Instrumented Bike User Manual

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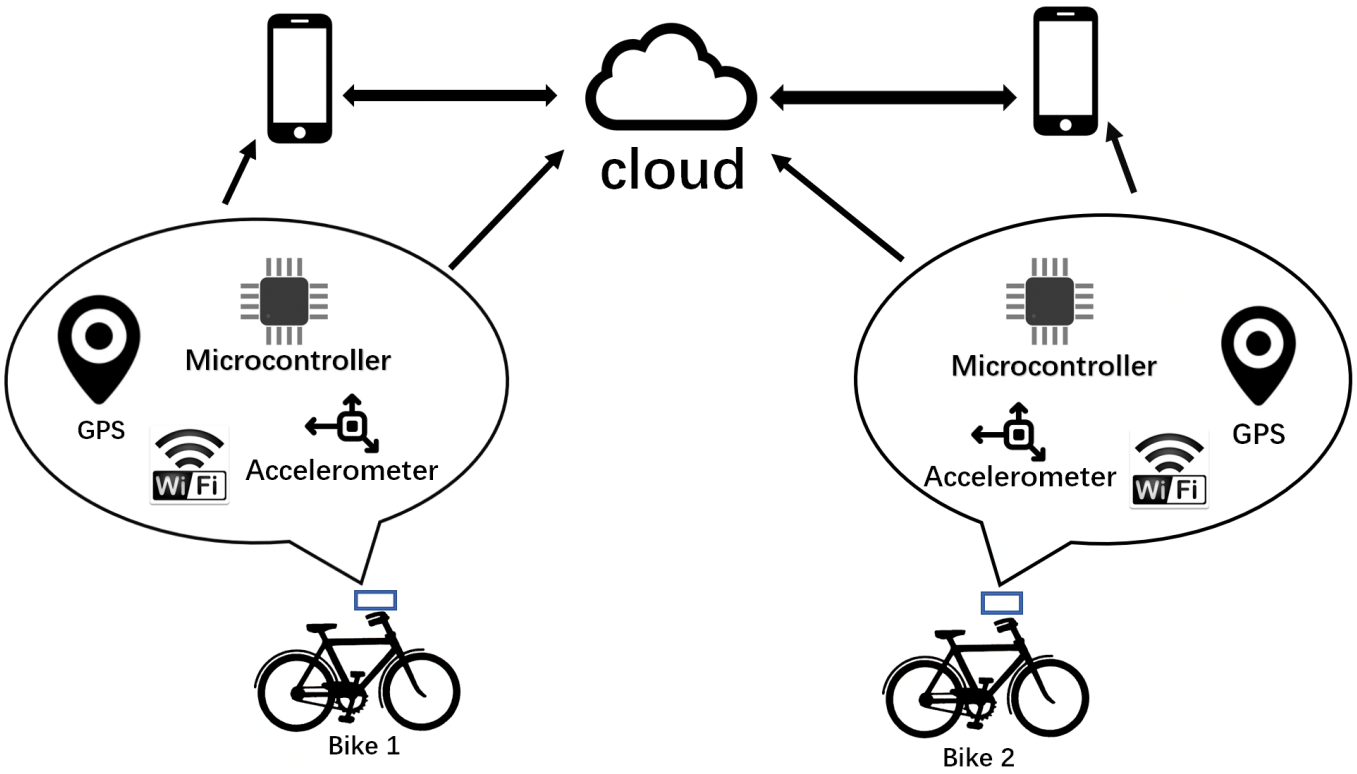
Members: Siwei Wen, Xilun Liu, Yuchang Zhang, Yifei Zhang

Catalogue

Introduction

Welcome to Instrumented bike user manual. If you want to know more about this bike with a set of components please read this user manual. We provide for you here a powerful system for that meet your needs. Instrumented Bikes are a new, innovative field. They are built on the concept that cars use a variety of sensors to gather data about the environment and focus on extending this idea to bicycles in order to analyze and report trail conditions.

Here are some of the key highlights: As transportation and the use of infrastructure increases, it is becoming imperative that the conditions of roadways and trails unreachable by cars are assessed. Utilizing the popularity and prevalence of the Internet of Things in modern society, and this technology provide the network and platform to connect physical devices. By taking various devices like electronics, sensors, and software, Instrumented Bikes communicate and exchange data between users. The information collected from this process is used to analyze and detect bumps in roads as well as assess infrastructural needs. To accomplish this, this technology uses chips, sensors, the cloud, and a mobile platform as depicted in Fig. 1



Installation of the Widget

This section will include the hardware and software operating environment introduction. For example, the operating environment for each processor, like appropriate temperature humidity that each processor requires. And the software development environment.

First of all, all the processor requires work on an appropriate temperature, after we test, a good temperature range is from 10 Celsius to 20 Celsius, especially the GPS processor, the GPS processor must work on a warm environment that can receive the longitude and latitude correctly. Then, to be specific, the accelerometer, the Openlog, and the micro-controller which is Particle Photon and Arduino Nodemcu all requires adding a rock solid 3.3 V voltage. If the voltage above the prescriptive voltage (3.3V) may damage the processors. As for the software operating environment of these processors, all you need is to be familiar with the developing environment of the micro-controller, Particle Photon and Arduino Nodemcu, because all other chips can be monitored by the micro-controller. For the Particle Photon, fortunately, the Particle provide a convenient method for users to access which is Web IDE. As for the Arduino Nodemcu, all you need to prepare is the software called *Arduino IDE*.

Above are the hardware and software environment for the processor, following will introduce the environment requirement of the mobile.

Firstly, you need to prepare an Android-based mobile phone with the operating system above 4.0, which is the requirement of the Android Studio. Otherwise, your mobile app may cannot run correctly. Secondly, you have to make sure your phone has already accessed into the developer mode when you are trying to develop your mobile application.

Configuration and Use

After all the components are installed perfectly on the Instrumented Bike, we can start to learn how to use this device. Because of our Instrumented Bike is a utilization of Internet of Things, you need to learn both how to use the components and how to upload and check the data on the cloud. You can follow the steps to operate the Instrumented Bike.

1. The operation of the device

(1) Please make sure the power switch is open. Then you need to set a complete set of components on the platform **(Keep the platform be horizontal!)** of Instrumented Bike. You need to make sure your device gets good fixation before you start riding.

(2) Please make sure the connection among all the components. There are three parts you need to pay attention. The connection state will be shown on the different light color or flicker frequency.

