**Memo**

To: Professor Pisano

From: SmartLoo (Arturo Asmal, Ben Corn, Bonnie To, Brandon Ng)

Team: SmartLoo: Team 20

Date: 4/29/18

Subject: Engineering Addendum

To Whom It May Concern,

It is with great pleasure that we welcome another set of brilliant minds aboard the SmartLoo team. In order to help you jump-start the continuation of the SmartLoo mission, here is a quick overview of the project in its current state.

For starters, our project is one that focuses around sensor communication. All of the sensors communicate to a SmartLoo Bridge, which would then pass that information along to the API.

The SmartLoo Bridge consists of:

* XBee S2C
* ESP32
* Master Node Casing

The ESP32 allows for the usage of WPA2 Enterprise networks. Initially the ESP8266 was chosen because it has plenty of ongoing support, and was easier to work with when thinking in a test setting. However, the ESP32 is a much stronger device that can be deployed in personal and enterprisal settings, as well as the implementation of WPA2 Enterprise security. We wish this was something that was noted beforehand because we did complete a lot of our early work with the ESP8266.

Connected to the SmartLoo Bridge, are all of the individual sensors that target different problem areas. Because each sensor has such specific usages, it was very vital for us to make the parts more interchangeable. That being said, the SmartLoo Sensor Node and SmartLoo Wiring Harness that we have manufactured are universal and can be attached to any sensor. We would recommend keeping the nodes modular in the future to make the installation process a lot easier for the customer!

A typical SmartLoo Sensor Node will consist of:

* Sensor Node
  + PCB
  + Power Supply (3xAA battery holder)
  + Sensor Node Casing
  + XBee S2C
  + Plastic Enclosure
* Wiring Harness
* Sensor (will vary based on problem area)

For work concerning the hardware, we would highly recommend focusing heavily on the SmartLoo Sensor Node PCBs. Concerning the PCBs, three versions were ultimately created with OSH Park as the selected PCB manufacturer of choice. The third revision was significantly reduced in size by removing unnecessary components and offered a more flexible option in power supply than compared to the first revision. OSH Park was also the chosen company because it is one that produces very quality boards for a relatively cheap price and it was perfect for us, as it gave us multiple opportunities to revise our boards and perfect it for the better. In the case of a future board revision, we highly vouch that multiple PCB boards be created and tested!

We initially were ambitious and wanted to try out various sensors, because with various sensors, there is more data that can be pulled. However, the complications that arise with multiple pieces of hardware is compatibility. We wanted to create a board that was uniform and could be used to program any sensor, in which we ran into our first problem: voltage requirements. It is recommended to make sure all your devices are running at the same voltage so that the PCB can be simplified for that voltage.

The second problem was the operating requirements of the hardware. Regarding the MPU6050, in order to implement angle measurement, we needed to collect a lot of sample measurements which then needed to be offset. This required a baud rate of 115200. However, the rest of our devices required 9600 baud rate. All the data collected by the MPU6050 would be processed at that baud, but the Xbee could not read all that data as it was operating at a slower one, then sending garbage data. It is recommended that all devices use the same speed.

With these issues in mind, and the need to continue with a product that is still viable, it was concluded that our basic goals could still be achieved with just one sensor. To the team, it looked simple, but sometimes engineering is best done when it is simpler.

Concerning the Sensor Node as a whole, it is a relatively big node that may be too noticeable to the daily restroom user. A future improvement for this project would be to minimize the size of the casing and the node and have it be hidden from the public eye. In future editions of the sensor nodes, we would recommend that you be aware of where the battery pack and where PCB will being placed inside the node. During our creation of the node, we did have slight issues with the placement of the interior components as well as with the placement of the ON/OFF switch. The components were a bit cramped so we would highly recommend multiple versions of the casings!

Another concern that we had was the power management of the entire system. We needed something that could be portable, and would reply on command, all while making it last up to a month. This meant we could opt for a large battery, which we found to be very pricey, or we could make it easily compatible and then implement low-power mode optimization to our devices. We recommend doing that latter, as power optimization is much less costly to do if possible. Hence we recommend choosing a low-powered microprocessor that can be optimized, as well as choosing hardware that requires less voltage to optimize overall power consumption right from the start.

Last but not least, we would also recommend being generous with the amount of sensors available for testing, in case the one sensor that is available happens to fail. Also, substitute sensors should also be considered (ex. LSM303 vs MPU6050) as well as ways to implement them, so that should anything be any issue, it can be easily implemented.

With all of the tips that are given with this letter, we wish you the very best with your endeavors and we cannot wait to see how SmartLoo can continue to improve!

Sincerely,

The SmartLoo Team

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