NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences

Mohammed Allahyani, Yu Sun, Khalid Alghamdi, James Sigler
Northern Arizona University

10-24-17
Dear Jane Scott,

We appreciate your interest in the project and plan to complete the project by the middle of May in 2018. We are meeting multiple times a week to ensure the completion of the project. Our team has chosen this project because we all are interested in what can be done with pedal assisted bicycles. This report will define the problem, which we will detail what is needed to be completed by the end of next semester. We have found some topics that needed to be researched to give us a better understanding to successfully complete the project. One topic being researched was the heart rate sensors built in on the bike. Another topic that was researched was the which motor would be best, either a mechanical or electrical motor. The third topic that was researched was the controller and display system for the bike. The last topic that was researched was the entire E-Bike system and how it will be integrated into the bike. We have also determined the four major subsystems to aid in the completion of this project. Those subsystems are: motor controller, torque sensor, cadence sensor, and display. We have began prototyping these parts and will present our findings. We have also included some components that we think will be needed for the completion of the project.

Once again, we appreciate you sponsoring the project and ensure that the project will be completed on schedule. We will dedicate our time to this project to provide the best outcome we can provide.

Sincerely,
Mohammed Allahyani, Yu Sun, Khalid Alghamdi, James Sigler

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Client Status Report

Three Wheel Bicycle Power Assist

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Problem Definition

Overview

There is a surprisingly long history behind the invention of the electric powered bicycle. People have attempted to motorize personal transport throughout the ages and the bicycle seemed like a perfect platform even back then. This assist model has varied in power and capacity but always included pedaling as an integral part of the propulsion process. It is this integration that has clearly separated electric bicycles from mopeds and motorcycles. As technology improved, the electric motors gained important sensors and controls that allowed the drive system to "Feel" the need for powered support, thus providing the added boost to the rider. The general idea of this technology was to add power only when needed, allowing the bike's power source to last longer and go further on a single charge [1].

Circumstances

In this project involves the retrofit of a 3-wheel recumbent bicycle to provide electric power assist so that a bicyclist can still pedal up steep hills with power assist even with marginal heart function. Moreover, we will design 3 wheels bicycle it will be helpful for who may need assist torque to move up hills and flat road. Also, it will be helpful for who may have heart problems.

Background

Indeed, we must design the 3-wheel bicycle power assist and regenerative braking to by these goals. First, the range of a fully charged system should be 10, miles assuming level road. Second, the user can pedal at the same time as the power assist is on. For example, when the user moves uphill, the power assistance working with pedaling at the same time. Third, the bicycle must have two levels of assist, assist to climb the hill, and assist for maintain a speed in flat road. Fourth, the maximum weight is 225 lbs. that include the estimating bicycle weight between 170 to 190 lbs plus motor, battery, and other parts. Fifthly, the bicycle must have a regenerative braking system. The regenerative braking system is very common on electric cars, and not common on electric bikes. The real problem in this system is the efficiency, in electric cars the efficiency is perfect because the velocity and weight are bigger than electric bicycles. On the other hand, the average efficiency for the regenerative braking system in electric bicycles is 5-20% [2]. Sixth, the bicycle must have Instrumentation and display for speed in miles/hour, miles. Moreover, we can add Instrumentation for level of power in battery and Instrumentation for motor temperature. Seventh, the bicycle should be water resistant to rain and snow. Because of that, this bicycle we need it to be useful an all seasons.

Needs

The wants that are requested by the user for the system are as follows. A torque sensor to detect how hard the rider is working and how much assist to provide. Also, there will be different modes that could assist or train the user depending on what mode they have selected. A heart rate monitor is requested to be implemented into the system. The information tracked would be exported to Excel so the user can see their statistics.

Wants

Some of the wants that the client is looking for is have a sensor connected to the front wheel to detect the angle the wheel is turning. Using this sensor would to be used to slow down the bike if the user is going too fast to prevent the bicycle from flipping over.