- Microcontroller (Particle Photon): If the Particle Photon be connected, the light should be cyan. About the other detailed connection states, please look over on the Particle Photon website: https://www.particle.io/products/hardware/photon-wifi
- Openlog: If the Openlog be connected, the light should be blue and twinkle with a regular high frequency. (If the GPS light twinkle only three times, please look over the Q&A)
- GPS: If the GPS be connected, the light should be flicker with the regular frequency. (If the GPS light does not twinkle, it means it does not work, please look over the Q&A)

2. The operation of the Mobile Application

(1) Enter the application. You need to have a user account. (About how to create the account, please look over the operation of the Database part)

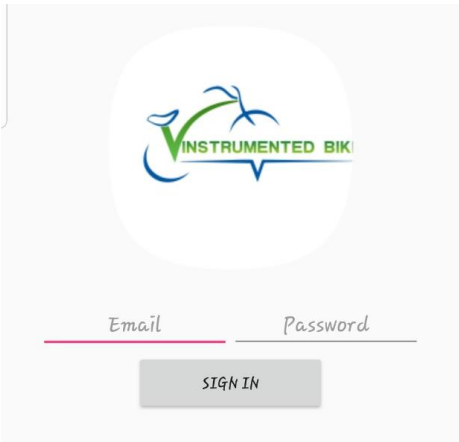


Figure 2. Log in interface

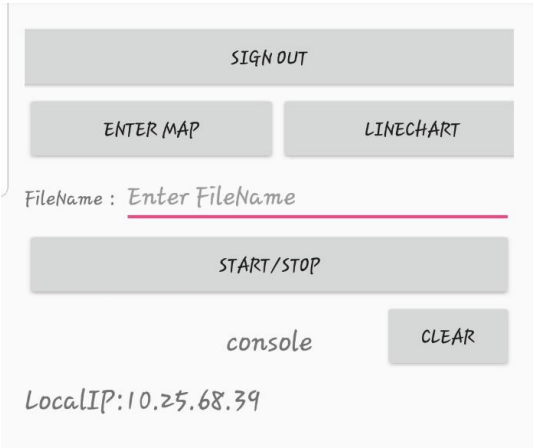


Figure 3. Main Interface

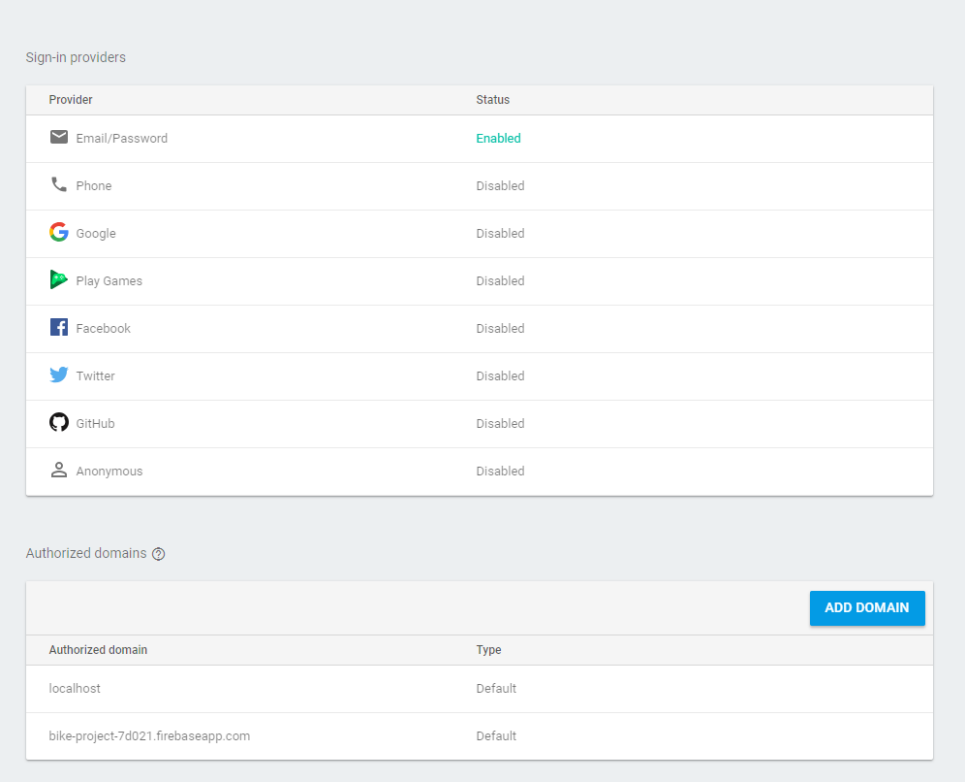
(2) When you enter the main interface, there are two main services are respectively MAPPING and LINECHART. Before you start to run the application, you need to make sure your phone port (Local IP) should be match the particle Photon port. (If they are not match, please look over the Q&A)

(3) Start to run the application to detect the bumps.

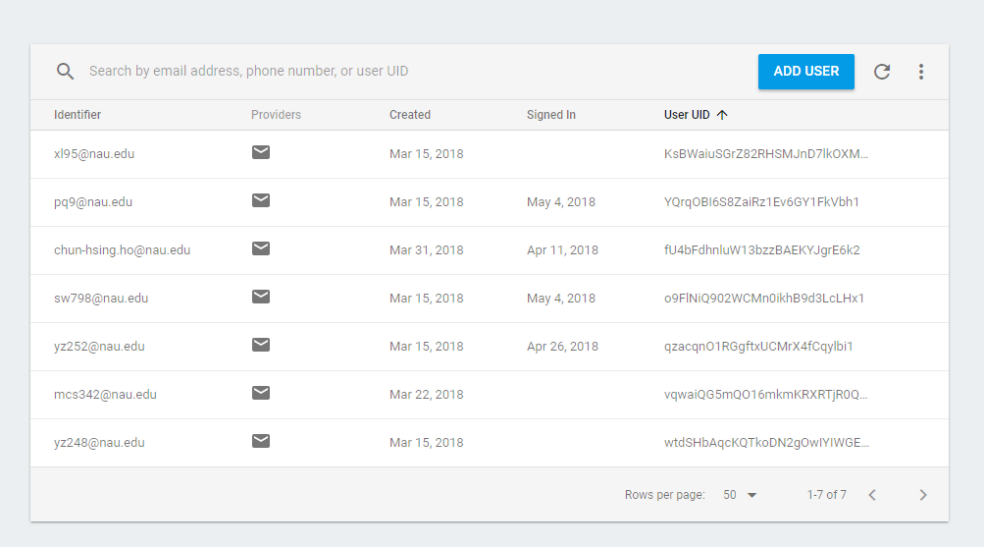
- Clear the data both on the main interface and the linechart!
- Select a filename: you can type in your own filename to make it easy to view. (it will be shown on the map, the linechart on the phone and document on the website)
- Click the start before you ride and click stop after you finish your path.
- When you want to check the data on the phone. Two parts are respectively the mapping and linechart, you can see the specific bumps in the map and the data of accelerometer 1 and 2.

