Trailblazer Final Report

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Abstract

For our project, we tasked ourselves with designing a bike modification kit that would allow a cyclist to modify their bike in order to be able to charge their mobile devices using the kinetic energy generated by riding the bicycle along with a mobile application to accompany it. Due to the transition to remote learning, we had to scale back on our idea and focus exclusively on the software component of the project. While all of our progress on the hardware end was made null and void, we were able to significantly model out and complete the software portion as the only task that remained with the software was fully linking the frontend to the backend. While we can't prove the viability of the kit due to a lack of hardware results, we were able to provide an invaluable software aide through our mobile application.

Introduction/Background Research

This topic was inspired by many bicyclists who need to train in an outside environment. One of the most common problems they experience is monitoring themselves whilst also keeping their electronics charged. It's important for athletes to keep track of how well they're performing on a route in order to keep pace. But many phones are held on the handlebars and drained immensely as the apps are used over the course of long distances. Thus, we decided to minimize that problem by allowing the pedaling itself to charge the phone in an efficient manner. Previous selling bicycle chargers suffered from high resistance to users, such to a point that getting from point A to point B became harder than it should have been. Therefore, we decided to negate the mechanical cranking aspect and simply allow users to pedal as they are, so we can regulate the different voltages from the battery pack or the pedaling directly as needed.

Generally speaking, a phone's internal temperature can reach up to 43 degrees Celsius. Any type of charging will bring a phone's temperature up, be it wireless or wired. Sometimes, a phone can automatically detect irregular temperatures and will stop charging. But the best case possible would be if the charging dock or wired cable has a smart sensor that detects overheating. Our idea would be to use a wireless charging device that implements smart sensors to prevent overheating as well as using the built in phone sensor, especially if we have varying degrees of input from users' pedaling which can lead to various issues.

Problem Statement

A current issue with competitive biking is the training aspect. Many bikers do not rely on contemporary training methods such as an in-home bike, since it does not supply a realistic training regimen as one would get with biking outside. Our product provides a bicyclist with the opportunity to keep their outside regimen whilst simultaneously allowing them to monitor and track their pace. The application would track their route as well as adjust their pace for any changes the user makes. All the while, our system allows for the bike to charge their phone by simply pedaling as normal. One of the main reasons our invention stands out is because other bicycle chargers do not provide consistent power output for mobile devices to intake. With the way we designed our power charging system, we will have an internal battery bank that is part of the bike that acts as a buffer. If the cyclist is pedaling at a consistent rate, then it will be able to charge the phone directly. However, if the cyclist is either pedaling too fast and producing too much power or is not pedaling fast enough to charge the phone, then the generated electricity will go into the battery bank and charge from the stored power.

User Survey/Specifications

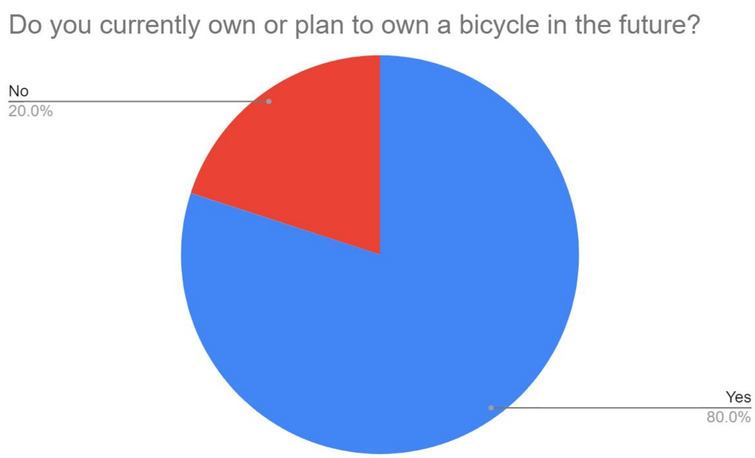
Hardware:

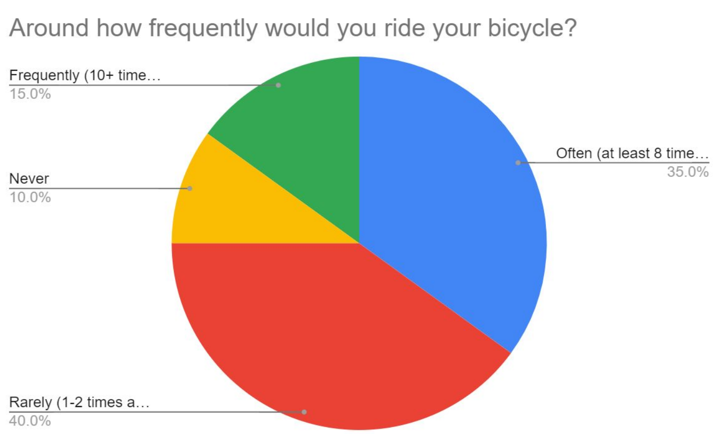
- Wireless Charging Mounting System for Phones
- Generator Placed Around the Bike's Back Wheel
- Balanced Weight for Ease of Use