Objectives

We plan to complete the assignment by the end of the Spring 2018 semester. In the beginning phases of the project we plan to do research to find what parts will work best for the system. After we have found what parts will be best we will purchase those parts and connect the entire system together. The next step would be to code the controller and the GUI all together and test the functionality of the system. Once the tests are completed and we find it is completed we will give the bike to the client.

Potential Applications

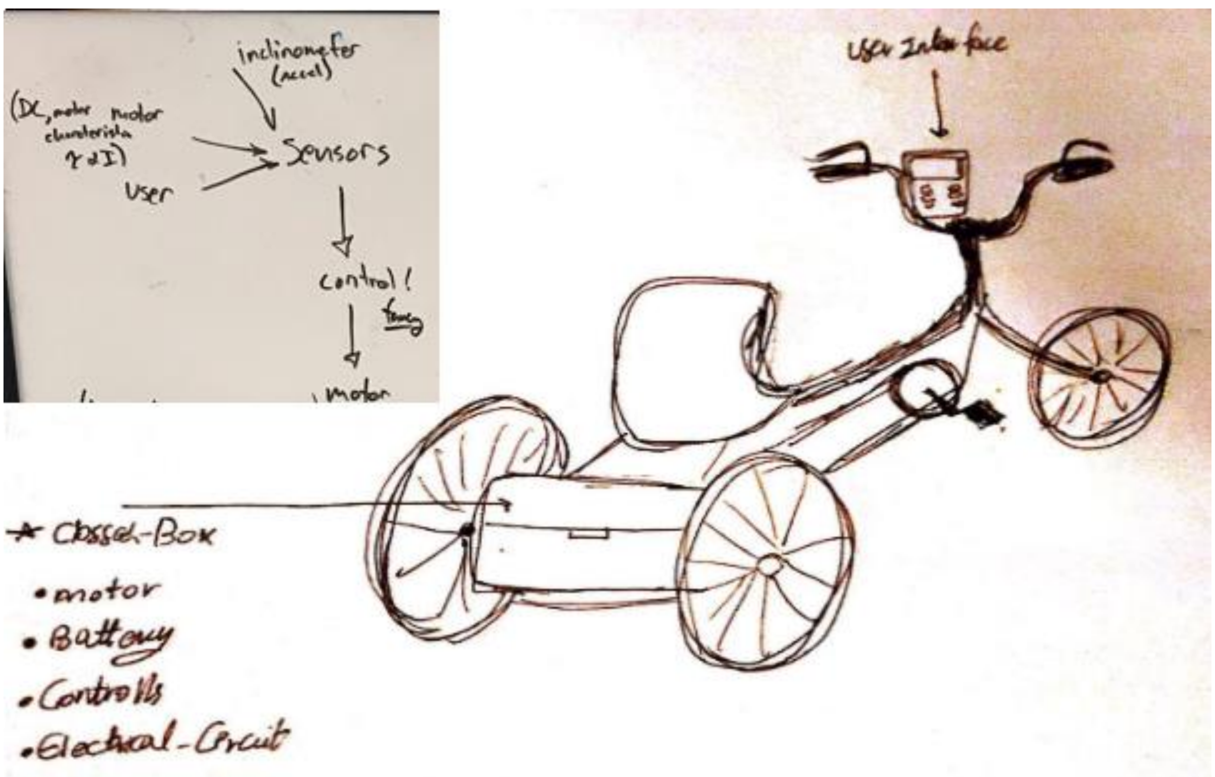
In fact, there are some of potential applications we will use it in this design. This technology will improve the bicycle performance. For example, we will use different modes one for help assistance and one providing resistance to train the cyclist. Also, we think to add GPS system to the user interface, and we plan to add heart rate monitor.

Benefits

Finally, we have three major elements we researched about it, Motor and types of it, controls system, and Implementation of the entire system. Then we will research the best and options from all these elements. There are many benefits to the system which can assist a user with a heart condition to ride a bike and can choose how much assistance that they need for a specific day.