3. The operation of the Database

(1) User Authentication: For the mobile application, we designed the authentication activity to improve the security, which means you only can access to the mobile app by using the user name and password which have been set by the mobile developer in the Firebase database. Besides, the user name could be e-mail address, phone number, Google account and so on. The detail is demonstrated as the following figure:



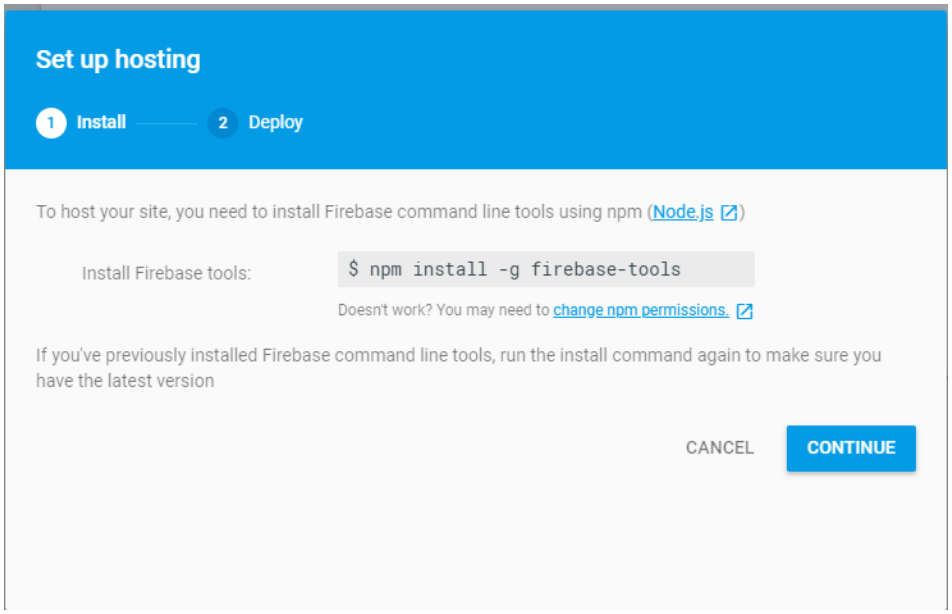
And the figure below shows as the example and the users that already been set:

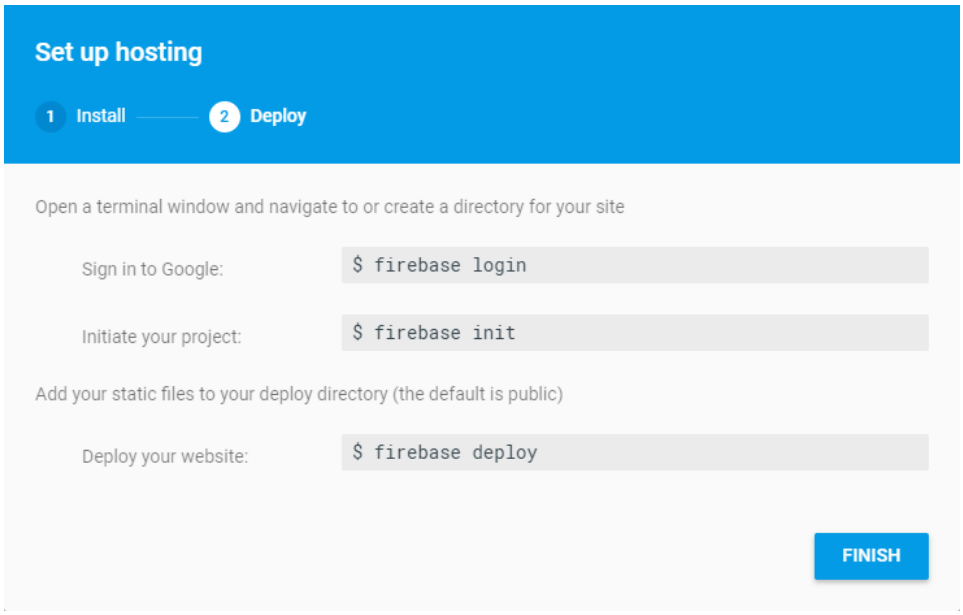


(2) The structure of database: The data structure in the Firebase real-time database is JSON tree. Thus, the developer need to structure the raw data to JSON format. Firstly, for the Arduino Nodemcu (please look

over the code for Arduino Nodemcu on GitHub), specify the data in the form of JSON and the path of destination. Secondly, for the Android Mobile Application, please look over FirebaseMaker activity the Android Code on GitHub.

(3) Web hosting: The web hosting will deploy the website to Firebase Hosting in order to allow other users to get access to this website. The developer will add the environment to computer and use Cmd to do the following steps.





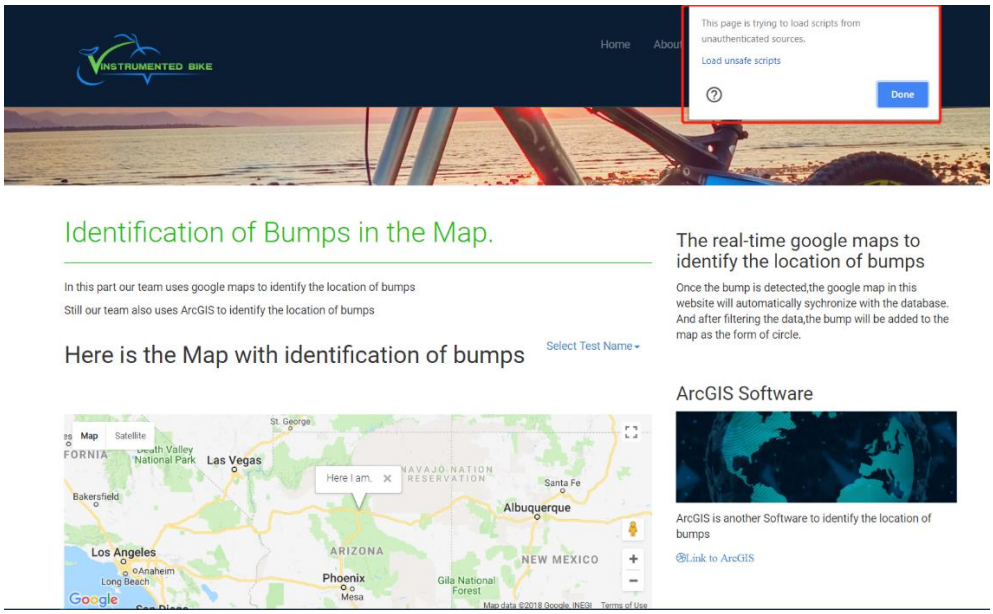
4. The operation of Website

(1) Home: It is the home page of our website which including the big picture, abstract and the important services of Instrumented Bike Project.