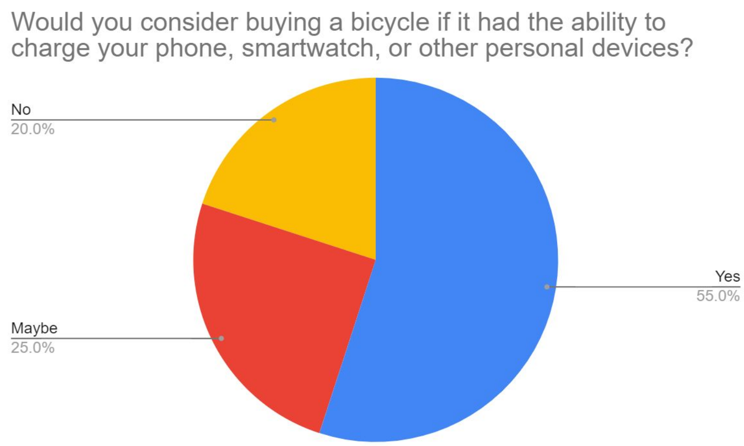
Software:

- Display Exercise Stats
- Route Tracking
- Power Output Display

Survey Results:

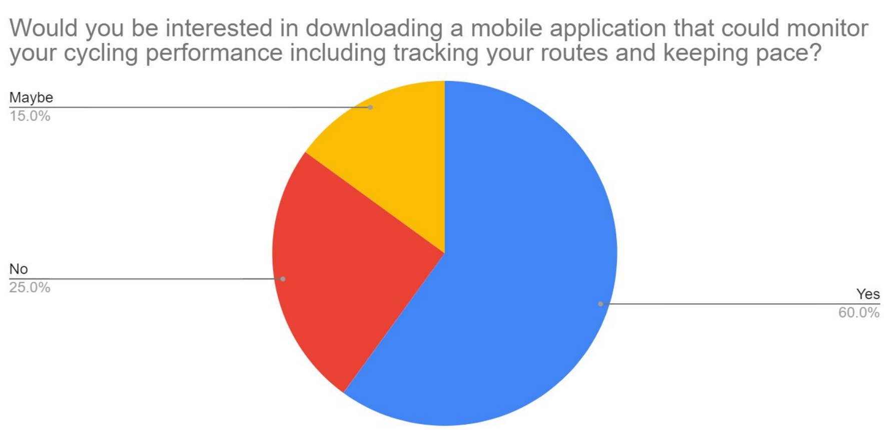






Are there any additional features you would like that would make you consider buying a bike?

Water proof
Bluetooth speakers
flying bike
Exercise stats
Show some kind of power output/easy mounting system for phones
Self cycling
Suspension and a good gear selector



Technical Specifications

Hardware:

- Weight of bicycle must be < 20 lbs and centered
- Generator must produce 12V DC output
- PowerBank intakes 12V DC
- PowerBank will output 9V DC
- Phone Dock inputs 5V-9V DC (allowing for pedaling variance)
- Phone Dock outputs 5W-10W

Software:

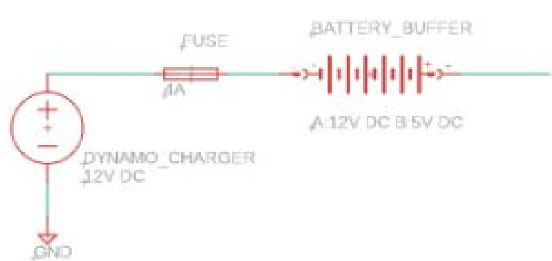
- Native Application
- Database created and stored locally
- Simple Calculation to improve pacing as specified by user
    - Comparing user’s current position to projected position based of improved pacing request
- State Machine to switch between different screens
- Comparing distance/time combination to national biking average when connected to internet and requested

