Team Instru-MEN-tation

Testing Result Report

4/1/2022

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EE486C
Team 5
Instrumented Bike
04/1/2022

To: Robert Severinghaus

From: Instrumented Bike Team

Date: 04/1/22

Subject: Testing Results Report

Project Overview:

This report will provide a detailed overview of our system, as well as the system architecture that will show the whole system showing areas that were tested. Next, it will show the fundamental requirements that have been used to complete the system and the testing. The requirement will have all the things that have been used in the excel file to understand the path that the team needs to use to complete the required test. Additionally, the report will explain the essential requirements to the clients, why it is essential, and the types of tests with the analysis of the results.

Executive Summary:

As a team, multiple tests were done: three Unit Tests Step by Step and one integration test. One test has been done for each component separately for the step-by-step test. Next is the integration test of the fundamental components together. One test started on the south side of campus then ended on the north side, from the business building to CIE (ISSS building). Finally, the test took the team a week to do, and each day took 2 hours since it had to be done multiple times to verify that the data was correct. A screenshot of the result was taken and added to the workbook to see that the team followed what we wrote in the action section.

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Introduction to the system:

We will talk about our clients, the problem we are solving, and the overview of our design. The first client's name is Dr. Chun-Hsing Jun Ho, an Associate Professor who works in the Department of Civil Engineering, Construction Management, and Environmental Engineering. He worked for the Washington Institute of Technology as a lead faculty in the Civil Engineering Graphics program. He got his Ph.D. degree from the University of Utah in 2010. The second client's name is Dr. Kyle Nathan Winfree, an Associate Director of Undergraduate Programs associated with the College of Engineering, Information, and Applied Sciences. He got his Ph.D. Biomechanics and Movement Science from the University of Delaware. He has many journal publications and proceedings publications. The problem that we are trying to solve that our clients provided to us is that we need to upgrade all the equipment that has been used in the past to detect the obstacles on the road. Most of our work starts from point zero, where we need to search for a new component building it instead of using old equipment. It is all because technology is improving every day, and we need to upgrade each piece of equipment to improve the work and make it easy for our clients to use. The overview of our design is that we used different types of components. The main component is the Arduino Nano, which acts as the project's hardware. On top of that, we are using GPS, Accelerometer, OpenLog (SD card), and a battery. All of our components will be inside a small box that will fit in a phone holder. The team will use a QWICC cable to connect all the components. We will use the GPS to identify the location of each obstacle, while the Accelerometer will help us detect the obstacles. The OpenLog will save everything that the GPS and Accelerometer detected. At the same time, it will show the date and time on the SD card to know what time and date we found the problem. We will be able to get the date and time using the GPS since it will be connected to the satellite, and the SD card will have a memory space of 32GB.

System Architecture showing areas that were tested:

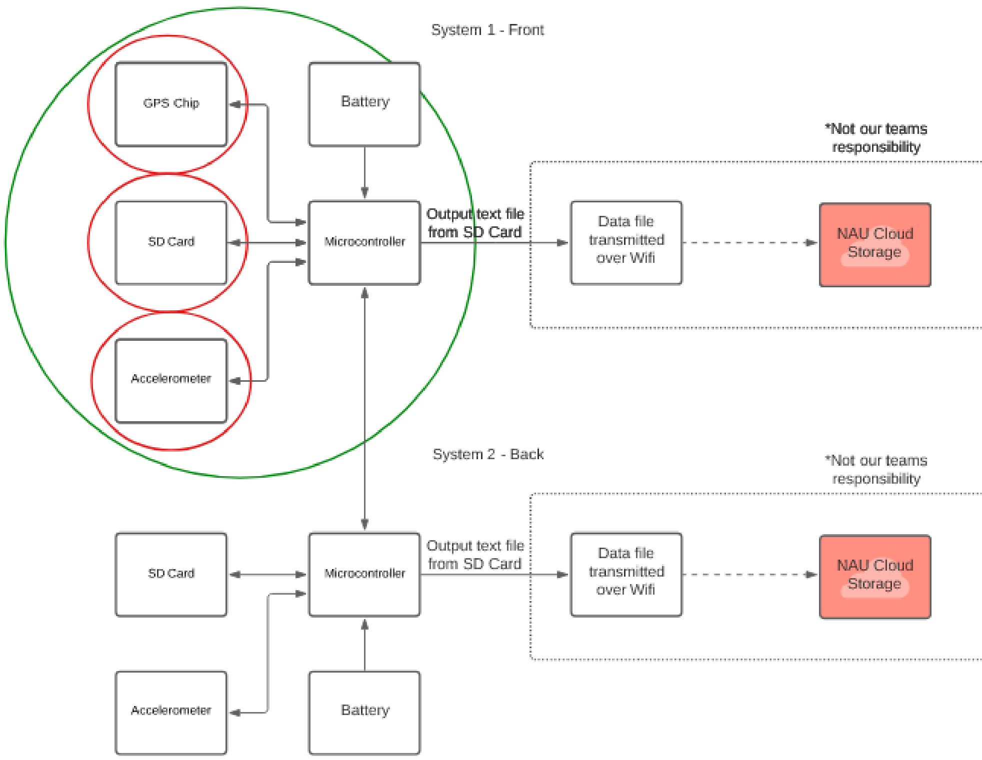


Figure 1: System Architecture

The figure above shows the team system architecture used for the testing process. It shows different notations. The red circle represents the step-by-step unit test, which was tested separately. The big green circle represents the integration test, which tested the entire system to get the results needed to meet the requirements needed. The team will use two systems, one on the front of the bike and the other one will be on the back of the bike. The team job will be testing the front system since both systems are similar, except that the one in the back will not have any GPS.

Requirements, status, type of test (Requirements tab on one page, color):

Type of Test	Status	Req #	Requirement
Inspect		1	GPS Chip for location
UTS	*	1.1	GPS sampling frequency at least 1 Hz
		1.1.1	Allows for the most accurate spatial resolution
Inspect		2	Accelerometer to recognize obstacles
UTS	*	2.1	Accelerometer sampling frequency at least 100 Hz
		3	Battery life
UTS	*	3.1	It needs at least 3 hours battery life to collect data
		3.1.1	Estimated trip takes about 25 minutes from North to South Campus and back to start
Inspect		4	SD card for storage
UTS	*	4.1	At least 100MB of memory to store multiple trips
		4.1.1	Currently using MicroSD Card with Adapter (32G)
		5	Being able to locate different obstacles location in different trail
Integration		5.1	Being able to locate holes that are at least 3 inches deep
Integration	*	5.2	Must be able to locate other obstacles in the trail
		5.2.1	Obstacles may include fallen branches, rocks, and other small objects that a bike can pass over
Integration		6	Searches for a WiFi connection when the system is stationary
Integration		6.1	Save battery life by searching for WiFi when not collecting data.
		6.2	System is considered stationary when sitting still for at least 10 minutes
Inspect		7	The size of the whole system will be no larger than a water bottle
		7.1	The system will fit inside a water bottle that fits in most water bottle holders on a bike
		7.1.1	Typical holder size: 5 in. tall and 2-⅞ in. diameter
Integration		8	Must be robust and durable
UTS		8.1	It needs to be able to handle the same wear and tear as the bike itself
UTS		8.1.1	Should be waterproof enough to withstand rain conditions
		8.1.2	Should be able to withstand hot and cold weather temperatures
UTS		8.1.2.1	Maximum temperature: 185° F
UTS		8.1.2.2	Minimum temperature: -40° F, GPS (-40 to 85 °C), Accel (-40 to 105 °C)

Most important requirements:

The most important requirements that we picked are GPS sampling frequency at least 1Hz, Accelerometer sampling frequency at least 100Hz, it needs at least 3 hours battery life to collect data, at least 100MB of memory to store multiple trips, and must be able to locate other obstacles in the trail. As a team, we picked those requirements because without them, we will not be able to make the project work. Our clients want the GPS to work as fast as it can to be able to locate the obstacles in the exact location. If we do not locate the obstacles in its exact location then it will be a problem and hard for our client to check if the location of the obstacle is correct. The same thing goes to the accelerometer, if it does not work at a 100 Hz and there are multiple obstacles then the accelerometer will only detect one obstacle instead of multiple ones. WIthout the battery working for at least 3 hours we will not be able to test it for a long period of time and we will have to recharge the battery every time we use it.