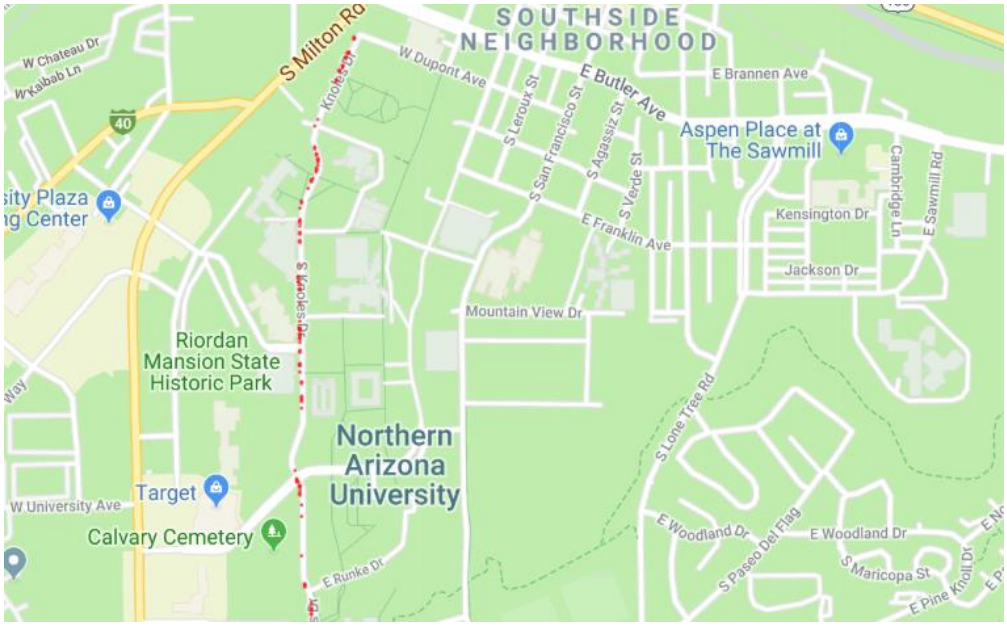
(2) About: It talks about the specific content, goal and the team member information.

(3) Demo: This part is the demonstration of tests including photography of real products, screenshot of mobile application and the data of the test results.

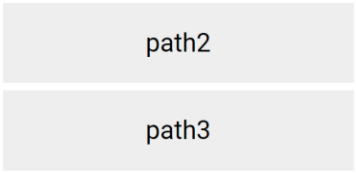
(4) Mapping: You need to load unsafe scripts to make sure the website could load the map.

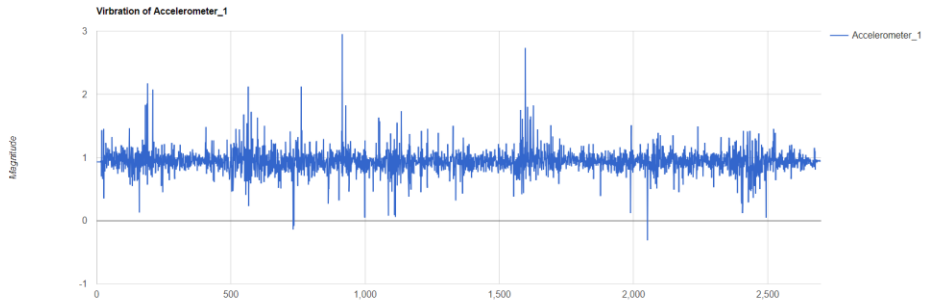


Then You can select the path which you take the test, it can show the bumps on the road.



(5) LineChart: About this part, you can select the file name to show data linechart





Also, you can export the csv file format download it, then you can use the algorithm to process the data.

(6) Contact: If you have more question, you can contact us.

Maintenance

In the hardware design, you need to import the libraries about the GPS processor and accelerometers and code for the Particle Photon through Particle Apps on website or download the Particle Photon IDE. Also, after the components connection, you need to use our mobile application to display the data and thus bring you convenience. Here are links for code and mobile application:

Code for Particle Photon: https://github.com/pq9/Instrumented-bike

Code for Android Studio: https://github.com/pq9/Instrumented-Bike-Android-Mobile-Application-Source-Code

Future Development

Currently, our project focuses on the realization of functionality of detecting bumps with instrumented bike. Nevertheless, there are still many aspects of this project that can be optimized: the mobile application, the data collection model, and the data processing algorithm.

1. Data Collection Model

Currently, in this project, our team developed two methods to collect the data and transmit the data, however, both of them have merits and drawbacks.

The first data collection model deployed Particle Photon as the microprocessor. The data flow of this model is as shown in Fig.1. The merits of this method are that the collected data can be directly transmitted to phone getting the visualization of longitude, latitude, accelerations in the form of text in real-time. Furthermore, the accelerations can be displayed in the Line Chart on application, and the bumps can be shown in the google map. Additionally, the phone is connected to Google Cloud (Firebase) to realize the data sharing between users. The main drawback of this model is that owing to the limitation of memory on the phone, the long-term operation of this application will lead to the reduction of data transmission rates. The second problem is that in this project, TCP/IP is used to realize the wireless transmission. Owing to the principle of TCP/IP protocol that the WiFi transmitter would keep to sending the data until the data is arrived in the destination, the occurrence of any error will cause 1-2 seconds block of the data transmission leading to data loss. The solution to this problem is that we can modified the TCP/IP protocol to UDP protocol since if errors occurred, the UDP protocol will not re-transmit the data. Although the UDP will avoid the blocking of thread, it will also occur some errors.

The second solution is using Arduino Nodemcu microprocessor. Differing from the Particle Photon, the Arduino Nodemcu will directly transmit the collected data to Google Cloud based on http protocol. The merits of this problem are that the microprocessor can directly transmit data to Firebase which means will reduce the loss of information. Still, this method has issues, and the main issue is also the data transmission rate. Owing to the usage limitation of Firebase database, the transmission rate is not able to match to the sampling frequency. The solution to this problem is that developing a back-end server to optimize the capability of the data transmission rates. The further developers can develop a server with database to restore the data. There are two main types of server, the first one is PHP server which is the most prevalent one nowadays. The second one is Java Web Server which is also a very popular server.

2. Data processing Algorithm

The data processing Algorithm should also be background since it has intensive computation. Specifically, in this case, the back-end server is expected. The data processing can be done in the server, which means the mobile application just needs to download the data which is recognized as the bump.

3. Mobile Application

The front-end of this Mobile Application is almost perfect realizing all the functionality of instrumented bike-the clear user interface, the google map with data processing algorithm, real-time line chart, backstage thread, data synchronization to cloud. Still there are some aspects that can be optimized. For instance, the optimization of backstage thread to reduce the usage of memory maximizing the user experience.

Trouble-Shooting

Q1: Why cannot my GPS receive data (Longitude & Latitude)?

A1: First, please confirm if there is a current flow through GPS.

Second, if there is power on GPS, please confirm if there are connection errors.

Third, if everything works well, please confirm temperature can start the GPS because temperature can influence operation of GPS. 10-20 Celsius is the best fit.

Finally, if it still does not work, please check your codes.

Q2: Why does failure of installing of app occur?

A2: First, please make sure your phone's operating system is Android. App does not support IOS system.

Second, if your phone is Android system, please make sure your version is beyond 4.0.

Third, when you are installing, you have to operate it under Developer Mode.

