lux of sunlight is greater than 6000, this sensor is designed to detect ambient light, so it can be useful for detecting small changes in darker environments. [7]

6 RECOMMENDATIONS

Overall, I believe the Adafruit Feather M0 board is the most versatile and robust option. It has plenty of memory and plenty of GPIO pins, which means it can support many different sensors. It also has several variations that use different communication methods, so it can be used in many situations depending on the environment. For communication, I believe wired or Wi-Fi communication are good options. Wired communication has a fast data transmission and an easier implementation. It can be useful for linear railways because the cable will not get caught on obstacles. Wi-Fi communication is useful for larger areas that have internet because Wi-Fi connections can go through obstacles. It also makes interaction with a web interface much easier. For the sensors, although there are a vast amount of sensors, these three options perform their jobs at a relatively low price.

REFERENCES

[1] Adafruit. Adafruit feather m0 basic proto. Adafruit. [Online]. Available: https://www.adafruit.com/product/2772

[2] Arduino. Arduino mkr wifi 1010. Arduino. [Online]. Available: https://store.arduino.cc/usa/arduino-mkr-wifi-1010

[3] ——. Arduino micro. Arduino. [Online]. Available: https://store.arduino.cc/usa/arduino-micro

[4] C. Franklin and J. Layton. How bluetooth works. How Stuff Works. [Online]. Available: https://electronics.howstuffworks.com/bluetooth.htm

[5] Sparkfun. Temperature sensor - tmp36. Sparkfun. [Online]. Available: https://www.sparkfun.com/products/10988

[6] S. Electronics. Mg-811 co2 gas sensor module. Sandbox Electronics. [Online]. Available: https://sandboxelectronics.com/?product=mg-811-co2-gas-sensor-module

[7] DFRobot. Gravity: Analog ambient light sensor for arduino. DFRobot. [Online]. Available: https://www.dfrobot.com/product-1004.html