Figure

The figure below is showing the major parts of our project. Within the closed box on the back of the trike all the electrical components on the bike will be connected through there. The information from each of the sensors are going to be passed through to the controller. The controller will then send the information to the motor that will output the right assist that is needed. The battery is what will allow the entire system to work which will be powering it. This is the overview of how the pedal assisted E-bike will work.



Research

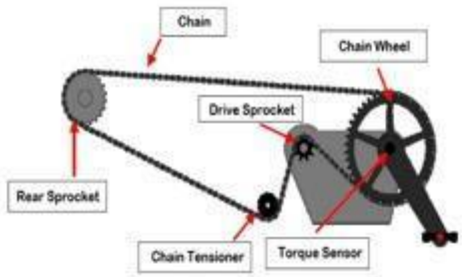
E-Bike System

We met with our client and he have us suggestions of topics to research. Our team has divided up the topics that each of us have researched. The topics are: motor, frame, control system, and full system assembly. We plan to ask local bike shops and NAU bike club to see if any spare parts can be donated to aid in the success of the project. For our plan, we have decided to each research different topics and discuss our findings. Once we have researched we will talk with professors. Below is some preliminary research that has been done.

None of the current technologies that are being used is E-Bikes. There are a variety of different E-Bike types. Some provide pedal assistance and some can provide power without pedaling. These bikes consist of a motor, torque sensor, controller, and battery.

Drivetrain

There are currently two main drivetrains. One of them is having the motor in the hub, which is known as a direct drive system. The other is mid drive motor, which has a geared motor with a wide ratio. The direct drive motor does not have any gears and increases current in the motor to provide more power. Some problems that may occur with direct drive is the motor overheating due to lack of power dissipation [3]. The mid drive motor has gears within the motor to change depending on the incline and cadence of the bike. Since they have gears they are more battery efficient than direct drive motors. E-Bikes can change their power assist depending on the setting. For flat land riding, you can choose no assist or assisted. When riding up an incline the motor can assist even more depending on what is needed.



Torque Sensor

The current technologies for torque sensors can use magnets to calculate the rider's cadence. The magnets will be placed in an evenly distributed circle on the crank arm. On the bottom bracket of the bike a sensor will be connected to read how fast the magnets are passing by the sensor. Doing this will then record the calculate the rider's cadence so the motor knows how much assistance to provide. The information from the torque sensor will then be relayed to the controller.

Controller

The controller is the brains of the system. The controller is what calculates how much power to output into the motor [4]. On the controller is the different modes than be used. One setting could be to not provide any assist. Another setting could be to provide an equal assist to what the bikers cadence is. A setting that could be used for hill climbing could be providing four times what the bikes cadence is. There are some bikes that can provide 100% assist without pedaling as well. The controller is usually located on the handlebars so the rider can easily adjust the setting.

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Battery

The battery is what provides the energy to power the system. The larger the battery the longer the bike can ride without recharging. It is very important that the battery is to be used efficiency to maximize the assistance it can provide. One important thing is to make sure that the battery is located at a safe place on the bike where it cannot be damaged. It is important that the battery remains contaminate free. Usually, the battery is located on the downtube of the bike.

Regenerative Braking

Some E-Bikes are equipped with regenerative braking. This would allow the energy when braking to be stored in the battery [3]. Some research has been done on this and has found that not much kinetic energy can be gained with regenerative braking [5]. The system works better with slower braking. If the rider brakes too fast not all the energy can be stored into the battery. One downside of using regenerative braking in when the motor is off there will be a resistance on the sprocket.

E-Bike Motor

Purpose of motor

Provide electric power assist so that a bicyclist can still pedal up steep hills with power assist even with marginal heart function. The Motor must be small but must be provide enough torque that assist the rider to move up hills.

Types of Motor

1. Pedal-assist system

With pedal-assist the electric motor is regulated via pedaling [6]. The pedal-assist augments the efforts of the rider when they are pedaling. These e-bikes – referred to as pedals – have a sensor to detect the pedaling speed, the pedaling force, or both. Brake activation is sensed to disable the motor as well.