Q3: Why cannot my particle photon work?

A3: First, please make sure your computer has runtime environment. You can download the driver on the particle photon website. Do not forget to install CLI, either.

Second, when you are flashing codes, you should keep the Wi-Fi connected. You must connect the Wi-Fi through the command line.

Third, please your code is right.

Q4: Why cannot my app work?

A4: First, please make sure your Android version is beyond 4.0.

Second, your phone needs to open hot-spot instead of connecting a Wi-Fi.

Third, before you run the app, you should give it a name.

Q5: Why cannot I access Instrumented Bike website?

A5: When you are accessing our website, your browser will notice there are some unsafe factor. You need to allow the website to run in the upper right-hand corner.

Q6: Why cannot I have a connection with Database.

A6: First, when you are uploading codes, you might connect the wrong database or your database has already deleted.

Second, please keep your authority on the public mode or user mode. You can modify it on the database website.

Q7: Why cannot my Openlog work?

A7: First, please try to format the SD card, and try again.

Second, the flash light will show you what the problem is. Please see the spark fun Openlog website.

Q8: Why is the data I collect from the SD card out of format?

A8: Please check your baud frequency if it fits in your set.

Q9: Why does my app crash?

A9: The only reason that would make it crash is the data format. You should change the format in particle IDE.

Q10: If port or IP address of my phone and particle photon is not march, what should I do?

A10: You should keep the port as the same. If your phone's port is 111, your particle port must be 111. IP address is the same.

Q11: Why does my app not show the location of mine?

A11: First, you should open you GPS positioning function on the phone.

Second, you should give the permission to the memory to store.

Q12: How to the registration of application programming interface (API)?

A12: 1. The Google map API is registered in the new google project.

2. The Firebase API is added to the android application in the Android IDE-Android Studio.

3. The Firebase API for Arduino Nodemcu is used by the library Arduino-Firebase.

Q13: How to get Authentication in Google Cloud?

A13: Using the Authentication in the Firebase to assign specific user name and password to each user.

Q15: If problems come to website hosting, what should I do?

A15: Please look over the Firebase Section about the using of anthentication.

Status of Planned Features (WBS)

Person Primarily Responsible: Xilun Liu				
ID	Activity/Task	Description	Deliverable(s)	Other People
1	Prototype			
1.1	Research	Accelerometer parameter	• Components Selection • Big Picture • Circuit Design	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang
1.2	Purchase Components		• Identify parts • Place order • Receive parts	Place order with Dr. ho and Mentor Kyle
1.3	Circuit Connect		• Power on • Parts works	
1.4	Code Testing	Build and Test		
1.4.1	GPS		• Received data • Format data	
1.4.2	Accelerometer	Make sure that data can be displayed on the particle photon.	• Received accelerated velocity • Format data	
1.4.3	Openlog		• Write data • Read data	
1.4.4	Wireless Communication		• Transmit data over air • Set up server and client	
2	Development			
2.1	Features & Specifications	Reminding people when in a specific vicinity	• Communication between bikes • Show locations	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang
2.2	Mobile App			

2.2.1	TCP/IP		• Achieve networking • Transmit data	
2.2.2	Inserted Map	Coding to get Google map	• Show map in the app	
2.2.3	Data Interchange	Achieve reading and writing	• Data sharing • Data storage • Data reading	Siwei Wen Yifei Zhang
2.2.4	Reminder	Coding to setup a specific bound to alert	• Setup notification and alert others	Siwei Wen Yifei Zhang
2.2.5	App Testing	Making the points can be displayed on the map.	• Received and display accurately • Add markers on the map	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang
2.3	Geographic Information System(GIS)	Mark locations		
2.3.1	Data Format	Find a format ArcGIS can read	• Text format to Excel format	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang
2.3.2	ArcGIS	App used to give a platform		Siwei Wen
2.3.2.1	Data Processing	Identify the bumps and holes by filtering	• Window interpolation algorithm	Peijie Qiu
2.3.2.2	Data Imported		• Import latitude & longitude	
2.3.2.3	Data Visualization	Getting a specific latitude and longitude on the map	• Add all the points on the map • Mark the bumps	Siwei Wen
2.4	Website	Line chart and map can easily on the website for	• Introduction and documentation	

		anyone use Android and IOS	• Insert the google map to identify bumps Download and display the raw data	
2.4.1	Interfaces		• Line chart • Mapping • Documentation • Project introduction	
2.4.2	Web hosting		• Hosting the website to sever	
3	Testing on the Road			
3.1	Hardware Testing	Test		
3.1.1	Installation	Make it tight enough	• Fix on the bike	Yuchang Zhang
3.1.2	Debug	Make sure the vibration will not affect normal operation	• Successfully receive the data • Work reliably	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang
3.2	Software Testing	Test		
3.2.1	Debug		• Notify others	Siwei Wen Peijie Qiu Yuchang Zhang Yifei Zhang

Work Breakdown Structure Summary:

Our project has already completed 100%. In this project, I am mainly responsible for the coding for particle photon, data processing and preliminary test.

The connection of components is not complicated, but we still need to figure out the variable of components and setup the right frequency of reading and writing data. After the components connections, the particle photon, as a microcontroller, can be programmed to control the accelerometer and GPS processor. The

task includes three steps: 1. Find the suitable library for each component and import it into particle photon IDE. 2. Coding for making sure that we can receive the data. 3. Coding for making sure the Particle Photon can connect to phone and information can be displayed on the mobile application through WIFI. TCP/IP protocol is used in this connection between the Particle photon and mobile application.

In addition to coding for Particle Photon, I am involved in the data processing. I tried several methods including FFT and moving average on Matlab. And after the test of these method, I combined two methods and create a new method called window interpolation algorithm. It can perfectly filter the bumps and holes in our map.

Finally, I am involved in the design of preliminary test. We use the pipelines as bumps to testify the accuracy of our data and data processing. I try the preliminary test several times and find the threshold to make our algorithm that filters the bumps and holes more precise.

The one big challenge in this project is that hardware sometimes is not stable and we did a lot research on which component can work well. Another one is that we are not familiar with IDE for Particle Photon and some library is not compatible for this type of Particle Photon. The biggest challenge of this project is that if we want to provide the users have more comfortable experience we need to develop a mobile application to display our data and points on the map. The coding for mobile application require us to have a deep understanding of java and frame of design.