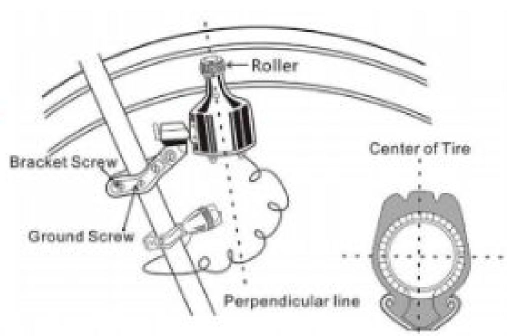
Design Development

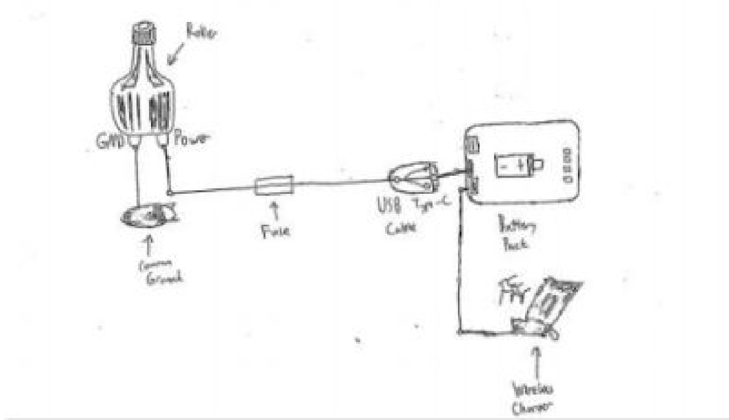
Hardware Design:

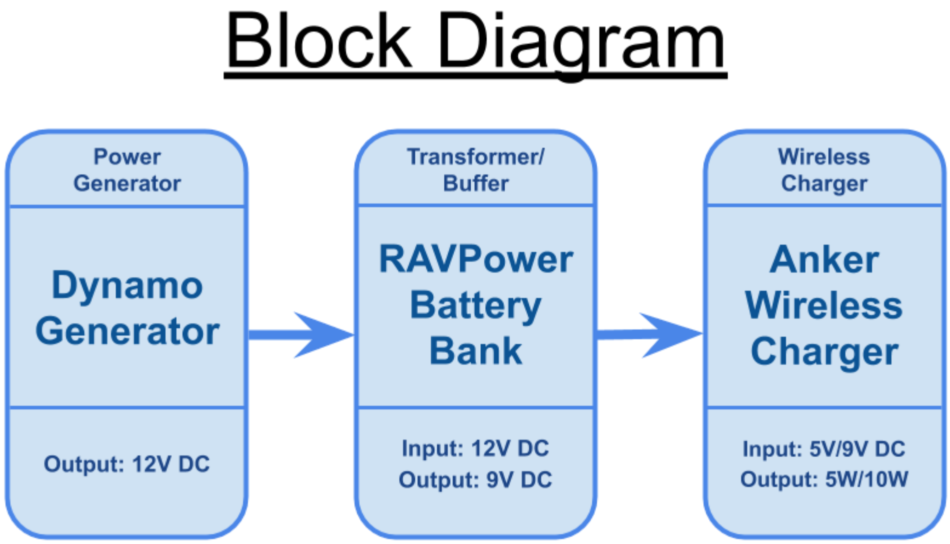
As part of our hardware design, we will hook up our generator to the backwheel of our bike. The generator contains a roller on one end of it that will generate power as the backwheel of the bike rotates. The power will be grounded on a node that attaches to the frame of the bike provided by the manufacturer of the generator. The power for the bike will feed through a fuse to act as a safety in case the power output is significantly larger than our system can handle. From there, it will feed into a battery buffer that will power the wireless charging mechanism for our bike. For the hardware implementation, we decided to take the simple and straightforward approach using a basic circuit in our design as that was recommended by our advisor in order to allow for ample time for running tests and experiments on our project. By starting off using mostly pre-existing products for our prototype, we are limiting the liability of our projects and the likelihood that we are infringing on any patents.

Electrical Diagrams:









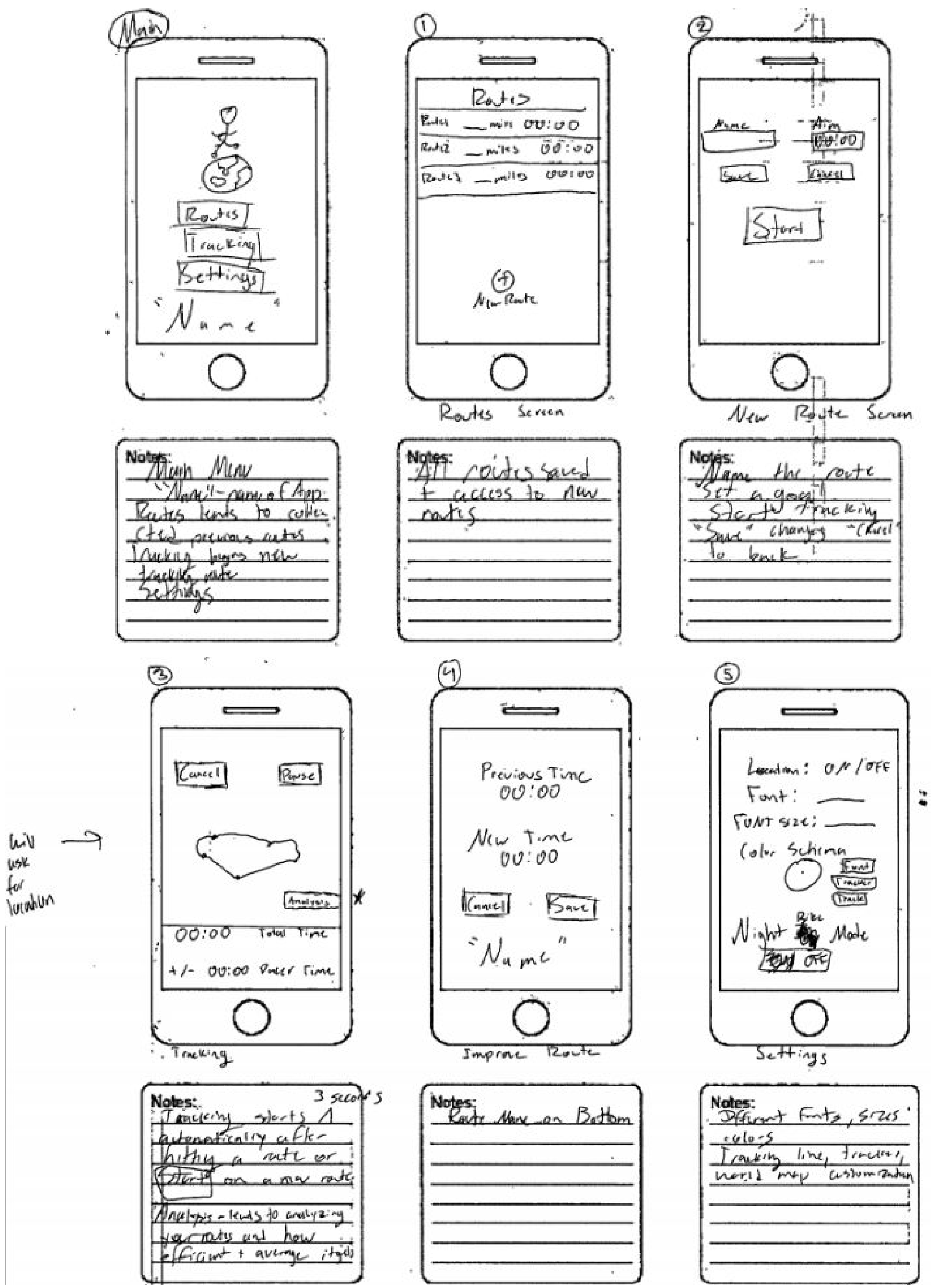
Software Design:

For our software, we plan on implementing our application on Android. We decided to use Android Studio for our application development since it is open source, contains all of the API's/extensions we would need, and we both have more familiarity with this developer environment as opposed to other developer environments. Since our advisor is familiar with Android Studio as he has taught Software Engineering classes that heavily involved this application, he will be able to more easily guide us throughout the entirety of the application development process.

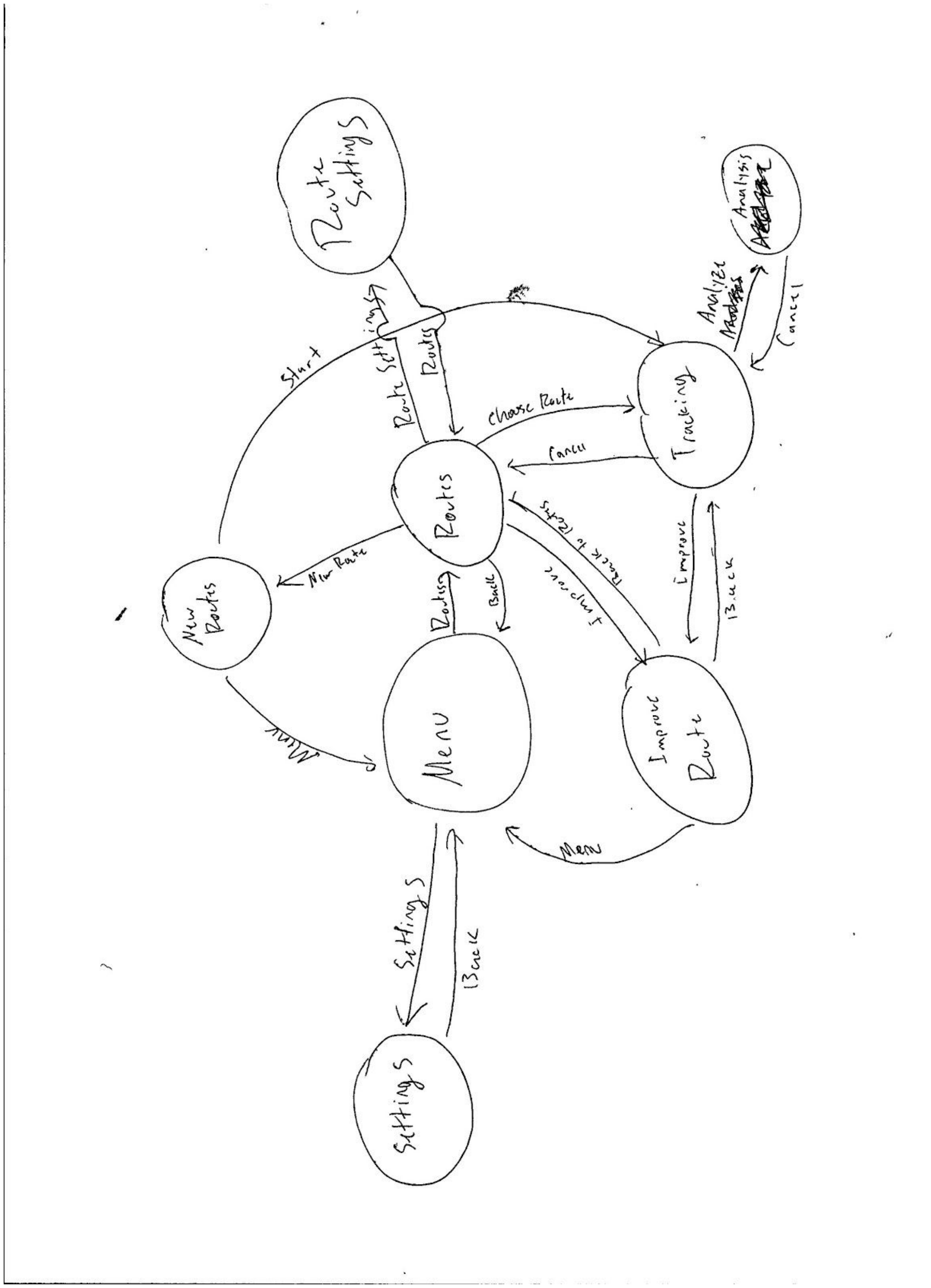
Our application uses Google Maps as its main mapping function with tracers to allow users to see their routes on a geographical scale. Each time a user repeats a route, they have the option to improve it by changing their expected total time and thus the screen will constantly calculate an accurate pace. The pace on the screen will alert the user with a green number if they are on or above pace and a red number to indicate they are falling below. This is the general gist of the pacing monitoring system.