2. Power-on-demand

With power-on-demand the motor is activated by a throttle, typically handlebar-set up similar to on most motorcycles or scooters.

Options:

- Hub Motors
- Crank Drive Motors

Hub Motors

The wheel hub motor additionally known as wheel motor, wheel hub power, hub motor or in-wheel motor, is an electric motor this is included into the hub of a wheel and drives it immediately [7].

The Advantages of a Hub Motor:

- The motor is handily placed in the wheel hub, causing no change in the basic design of the bike.
- Because of this positioning, a hub motor can be retrofitted to almost any bike using a conversion kit.
- Hub motors are relatively simple motors and are completely self-contained [8]. This means you can use one off the shelf on almost any bike, and move it from bike to bike if you upgrade your bike.

- Because the motors are sealed they are extremely low maintenance. They are usually impervious to wind, rain, snow, and sleet.
- The hub motor is directly attached to the wheel it is powering, making for high efficiency – the motor can move the wheel very efficiently, as it is in the wheel.
- The center of gravity is quite low, which is good for balance and retaining the classic bike feel.
- It is easy to access a hub motor if it needs service or repair.
- If it fails completely, you can usually just replace the motor while not impacting any other part of the bike. You can also easily update to a newer motor if you want.

The Disadvantages of a Hub Motor:

- The cost is relatively high because the motor is more complicated than some other kinds of electric motors [9].
- The sealed aspect of the motor means that there can be overheating issues, as there is no easy way for heat to escape
- The hub motor makes the wheel quite a bit heavier. The minimum extra weight is around 5 pounds, but it can be substantially more than that.
- It’s hard to tell the difference between a good hub motor and a bad one, as they all look the same.

Crank Drive Motors

Also called mid drive motors, crank drive motors directly power the crank drive, and usually work in concert with your gears [10]. Crank drive motors tend to be more about smooth and efficient performance than simple brute force.

Advantages of a Crank Drive Motor

- The motor has a fanned casing which allows for heat to be more effectively released than in a hub motor.
- By definition, a crank motor will be in or near the bottom bracket, so the extra weight is low on the bike – contributing to good balance and a classic bike feel.
- The key advantage is that by working synergistically with the bike's gears, the bike can perform better on hills than an equivalent sized hub motor

- Crank motors can do well with quite low power levels because they work so efficiently. As a result, you don’t need to pay for a huge motor to get up hills

Disadvantages of a Crank Drive Motor

- The entire unit is sealed (motor, controller, and torque sensor). So, if one component fails you have to replace the whole thing
- There are a lot of great crank drive motor systems. However, they are all proprietary. So, if you ever need parts and the company has disappeared, it could be expensive or impossible to do repairs.
- The key limitation on crank drive motors is that they are limited by the strength of the chain and the sprocket. To date almost all systems use standard bike chains and sprockets, which were never designed for motorized use, so the power has to be kept quite low.
- Inevitably, a crank drive will lead to increased maintenance on the drive chain, including all cogs and sprockets.