Person Primarily Responsible: Yuchang Zhang				
ID	Activity/Task	Description	Deliverable(s)	Other People
1	Prototype			
1.1	Research	Research the functions of micro SD card of openlog	• Components Selection • Big Picture • Circuit Design	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu
1.2	Purchase Components	Bought two batteries.	• Identify parts • Place order • Receive parts	Place order with Dr. Ho and Dr. Winfree

1.3	Circuit Connect		• Power on • Parts works	
1.4	Code Testing	Build and test		
1.4.1	GPS	Achieve the functions of GPS, which means device can receive longitude and latitude successfully.	• Received data • Format data	
1.4.2	Accelerometer		• Received accelerated velocity • Format data	
1.4.3	Openlog		• Write data • Read data	
1.4.4	Wireless Communication		• Transmit data over air • Set up server and client	
2	Development			
2.1	Features & Specifications	Using real-time Firebase to store data from chips	• Communication between bikes • Show locations	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu
2.2	Mobile App	Build and test		
2.2.1	TCP/IP	Set up the correct port number and IP address, using hot spot to connect the Particle Photon and phones and make sure these data can show under the proper format	• Achieve networking • Transmit data	Peijie Qiu
2.2.2	Inserted Map	Choose Google Map API, and inserted into app.	• Show map in the app	Peijie Qiu

2.2.3	Data Interchange		• Data sharing • Data storage • Data reading	
2.2.4	Reminder		• Set up notification to alert others	
2.2.5	App Testing	Testing the functions of Google Map, make sure it can show the correct location	• Received and display accurately • Add markers on the map	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu
2.3	Geographic Information System(GIS)	Mark locations		
2.3.1	Data Format	Make sure the receiver can use the correct format while using these date	• Text format to Excel format	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu
2.3.2	ArcGIS	Provide a platform		
2.3.2.1	Data Processing		• Window interpolation algorithm	
2.3.2.2	Data Imported	Processing data from contributes and make sure latitude and longitude can be inserted into map successfully	• Import latitude & longitude	Yifei Zhang
2.3.2.3	Data Visualization		• Add all the points on the map • Mark the bumps	
2.4	Website		• Introduction and documentation • Insert the google map to	

			identity bumps ● Download an display the raw data	
2.4.1	Interfaces		● Line chart ● Mapping ● Documentation ● Project introduction	
2.4.2	Web hosting	Web hosting	● Hosting the website to sever	
3	Testing on the Road			
3.1	Hardware Testing	Test the functions of hardware		
3.1.1	Installation	Provide bike	● Fix on the bike	Xilun Liu
3.1.2	Debug	Have a ride on the road to test if the hardware works well	● Successfully receive the data ● Work reliably	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu
3.2	Software Testing	Test the functions of software		
3.2.1	Debug	Use phone to remind other bikers while using it to test if the alert function of app can work well	● Notify others	Yifei Zhang Siwei Wen Xilun Liu Peijie Qiu

Work Breakdown Structure Summary:

This is my Work Breakdown Structure of this whole project during this whole year and our project is 100% finished. Following is details. At the beginning, we briefly divide into three parts, Prototype, Development, and Testing on the Road.

Firstly, for the Prototype, at the very beginning, each member of our group did lots of research according to

the requirement of the project. My section is to make sure I am fully understood the functions of microSD card of the Open log processor. After that, I am focus on the code testing of GPS processor for the prototype. I spent almost two weeks to develop and study the function and code of the GPS, which means make sure the GPS had to record the location information correctly like received the longitude and latitude. The purpose of we use the GPS processor is that once the system detects there are some bumps and holes on the road, GPS had to get the right location information of these bumps, then we can alert neighboring bikers through our Android-based mobile app. In short, that is what I did for the prototype section. For the second part, Development, the first job of mine is study and establish the structure of the connection between the system and the Cloud which is real-time Google Firebase. After that, our group tried our best to develop the mobile app by ourselves. During the mobile app developing period, I mainly in charge of: (i) make sure the app can receive data from micro-controller through TCP/IP protocol. (ii) App testing, to test the functions of Google Map, make sure it can show the locations of all bumps correctly. (iii) Data Format, which means to rearrange the format of data to become the format that what we want, like the order of each data from each processor. Further, after we basically finish the mobile app, we continue to focus on the road test which we spent almost a while month to make sure all the functions and components are work effectively. On the section of Testing, I mainly did following things: (i) Hardware testing, to be specific, installed the back platform which used to hold a box with all the processor in it, and make sure the circuit connection is stable enough. (ii) Software testing, which means test the whole functions of our mobile app.

For me, the most challenge part is established the connection between the phone and micro-controller, it is a part of the mobile development, the reason why I think it is the most difficult is we all did not have any experience of mobile developing, to be specific, the working mechanism of the micro-controller, which is Particle Photon, is hard to understand.

Person Primarily Responsible: Peijie Qiu				
ID	Activity/Task	Description	Deliverable(s)	Other People
1	Prototype			
1.1	Research	Research the function and implementation of particle photon which is the control unit	• Components Selection • Big Picture • Circuit Design	Yuchang Zhang, Xilun Liu, Siwei Wen, Yifei Zhang

1.2	Purchase Components		• Identify parts • Place order • Receive parts	Place order with Dr.Ho and Dr.Winfree
1.3	Circuit Connect	Collect all the components with wires and resistors and make sure the perfect work of each component	• Power on • Parts works	
1.4	Code Testing	Build and Test		
1.4.1	GPS		• Received data • Format data	
1.4.2	Accelerometer		• Received accelerated velocity • Format data	
1.4.3	Openlog		• Write data • Read data	
1.4.4	Wireless Communication	Setup the photon as server and then write specific codeword to set IP and PORT, ensuring the transmission success	• Transmit data over air • Set up server and client	Siwei Wen
2	Development			
2.1	Features & Specifications	Use TCP/IP protocol to transmit data to phone and data visualization in the google maps	• Communication between bikes • Show locations	Yifei Zhang, Yuchang Zhang, Siwei Wen, Xilun Liu
2.2	Mobile App	Build and Test		
2.2.1	TCP/IP	Writing codeword to setup specific Port and IP address which is match to the IP address in the photon. Then using TCP socket to allot a thread to each connection	• Achieve networking • Transmit data	Yuchang Zhang

2.2.2	Inserted Map	• Add my location button to identify my current location • Add makers in the maps	• Show map in the app	Yuchang Zhang
2.2.3	Data Interchange		• Data sharing • Data storage • Data reading	
2.2.4	Reminder		• Set up notification to alert others	
2.2.5	App Testing	• Testing the TCP/IP protocol to receive the data from the photon • Make sure the precise display of new makers	• Received and display accurately • Add markers on the map	Yifei Zhang, Yuchang Zhang, Xilun Liu, Siwei Wen
2.3	Geographic Information System(GIS)	Make locations		
2.3.1	Data Format	Setup the data format to match the requirement of ArcGIS software	• Text format to Excel format	Yifei Zhang, Xilun Liu, Siwei Wen, Yuchang Zhang
2.3.2	ArcGIS	Provide a platform		
2.3.2.1	Data Processing	Using Fast Fourier Transform to process the z-axis data form the accelerometer in order to easily distinguish the bumps among the whole data. Creating a new algorithm which is called window interpolation algorithm to identify the bump.	• FFT in MATLAB • Insert the window interpolation algorithm to Android mobile application.	
2.3.2.2	Data Imported		• Import latitude & longitude	
2.3.2.3	Data Visualization		• Add all the points on	

			the map • Mark the bumps	
2.4	Website	• Introduction and documentation • Insert the google map to identify bumps • Download and display the raw data		
2.4.1	Interfaces	•	• Line chart • Mapping • Documentation • Project introduction	
2.4.2	Web hosting	• Make sure users can get access to this website over Internet.	Hosting the website to sever	
3	Testing on the Road			
3.1	Hardware Testing	Test the function of hardware		
3.1.1	Installation		• Fix on the bike	
3.1.2	Debug	Check the data and take the photos of bumps and our testing	• Successfully receive the data • Work reliably	Yifei Zhang, Yuchang Zhang, Siwei Wen, Xilun Liu
3.2	Software Testing	Test the function of software		
3.2.1	Debug	Debug the app if there were some problems	• Notify others	Yifei Zhang, Yuchang Zhang, Siwei Wen, Xilun Liu