Types of tests:

The team did four types of tests, three of them were for the step-by-step tests, and one integration test. Each component has one step-by step test, and the entire system was tested using the integration test. Each team member did the step-by-step test for his part of the project. One team member was working on the GPS test, the other was working on the Accelerometer test, and the last one was working on the OpenLog test. The person who is responsible for the GPS test was doing his test and was confirming if it passed its own test using the excel sheet that has all the information needed to make sure if it passed or not. GPS passed the test successfully and it was confirmed in the excel sheet. To confirm that the GPS passed the test, the GPS needed to show the exact location, the date and time. This information is important for the integration test in the future that will require the GPS' location data to be accurate and the time coming through the GPS from the satellite it is connected to must be printed at the top of the system's output file to indicate the day and time of the test. One of the results that we got for the GPS was to test it to see if we got the exact location (as shown in appendix 2 & 3). Once that was done, the other team member started testing the Accelerometer. The team member followed the instruction that is in the excel sheet, and he followed the instructions to make sure that he was in the right direction. The Accelerometer needed to show different changes in the axes to confirm it was passing the test. The axes of data being changed indicates that the accelerometer can detect obstacles that the bike runs over or even whether the bike is going uphill or downhill (as shown in appendix 4 & 5). The third person on the team did his own test which was on the OpenLog, and he made sure that the SD card was saving the data. From that, he will know that if OpenLog saved the data needed that means it passed the test. Once all the components were passing their own test that means the team can move to the most important phase of testing which is the integration test. The integration test requires the team to combine their individual components, make sure they work properly together, and then get a combined data file from a set path.

Major tests:

The integration test requires the team to combine all of their parts together to create the system seen in the system architecture above. The main purpose of integration testing is to verify that all the parts will work together and output a data file as expected. The test begins with connecting the system together using QWIIC cables and uploading the program to the Arduino. After uploading has finished the system is put into the container and placed in the cell phone holder on the bike (as shown in appendix 1). The routes for testing were predetermined by the team and consisted of three paths across campus. One of the paths was from the Business building to CIE and the other one was from SkyView to the University Union (as shown in appendix 7, 8, & 9). The map in the appendix indicates both the path that the team took for the testing and the obstacles that the bike ran over for both the union path and the CIE path (as shown in appendix 7, 8, & 9). The second part of the integration tests involved mapping the data points from the tests on a map overlay and using an algorithm to mark where obstacles were in the path. This was done with help from Dr. Ho and a GTA that was helping us, Yifei Zhang. We gave them the data from our tests and they mapped it for us using an algorithm they created. The data is output to a micro SD card in the form of a CSV file. The other two most important tests were the GPS and Accelerometer tests that were described above. Their results can be seen below.

Analysis of results:

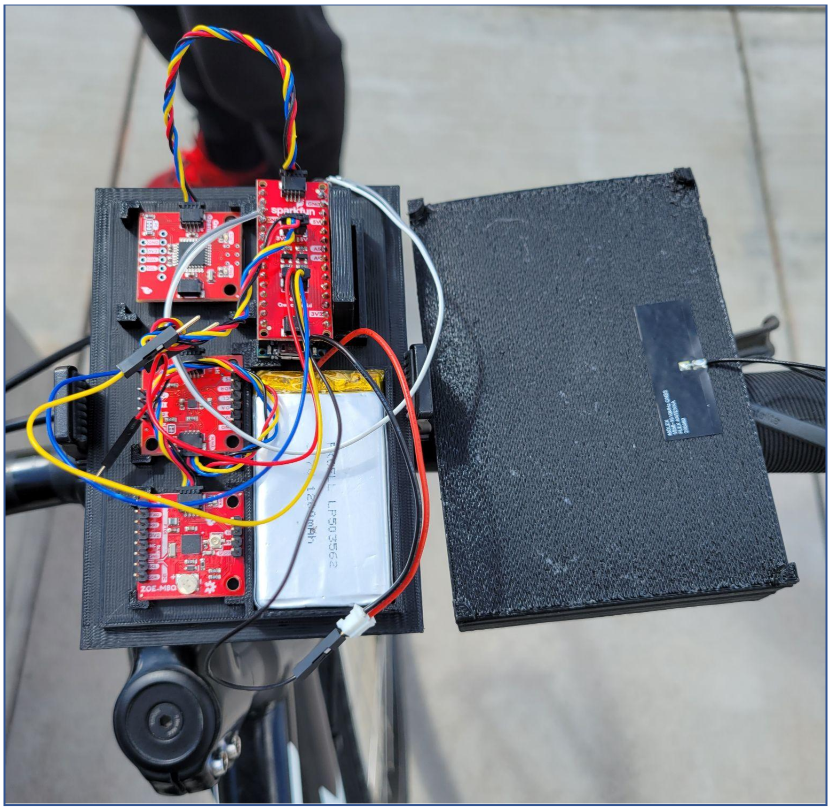
For the analysis of results, the team performed one of the tests when the weather was raining and it passed the test on that condition. The other condition was snowing, so they did perform the test under that condition and it passed while everything was working as expected. Even the weather was supposed to stop the signal between the satellite and the GPS, but the GPS was working as expected. The team thought that the water might enter the box since there was a small gap in the box however nothing entered the box. Before the team did the test under those weather conditions, they did a test where it was too hot, but the equipment was able to pass the test without any problem since the components can work under a high temperature. So, all the tests went as expected. At the same time that the team was testing, they were checking if they met the most important requirements which were satisfactory without facing any problems.

Lessons learned:

We learned that testing results may differ depending on the magnitude of the tests we do. For example, the first integration tests we did only took less than 3 minutes to complete as we did it in ~100ft area. Even though these tests were successful, they did not reveal the issues that we ran into in later stages of testing. In one instance, the system did a reset as we were testing it around campus. This was due to the positioning of the Reset Button, as it was accidentally pressed due to the shaking of the bike. This issue was solved when we secured the Reset Button in a place so that it cannot be accidently clicked again. Therefore, integration tests must be done numerous times and with larger magnitudes which may uncover bugs in the system that may not be obvious in smaller tests. Furthermore, we had to remove the WiFi requirements as we learned that connecting the Arduino to NAU WiFi is not as simple as plugging usernames and passwords, but requires multiple steps of verifications which makes it impossible to do according to the ITS department. We had a side requirement that we thought it was a good idea to include it in the system which is an ON/OFF switch. It was the team idea to add it since we want it easy to use at all times. However, the battery was not able to power the entire system while the button switch was connected. We tried connecting it in different ways, but no luck with that. So, the team decided to remove it from the system. It was not a requirement that we needed to meet for our clients. All the requirements were easy to test while the system was separately or combined together.

Appendix:

[1] The 3D printed system container mounted onto the bike (Opened)



[2] Serial Monitor GPS Result

```
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
Lat: 351777236 Long: -1116570727 (degrees * 10^-7)
```

[3] Google Map Prove of the Location

[4] Serial Monitor Accelerometer Result

```
X: 0.0041g   Y: -0.0057g   Z: 1.0033g
X: -0.0164g   Y: 0.2819g   Z: 0.9656g
X: 0.0224g   Y: 0.6417g   Z: 0.7675g
X: 0.0020g   Y: 0.6034g   Z: 0.8041g
X: 0.0007g   Y: 0.6147g   Z: 0.7950g
X: -0.0331g   Y: 0.5375g   Z: 0.8512g
```