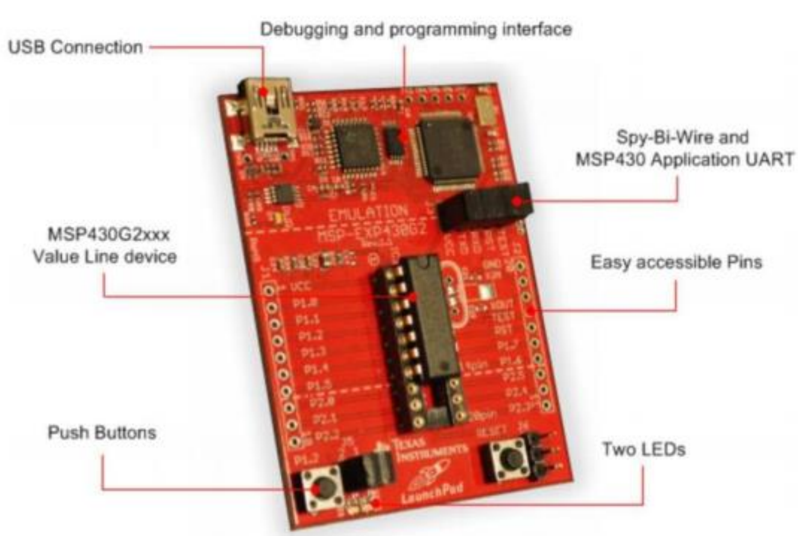
Display System

In the display system, our group needs to display for speed in miles per hour when the bicycle is running and display miles remaining before recommended charge, charging indicator, and charge complete indicator. Miles remaining can be changed to battery power remaining.

Instrument Selection

MSP430G2211

First, MSP430G2211 can be chosen as the single chip microcontroller to realize the function of speed detection mainly. The MSP430G2xx Value Series features flash-based Ultra-Low Power MCUs up to 16 MIPS with 1.8–3.6 V operation [11]. It Includes the Very-Low power Oscillator (VLO), internal pull-up/pull-down resistors, and low-pin count options. Besides, The device comes in a variety of configurations featuring the usual peripherals: internal oscillator, timer including PWM, watchdog, USART, SPI, I²C, ADCs, and brownout reset circuitry.



Magnetic Reed

The reed is made by soft magnetic material. The two reed sheets are insulated but they will become N pole and S pole under the influence of magnetic field when magnet is near the switch. Then, they will be connected together and make circuit connected. Although Hall sensor can be used to detect speed but reed has more advantages for example small size, low dissipation, long lifetime, and perfect electrical property

Sensor Body Material	ABS
Filling	Epoxy
Max. Contact Rating	10W
Max. Switching Voltage	100VDC
Max. Switching Current	0.5A
Min. Breakdown Voltage	250VDC
Max. Release Time	0.4ms
Max. Operate Time	1.0ms
Max. Initial Contact Resistance	100mΩ
Min. Insulation Resistance	1010Ω

LCD1602

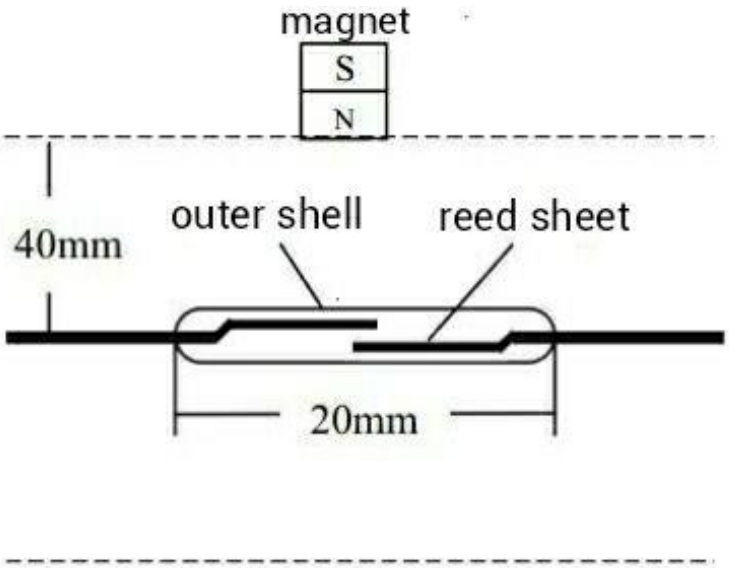
SunFounder LCD1602 Module has 3.3V Backlight for Arduino Uno R3 Mega2560 Raspberry Pi 16x2 Character White on Blue Background. It can display 2 lines of 16 characters including letter, number, and symbol. The working voltage is 5V and module dimensions is 80 x 36 x 12 mm. Viewing area size is 64.5 x 16 mm. It displays characters clearly and has low cost and is easy to use. The LCD1602 is connected to MSP430G2211 directly and displays speed of bicycle in miles per hour and residual electricity by programming to achieve the function.