Work Breakdown Structure Summary:

First above all, our project is perfectly completed and I also have 100% completed my tasks in my work breakdown structure (WBS). Our whole project is divided to 3 main parts-Prototype, development, and test. Firstly, I researched numerous previous works to come up a big-picture of this project. And specifically, I also researched the main components used in this project: microprocessor, triple axis accelerometer and Global Positioning System (GPS) processor. Subsequently, I built the circuit connecting all the components and guaranteed that all the components function well. Additionally, I wrote the code of our microprocessor to read the data from accelerometers and GPS processor. Then I wrote the code of wireless data transmission form the microprocessor to the mobile phone with Siwei Wen. For the development part, I built the mobile application with Yuchang Zhang and did the data processing part. For the mobile application, I mainly built the TCP/IP protocol to enable the wireless communication with microprocessor and inserted google map to this application to get the visualization of bumps. In order to achieve better user experience, I developed the backstage thread to handle the time-consuming activities in this application, as well as user interfaces to guide users. Finally, I developed an algorithm to process the raw data in order to accurately identify bumps. Additionally, this data processing method are inserted into mobile application to process the data in real-time. For website part, I hosted the website to Google cloud (Firebase) to display the data, download the data, and identify the bump in google map. For the testing part, I debugged the software and revised the mobile application and website.

Challenges:

1. One challenge in my part is the wireless data transmission between microprocessor and mobile application.
2. The development of the mobile application, specifically, user interfaces, data interchanging, and the utilization backstage thread.
3. The data processing part is also a big problem. Since, it is difficult to find a proper way to identify the bump. Thus, a new method is created based on previous researches.

Person Primarily Responsible: Siwei Wen				
ID	Activity/Task	Description	Deliverable(s)	Other People
1	Prototype			
1.1	Research	Research the GPS part	• Components Selection • Big Picture	Xilun Liu Yuchang Zhang

			• Circuit Design	Yifei Zhang Peijie Qiu
1.2	Purchase Components		• Identify parts • Place order • Receive parts	Place order with Client Ho and Professor Kyle. Winfree
1.3	Circuit Connect		• Power on • Parts works	
1.4	Code Testing	Build and Test		
1.4.1	GPS		• Received data • Format data	
1.4.2	Accelerometer		• Received accelerated velocity • Format data	
1.4.3	Openlog		• Write data • Read data	
1.4.4	Wireless Communication	Upload the data and transmit to other bikes	• Transmit data over air • Set up server and client	Peijie Qiu
2	Development			
2.1	Features & Specifications	Mark the points on the map automatically by ArcGis software	• Communication between bikes • Show locations	Xilun Liu Yuchang Zhang Yifei Zhang Peijie Qiu
2.2	Mobile App	Build and Test		
2.2.1	TCP/IP		• Achieve networking • Transmit data	
2.2.2	Inserted Map		• Show map in the app	
2.2.3	Data Interchange	Program the “read” and “write” parts code	• Data sharing • Data storage	Xilun Liu Yifei Zhang

			• Data reading	
2.2.4	Reminder	Program the monitor to sperate the latitude and longitude	• Setup the notification to alert others	Xilun Liu Yifei Zhang
2.2.5	App Testing	Test the app can upload and download the data from the firebase	• Received and display accurately • Add markers on the map	Xilun Liu Yuchang Zhang Peijie Qiu Yifei Zhang
2.3	Geographic Information System(GIS)	Mark the location		
2.3.1	Data Format	Find a specialized format for ArcGis	• Text format to Excel format	Xilun Liu Yuchang Zhang Peijie Qiu Yifei Zhang
2.3.2	ArcGIS	Provide a platform		
2.3.2.1	Data Processing		• Window Interpolation Algorithm	
2.3.2.2	Data Imported		• Import latitude & longitude	
2.3.2.3	Data Visualization	To mark the bump points different with the other points	• Add all the points on the map • Mark the bumps	Xilun Liu
2.4	Website		•	
2.4.1	Interfaces	To make sure people can get our data intuitively Insert all the function into the website	• Mapping • Linechart • Documentation • Project introduction	
2.4.2	Web hosting	Make sure users can get access to this website over Internet.	• Hosting the website to sever	

3.1.1	Installation		Fix on the bikes	
3.1.2	Debug	Record the data from two bikes	● Successfully receive the data Work reliably	Xilun Liu Yuchang Zhang Peijie Qiu Yifei Zhang
3.2	Software Testing	Test the function of software	●	
3.2.1	Debug	Inspect the code part if there are some problems	● Notify others	Xilun Liu Yuchang Zhang Peijie Qiu Yifei Zhang

Work Breakdown Structure Summary:

About our project, I finished all the part of my breakdown structure. Our Instrumented Bike project is divided into three parts are respectively Prototype, Development and Test. At first, we separated the prototype to five subsystems and I did the research about the GPS. We use a specific GPS chip to make sure we can get the accurate longitude and latitude. In addition, I did the wireless communication with Peijie Qiu. The most important of this part is the TCP/IP protocol. We programmed the microcontroller to connect the Google cloud and realize the transmission of real-time data.

Secondly, I have done three key points are GIS, mobile application and the website. About the GIS, since the goal of this project is filtering barriers on roads and detecting bumpy pavements, we need to analysis and choose points that may form obstacles for bikes on maps. The ArcGIS software can provide powerful functions on points choose and visualizations. I used it to do the most work about formatting and processing the data. About the mobile application, it is a significant part and all teammates worked on together. It has four main parts are Data Transmission, Dara Interchange, Reminder and Application Test. I mainly worked on the data interchange and reminder. The difficulty of this part is the code. No matter the “read” and “write” code or the code of the monitor, it is a new challenge field for us. I learned a lot of the code about the Android development to finish this part. About the website, I mainly worked on the interface of our website. This website is about our Instrumented Bike including our Project Introduction, Documentation, Mapping and Linechart. Resembling the mobile application,

the line chart, Google Maps, and data processing algorithm are all inserted into the website. It just enables the same functions to be used just on a different platform.