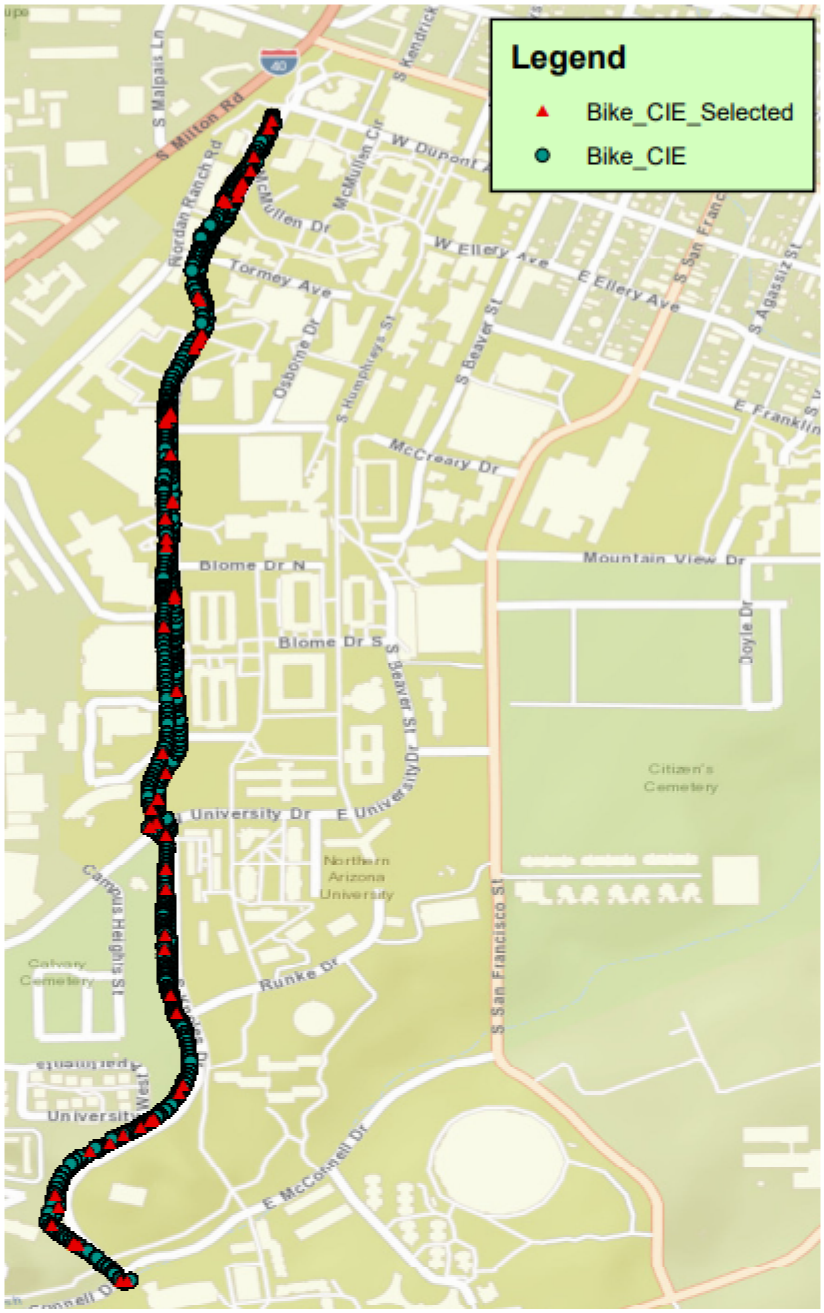
[5] Serial Monitor Accelerometer Result

```
X: -0.0377g   Y: -0.2163g   Z: 1.0188g
X: 0.3831g   Y: -0.1847g   Z: 1.8972g
X: 0.1309g   Y: -0.1223g   Z: 0.9882g
X: -0.0605g   Y: 0.0630g   Z: 0.2761g
X: -0.1115g   Y: -0.0482g   Z: 0.5768g
X: -0.0988g   Y: -0.0341g   Z: 0.9138g
```

[6] SD Card data

```
247336, 35.18051, -111.65797, 2022-3-20-14-6-28
24098, 35.18053, -111.65794,
249118, 0.2079, -0.0036, 1.0611
24919, 0.5253, 0.1165, 0.6201
249171, 0.3340, 0.1545, 0.9736
249193, 0.3169, 0.2475, 1.2019
```

[7] Test from Business building to CIE building



[8] Test from Skyview to Student Union (Next to Chick-fil-A)

[9] Test from Skyview to Student Union (Next to Starbucks)