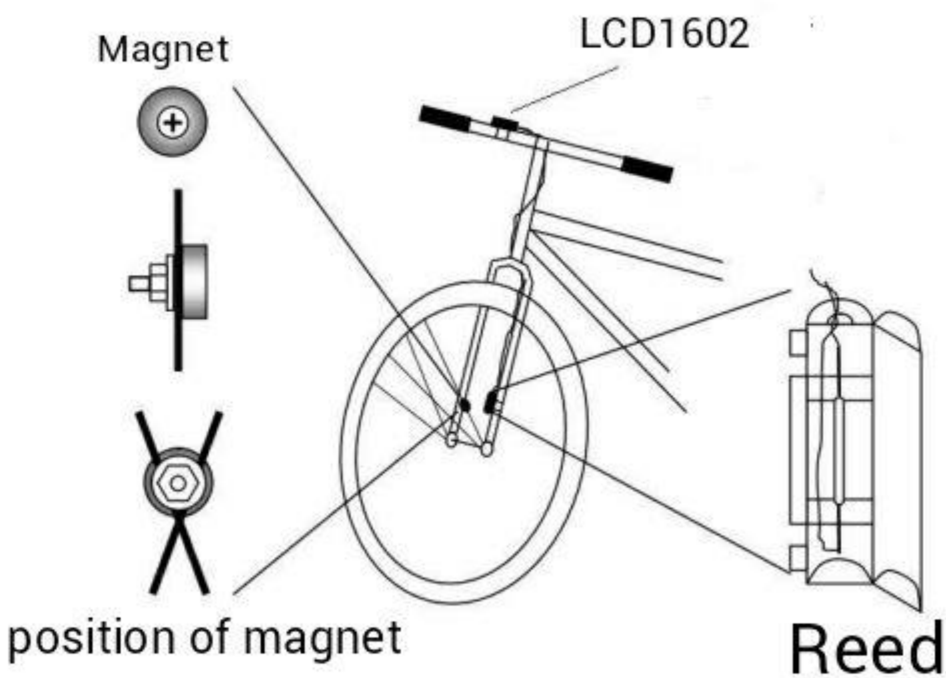
Principle of the whole system

The functions of system can be realized in three steps: signal collection, data processing, and LCD display. The signal collection can be finished by reed. Then we will write code of formula for calculating and estimating the speed to make MSP430G2211 process the date given by reed. Finally, the output interface will be connected to LCD1602 to display all information.

Signal Collection

A permanent magnet is fixed on X-shaped cross wire of the wheel of the bicycle. The reed can be fixed on bracket of front wheel. With rotation of the wheel, magnet will be synchronized with the rotation. When the magnet gets closed to reed every time, the two sheets in reed will be connected, which will generate a pulse signal. When magnet keeps away from reed, the two sheets will be divided. The number of generated pulse signal generated depends on how many turns the front wheel rotates, which can be used to calculate rotating speed.


magnet
S
N
40mm
outer shell
reed sheet
20mm


Magnet
LCD1602
position of magnet
Reed

Data Processing

The reed generates some pulse signals and then send them to single chip microcontroller by input interface. Then we will write code to achieve some functions of MSP430 such as TA model, watchdog, and clock.

LCD display

LCD1602 needed to be connected to MSP430 by two I/O interfaces. The battery of bicycle need to afford electricity for LCD and SCM.

Voltage reduction system

The acceptable voltage range of MSP430 is 1.8V-3.6V. And the output of battery is much higher than the maximum value. So, we need to design a voltage reduction circuit in case the huge input current damaging chips. We plan to use Altium Design to design the voltage reduction circuit and use it to make printed circuit board(PCB). Finally, we will use the PCB to connect SCM and battery.

Programming Design for the speed detection system

Language choosing

There are two languages can be used in MSP430: C language and assembly language. The generation efficiency of machine code of assembly language is high and assembly language has good performance of controlling. But, its performance of portability is not good enough.

According to C language, it has nice modularization and is easy to read, to understand and to maintain. Besides, programming model of C language is easy to transplant. Based on all of these, we choose C language.