Each time a new route is added, the application requests tracking privileges from the user. This prevents us from constantly tracking the user’s motions and creating an unethical situation. We’ve created a state diagram to manage traversing the application with back and forth activity.

Application Storyboard:



State Diagram:



Ethical Consequences

After careful consideration over the implementation of our project, we've determined that our product doesn't create any ethical consequences in the way that we designed it. The only aspect of our project that could potentially be unethical would be if we collected a user's data and tracked their location without their permission through our mobile application. We have no intention of doing so as all of the data from our application is stored locally and the application doesn't communicate to any servers or other devices. We will also require the user to grant the app location tracking permissions in order to use the features of the application that it requires. The hardware aspect of the project has no potential ethical consequences as creating a portable charger for a bicycle only encourages energy efficient travel!

Intellectual Property Considerations

There were a few patents that came up during our research with potential similarity. With these patents, we were certain to ensure that no patent claims were being infringed on. Not only that, but the patents have considerably more different designs than us. The patent in consideration was US 20160221627 A1. This is comprised of a bicycle which interacts directly with a mounted smartphone. The bicycle contains a processor that communicates with the bicycle and interacts with a server whilst running software on it. The difference here would be that our software runs exclusively on the phone. The patent also contained a method to charge the phone intricately through a battery, whereas our devices use one functionality of the bike to charge the phone, using two separate entities.

Another patent we considered similar was US patent 20120119575 A1. This patent describes a wireless energy transfer system for vehicles. The reason we do not infringe on this idea is because we are developing a transmitter while this patent designed a wireless receiver. We are also implementing the Qi protocol since it will be designed to charge mobile devices whereas this system does not specify Qi protocol.

Alternate Design(s)

The initial hardware implementation for our project had a very different design for our generator. We had originally planned to wrap a copper coil fixed around the axle of the backwheel and have magnets attached to the inner rim of the wheel. The magnetic flux created from the magnets moving around the back wheel would have generated electricity and would have been used to power our system. Our advisor was against the idea of developing our own generator in this fashion as there were already generators that are on the market that were guaranteed to work; he felt that the time and resources it would take to develop it would be impractical for the scope of our project as there was no guarantee that we would be able to get it to properly produce power and may not even be as efficient as using another type of generator. We also decided to alter the idea of an entire charging basket on the bike after further research into how QI wireless charging worked; since the coils on the power transmitter (the bike) and receiver (smartphone) would need to be properly aligned in order to properly charge the device without damaging it, it would be a bad idea to have any devices inside of a basket to charge since they are not fixed in place and would cause the coils in the phone to constantly be shifting in and out of alignment . Instead, we settled on using a wireless charging mount attached to the handlebars of the bike so that this issue wouldn’t occur. Because the software aspect of our project is straightforward in scope, we didn’t need to make any adjustments in our software design. However, we did decide to scrap the iOS version of our application so that we could focus on one application for the project and would ensure that all of the features we wanted to implement would be on our finished project.