Thirdly, we tested our instrumented bike on the three paths in NAU. This part I recorded the data of two bikes and test our mobile application. I did the test to make sure our device could transmit data successfully and our mobile application could achieve the regular function.

In the whole year of our project, the most challenge part I think is the Mobile Application. Because we are not the student of Computer Science, although we learn some of the JAVA, C and the VHDL, Android platform is still a new challenge field for us. About this part, our group spent around one to two weeks to research the code and refer other applications' interface or functional code, finally, we developed a preliminary application. After that, during the rest of the part including the preliminary test and the road test, we kept improving our application like adding the threshold to make the bumps detection more accurate. Furthermore, the road test is also a challenge. This part is not so difficult but it took much time and we found massive problems and we had to fix them. For example, some problems like the waterproof of the device would be revealed only when we ride the bike went through the bumps in a rainy day. However, we overcome all these challenges and finish the whole project fortunately.

Person Primarily Responsible: Yifei Zhang				
ID	Activity/Task	Description	Deliverable(s)	Other People
1	Prototype			
1.1	Research	Research battery and battery babysitter which will provide the power with the whole system.	● Components Selection ● Big Picture ● Circuit Design	Peijie Qiu, Xilun Liu, Siwei Wen, Yuchang Zhang
1.2	Purchase Components	Prepare the materials for needed components to have a backup.	● Identify parts ● Place order ● Receive parts	Place order with Dr. Ho and Dr. Winfree.
1.3	Circuit Connect		● Power on ● Parts works	

1.4	Code Testing	Build and test		
1.4.1	GPS		• Received data • Format data	
1.4.2	Accelerometer		• Received accelerated velocity • Format data	
1.4.3	Open log	Achieve writing and reading functions of data, and store the data in the open log.	• Write data • Read data	
1.4.4	Wireless Communication		• Transmit data over air • Set up server and client	
2	Development			
2.1	Features & Specifications	Contribute the idea for utilizing the Android Studio.	• Communication between bikes • Show locations	Peijie Qiu, Xilun Liu, Siwei Wen, Yuchang Zhang
2.2	Mobile App	Build and test		
2.2.1	TCP/IP		• Achieve networking • Transmit data	
2.2.2	Inserted Map		• Show map in the app	
2.2.3	Data Interchange	Collect the data to transmit.	• Data sharing • Data storage • Data reading	Siwei Wen, Xilun Liu
2.2.4	Reminder	Test the codes make sure there will be a sound from the reminder.	• Set up notification to alert others	Siwei Wen, Xilun Liu
2.2.5	App Testing	Test the reminder function to see if it works.	• Received and display accurately • Add markers on the map	Peijie Qiu, Xilun Liu, Siwei Wen,

				Yuchang Zhang
2.3	Geographic Information System(GIS)	Mark locations		
2.3.1	Data Format	Contribute the data.	• Text format to Excel format	Peijie Qiu, Xilun Liu, Siwei Wen, Yuchang Zhang
2.3.2	ArcGIS	Provide a platform		
2.3.2.1	Data Processing		• Window interpolation algorithm	
2.3.2.2	Data Imported	Contribute data about latitude and longitude.	• Import latitude & longitude	Yuchang Zhang
2.3.2.3	Data Visualization		• Add all the points on the map • Mark the bumps	
2.4	Website		• Introduction and documentation • Insert the google map to identify bumps • Download and display the raw data	
2.4.1	Interfaces		• Line chart • Mapping • Documentation • Project introduction	
2.4.2	Web hosting		• Hosting the website to sever	
3	Testing on the Road			
3.1	Hardware Testing	Test the functions of hardware		

3.1.1	Installation		● Fix on the bike	
3.1.2	Debug	Have a ride on the road to test if the hardware works well.	● Successfully receive the data ● Work reliably	Peijie Qiu, Xilun Liu, Siwei Wen, Yuchang Zhang
3.2	Software Testing	Test the functions of software		
3.2.1	Debug	Use phone to see if we can receive the information and messages from other phones.	● Notify others	Peijie Qiu, Xilun Liu, Siwei Wen, Yuchang Zhang

Work Breakdown Structure Summary:

I had 100% finished my mission in this project. Our team divided the entire project into 3 parts. The first one is prototype, the second one is development, and the third one is testing on the road.

For prototype part, my major job is figuring out how the openlog worked. Openlog as a stored component needs to store the information that our team collected. Therefore, I need to study how to write and read data from it, and achieve the function of outside interchange eventually. What is more, research and components are two significant portions, too. During the research, I did the power supply part to find one battery which is much fittest for our project. I also placed the order about components with Dr. Winfree and Dr. Ho.

For development part, I got the idea that using the Android Studio to develop our mobile app. When we were working on the mobile app, Xilun, Siwei, and I were in charge of the functions of data interchange and reminder. Our team together did the app test. In the data interchange portion, I provided the data to transmit to see if it can work. In the reminder portion, I need to give it a voice. When we need it to make a sound, it has to make a sound. App testing is an important job because we need to see whether this app can really work. I did the reminder part, so the reminder test is a job for me. Geographic Information System(GIS) is also a big part for development. We separated it into two portions. First is data format, and second is ArcGIS that is a tool for marking points on the map. Our team did the data format together, and I contributed the data. In the ArcGIS tool, Yuchang and I imported the data. I contributed the data about longitude and latitude.

For the testing on the road, we all did it together. We split it into two which are hardware and software. For hardware, I had a ride on the road to see if the components would fall apart. For software, I use the phone to see

if we can receive the information from other phones.

I thought openlog part was the most difficult part for me because I am struggling with coding even now. However, I had to study the code to help my team solve one tiny problem.

Conclusion

First of all, we really appreciate our client, Dr Chun-Hsing Ho, give us the opportunity to involve in this interesting project *Instrumented Bike*. The idea of this project is come from the advance smart vehicle, which can detect the road condition very well, but the smart vehicle also has some drawbacks, one of the most significant points is that the vehicle cannot access anywhere. Accordingly, our instrumented bike aims to detect the bumps on the road and use the GPS to record the location information of these bumps, further, to alert the neighboring bikers through our mobile app. Also, we can generate a road condition report and deliver it to the department which in charge of the road maintenance.

To sum up, after all the members struggled for these two semesters, our project has been 100% finished this April. Every member of our group all gained a lot from this project, to be specific, we have learned lots of technologies like the web designing, Android mobile app development and so on. In the future, we will continuous pay close attention to the relate instrumented bike field and try our best to contribute. Finally, with best wishes from *Instrumented Bike member* product developer: Peijie Qiu (pq9@nau.edu), Xilun Liu (xl95@nau.edu), Siwei Wen (sw798@nau.edu), Yuchang Zhang (yz252@nau.edu), Yifei Zhang (yz248@nau.edu). While we are all moving on to professional careers, we would be happy to answer short questions in the coming months to help you get the product deployed and operating optimally in your organization.