Programming module

In main program, we will initialize every interface of chip and close the watchdog to reset all system. Then set suitable clock and input and output of I/O interface. We will also need to set way of interrupting and counting way of TA module.

Research Results

Compiling all of the research completed we have found that the hub motor may be the best option rather than a crank driven motor. We have found the crank motor will be very complex and cost much more than a hub motor. We are planning on implementing the hub motor on the freewheel of the tricycle. For the controller, we plan to use an Arduino rather than a MSP430. We have found that using an Arduino will provide us the power we need to read all of the data then will then be shown in a display. We have a great understanding of how each of these parts will be connected on the bike and will start testing our findings by working on a prototype.

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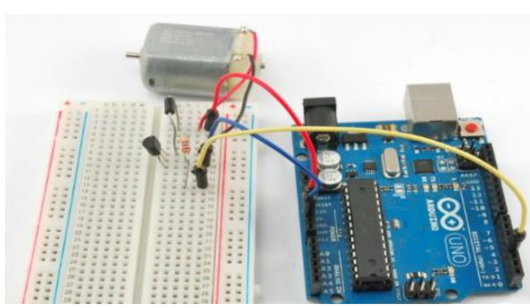
Project Breakdown

In the paragraphs below we will breakdown four major subsystems to aid in the completion of this project. The first subsystem is the motor controller. This system will be what is controlling the motor and how fast it operates. The second subsystem is the torque sensor. This system will calculate the torque that the rider outputs to the bike. The third subsystem is the cadence sensor. This subsystem will calculate how fast the wheels are spinning which will then be able to determine how fast the rider is going. The last subsystem is the display. This will display information from all of the other systems on a LCD display.

Motor Controller

We have found a couple possible solutions for the motor controller. One solution is to use the motor controller that comes with the hub motor package. Another solution is to use a 3rd party controller that we will buy separately and then understand how it works. Another solution is to build our own motor controller using an Arduino. In the picture below is a very basic motor controller.



When comparing these solutions, we found that the motor package and the Arduino build are the best options. The motor package we be the easiest because we can just install it and it will be completed. However, this is not the solution we are intending on using. We are planning on building the Arduino motor controller. We have begun prototyping for the Arduino built motor controller and have found that this may be a good way to control the motor. One major flaw about choosing the Arduino over the motor package is that it will be much less efficient than the motor package [12]. The motor package will have many features already built in. We plan to code many of these features into our Arduino code.

	Motor Package	Arduino Build	3rd Party
Cost	1	5	3
Ease of use	5	3	1
Ease to code	3	5	1
Efficiency	5	1	3
Total	14	14	8

*Ranking: 1 = worst, 5 = good

In conclusion, we have determined to use an Arduino to build our own motor controller. WE chose this over buying a commercially made one because it is cheaper and will not be a large task to build our own. For the prototype, we have built a very basic motor controller that will control the motor for a RC motor. We will use the information from this prototype to have a better understanding of how the motor controller will work on the actual tricycle. This code we generate now may also be implemented when making the final model.

Torque Sensor:

There are different types of torque sensors. The first solution is the Magnetic Ring Sensor, and it locates in the crank [13]. As the rider is paddling it will calculate the rate of paddling. Another solution is the bottom bracket sensor, and it locates between the two paddles. The third solution is the power crank sensor, and it is a whole kit, and it has to be replaced by the original one.

	Magnetic Ring Sensor	Bottom Bracket Sensor	Power Crank Sensor
Cost	5	2	1
Ease of use	3	2	4
Ease of code	3	4	2
Efficiency	3	4	4
Total	14	12	11

*Ranking: 1 = worst, 5 = good

We compare all three types, and we found the Magnetic Ring Sensor is our best solution. The power crank sensor is very expensive, and it includes a whole kit (motor, torque sensor, cadence sensor). But, we are looking to build our own. The bottom bracket sensor is a very good choice, but it will be over our budget cost [14]. We choose the magnetic ring sensor because it’s very cheap. The magnetic ring sensor is basically having combination the disk and the magnet in one ring. So, when the rider starts paddle the sensor will calculate the rate that applied by the rider, to get the appropriate power for the bike to move. Also, it will have almost the same accuracy with the other types of sensor. It’s very easy to use and we may use it in different locations.