Cost Analysis and Bill of Materials

For our project, we were easily able to remain within the constraints of our $500 budget, since the vast majority of materials needed to implement our project are either readily available within the senior lab or were of little to no cost as implementing the hardware aspect of our project is very simple and straightforward in scope. Most of the cost associated with the purchases of our project were for products that are required for our testing configuration and for prototyping our design. Because we were able to minimize our cost so much, it will be easy for us to stay within the budget if we need to order more parts in the future. Although we were able to minimize our costs effectively, we encountered an error when trying to order our bike as it was an ineligible product to be ordered for senior design. In order to work around this restriction, we could just test our implementation on just the backwheel of a bicycle as we easily have access to that resource.

BOM:

Part	Store	Part #	Manufacturer	Manufacturer Part #	Contact Email	Manufacturing Rep	Price	Quantity	Cost	Total Cost
~~Bicycle~~	~~Amazon~~	~~B07BCZP4TH~~	***INELIGIBLE PRODUCT FOR PARTS ORDER FORM***				~~$135.00~~	~~1~~	~~$135.00~~	**~~$401.50~~**
Wireless Charger	Amazon	B07DBXZZN3	AnkerDirect	AK-A2524011	support@anker.com	N/A	$16.00	2	$32.00	**$266.50**
Fuzbaxy Generator	Amazon	B01LAGN522	Fuzbaxy	***MANUFACTURER LEFT NO INFO***			$24.00	1	$24.00	
Bike Mount	Amazon	B073TT2NN7	Reliancer	710280340931	info@reliancer.com	N/A	$28.00	1	$28.00	
Motor	Amazon	B00D3ORRQU	Powerhouse Engineering Inc.	P40-350	powermail@email.com	N/A	$75.00	1	$75.00	
Belt	Amazon	B004ELAAGU	CONTINENTAL	20042010	sales@carid.com	N/A	$17.00	1	$17.00	
Pulley	Amazon	B00004RAO8	Chicago Die Casting	200A 1/2	robb@chicagodiecasting.com	N/A	$8.00	1	$8.00	
Motor Battery	Amazon	B003S1RQ2S	ExpertPower	EXP1270	support@expertpower.us	N/A	$18.00	1	$18.00	
Battery Bank	Amazon	B01LRQDAEI	RAVPower Official	RP-PB058-2	support@ravpower.com	N/A	$60.00	1	$60.00	
Glass Fuse	Mouser	576-0362005.H	Littelfuse	0362005.H	N/A	Aftermarket Sales Inc	$0.45	10	$4.50	

Governmental Regulation Impact Study

Title 16, Part 1512 in the Code of Federal Regulations (CFR) contains the regulations regarding bicycles that will affect the design of our project. In 2011, the Consumer Product Safety Commission (CPSC) made amendments for requirements of consumer grade bicycles that are still active that altered the safety requirements for bicycles. Section 1512.4(b) prohibits "unfinished sheared metal edges or other sharp parts on bicycles that are, or may be, exposed to hands or legs."[1][2] Since most of our wiring we would need to do on our bicycle would be built around the frame of the bicycle, we would need to ensure that the way we are securing the cables wouldn't produce any sharp protrusions that could potentially harm or injure the cyclist. The FCC also established regulations that will affect the WPT system within our bicycle. Under KDB 680106 section 5 it establishes the following requirements for WPT:

> (1) Power transfer frequency is less than 1 MHz.
> (2) Output power from each primary coil is less than or equal to 15 watts.
> (3) The transfer system includes only single primary and secondary coils. This includes charging systems that may have multiple primary coils and clients that are able to detect and allow coupling only between individual pairs of coils.
> (4) Client device is placed directly in contact with the transmitter.
> (5) Mobile exposure conditions only (portable exposure conditions are not covered by this exclusion).
> (6) The aggregate H-field strengths at 15 cm surrounding the device and 20 cm above the top surface from all simultaneous transmitting coils are demonstrated to be less than 50% of the MPE limit.[3]

Because our project is using an already existing wireless charger that is QI compliant in the prototype, we don't have to worry about violating these conditions, but when it becomes time to implement our own QI transmitter in the bike, then we will need to follow these technical specifications.

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[1] https://www.federalregister.gov/documents/2011/05/13/2011-11742/requirements-for-bicycles
[2] https://www.govinfo.gov/content/pkg/CFR-2019-title16-vol2/xml/CFR-2019-title16-vol2-part1512.xml#seqnum1512.6
[3] https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=41701&switch=P

Industry Standards

As far as industry standards are concerned, we are following all of them to allow our product to be developed. For the wiring of our bike, we will need to color code it so that our ground wire is either blue or black and our power wires need to be red in order to boey electrical code. In our software, we will need to request the permissions from the user in order for them to have full functionality with our application.

Health and Safety Study

As we discussed previously, Title 16, Part 1512 in the CFR establishes the safety requirements we would need to follow in order to ensure that our product is safe for users of our cyclist. To ensure that the steering and handling is still balanced on the bicycle, we are going to space our components in a manner that will evenly distribute the weight of the bike.

Environmental Impact

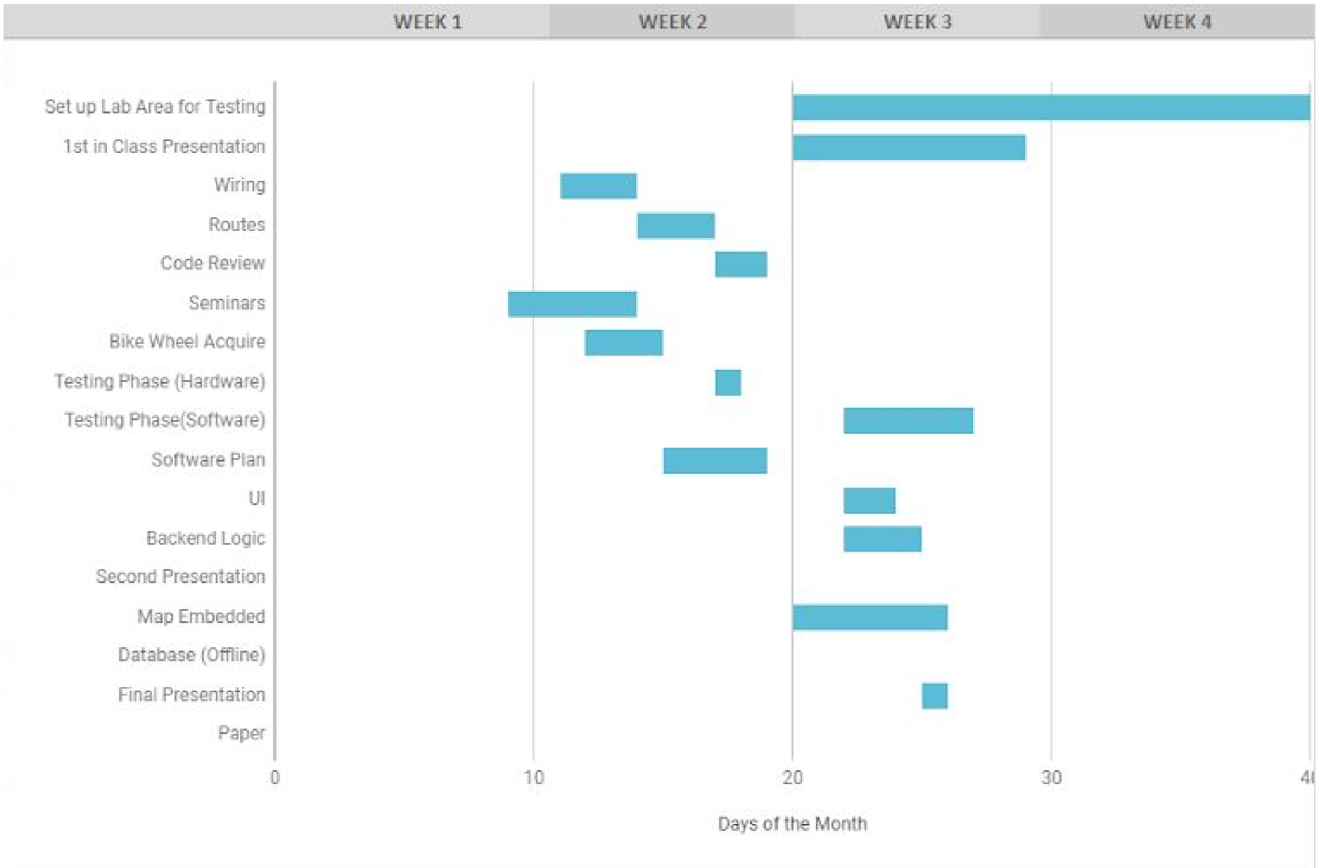
Based on the design of our project, we anticipate that it would have a minimal negative impact on the environment. The only negative impact that our product would potentially have on the environment will be the waste produced from the battery buffer when it would become unusable and need to be replaced. Because our product is producing clean energy, it would have a much more significantly positive impact on the environment as our product is incentivising reduced usage of forms of travel that negatively impact the environment like motorized vehicles.

Project Management Study Gantt Chart

In terms of continuing progress, our team always produced some form of output each week. Most often, we faced issues in our design and thought processes brought up to us by our advisor. The first problem we overcame was the weight issue. Most devices that previously existed to charge bicycles had an overbearing weight. This caused an imbalance in the bicycle to one side or the other, for ineffective flight. To counteract this, we decided to go one of two routes: using the weight as an added feature where cyclists can add or lessen weight to a degree to make treks harder, or centralize the weight to keep the balance. Of course, we chose the latter.

Once we had the design down for our project, we came across the task of finding a solution to our aforementioned overheating problem with the wireless charger. The only way to solve that issue was to rely on a regulated method of pedaling and stored battery so the phone receives a constant stream. Plus, all contemporary phones have a built-in temperature sensor to stop charging from heating up the internal temperature.

Waiting for our parts to arrive has also proven difficult to make progress. At this time all we can work on is the software, which is just the Android app. While we did initiate our ideas with both iOS features and Android, we quickly realized that Android was more familiar to us due to previous experience. It was the sound choice in terms of making more progress and quality.



TASK NAME	START DATE	DAY OF MONTH*	END DATE	DURATION* (WORK DAYS)	DAYS COMPLETE*	DAYS REMAINING*	TEAM MEMBER	PERCENT COMPLETE
Kineticycle								
Set up Lab Area for Testing	1/20	20	2/28	39	39	0	Logan	100%
1st in Class Presentation	1/20	20	1/29	9	9	0	Both	100%
Wiring	2/11/2020	11	2/14	3	3	0	Logan	100%
Routes	1/14	14	1/17	3	3	0	Shreshth	100%
Code Review	2/17	17	2/19	2	2	0	Both	100%
Kineticycle Continued			1/13					
Seminars	2/9	9	2/14	5	5	0	Both	100%
Bike Wheel Acquire	2/12	12	2/15	3	3	0	Both	100%
Testing Phase (Hardware)	2/17	17	2/18	1	1	0	Logan	100%
Testing Phase(Software)	2/22	22	2/27	5	5	0	Shreshth	100%
Trailblazer			1/18					
Software Plan	3/15	15	3/19	4	4	0	Both	100%
UI	3/22	22	3/24	2	2	0	Logan	100%
Backend Logic	3/22	22	3/25	3	3	0	Shreshth	100%
Second Presentation	3/26	26	3/26	0	0	0	Both	100%
Map Embedded	4/20	20	4/26	6	6	0	Logan	100%
Fourth Sample Project			1/24					
Database (Offline)	4/20	20	4/20/2018	0	0	0	Shreshth	100%
Final Presentation	4/25	25	4/26	1	1	0	Both	100%
Paper	5/6	6	5/6	0	0	0	Both	100%
								0%

Experimental Evaluation/Project Results

Due to the transition to remote learning, we had to completely scrap the hardware component of our project as well as make significant changes in the way that we were approaching developing our software.

Since we're unable to access our hardware calculations left in the laboratory, which included various charging rates at different cycling speeds, we have to rely on software results. Our main goal for the software was to provide users with the ability to compare previous paces with new paces, specifically improvements. The granularity is updated depending on the application you use. For iOS, it is possible to set the time intervals to 10 seconds or even less than that. The variability of this allows for more intensive training. Our pace calculates from the beginning of the route to your next timestamp, taking in the distance.value (which can be miles/kilometer depending on user preference) which is automatically measured in meters initially, then converted according to our PaceConversion class.

Time is always taken as seconds and then converted to hours, setting the pace to either mph or kph. Some of the more important aspects of this program are the energy saving efficiencies: i.e if you step away from the run view, the CoreLocation tracking turns off to save power consumption from the phone. Also, if the app is running in the background, the map overview is not necessary and thus temporarily stops running to allow less power consumption as well. Overall, the application works efficiently enough with our goal in mind to allow longer phone duration for bike routes.

Conclusion

Through the research and development of our technology there are some things that we came across that enlightened us in the world of software and hardware development. Before March, one of our heavier problems was figuring out a way to charge the battery pack using the generator we had to attach to the bicycle. After buying our products online, we saw that the generator we had purchased was very heavy, and using it to generate power was creating unforeseen problems for us. A method to combat this would have been to storyboard out a plan or procedure, a formulated path to process the technology and individualize testing of each equipment as well as a well-thought out method to incorporate all working pieces together. If we had done this earlier, a lot of issues coming with the hardware would not have existed. This comes back to pre-planning and understanding the layouts of our design. To even have a layout, we need to figure out exactly what we are setting out to accomplish and the foundations we need to get there. This project taught us an incredible amount of planning.

Future Plans

If we were given the opportunity to continue doing research then we would continue to flesh out the features of our mobile application as well as being able to completely link our frontend code with our backend code. We would also use the additional time to polish the application even further and do more testing with it. Since the testing of our hardware was interrupted by the transition to remote learning and were unable to obtain significant test results due to this, we would have continued with testing the hardware portion of the project and continued prototyping it.

If we were to expand the scale of the project in the future, then we would look into implementing alternative designs that use a different method of generating the energy to power the bike like solar power or through magnetic induction in a similar fashion to one of our earliest designs. We would also look into implementing more of our own designs into the charging mechanism as we mainly leveraged pre existing products for the components needed.