In conclusion, we choose to use the magnetic ring sensor. it's very popular and it has a standard connection, so it will fit with all kinds of e-bike controller. Also, the magnetic sensor can be installed in different location. it has a good accuracy, and water resistance.

Speed and Cadence Sensor

In fact, we have found many different option solutions. But we minimize these solutions to three options. First option, Polar sensors. Second options, Wahoo sensors. Third option, Garmin. All these types of sensors are good but some there are small differences between them. For example, Polar speed sensor has cable ties and wheel magnet. On the other hand, Garmin is Magnet-less and it just attaches to the hub. Finally, we decide to make decision matrix to determine what the best possible solution from these three options.

#	Polar	Wahoo	Garmin
Cost	1	2	3
Ease of use	4	3	3
Ease of code	2	2	2
Efficiency	3	3	3
Total	10	10	11

*Ranking: 1 = worst, 5 = good

As the result of the decision matrix we decide to use Garmin speed/cadence sensors. The Garmin sensors are the best choice for our project because these advantages. First, easy to install it basically attach the sensors in less than five minutes, with no magnets or other exposed parts [15]. Second, Speed sensor is attached to the hub and self-calibrates with Microcontroller and display to give you accurate speed and distance. Third, cadence sensor is attached to crank arm size and measures pedal strokes per minute. Also, when I did the deep research about speed and cadence sensors I found that the Garmin sensors have highest rating in most of bicycles websites and E-commerce websites.

Display

We have found a couple possible solutions for the displayers. One solution is to use Sun Founder LCD1602 to connect MSP430 microcontroller. Another solution is to use OSOYOO 12864 LCD to connect Arduino Uno R3 Microcontroller. Another solution is to use Sun Founder LCD2004 to connect Arduino Uno R3 Microcontroller.

#	Sun Founder LCD1602	OSOYOO 12864 LCD	Sun Founder LCD2004
Cost	3	1	2
Ease of use	3	2	3
Ease of code	2	1	2
Efficiency	3	5	4
Total	8	9	11

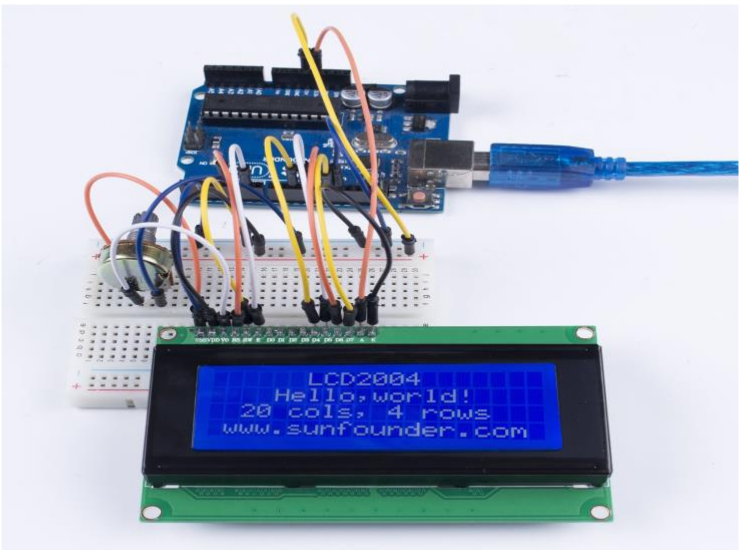
*Ranking: 1 = worst, 5 = good

LCD2004 is our best solution. When comparing these solutions, we found that the LCD1602 is the cheapest LCD displayer. However, this is not the solution we are intending on using because this type of LCD just has two rows that is not energy to display the information's we need. For our project, we need to display the model that the user chooses to provide power assist, speed in miles per hour, miles remaining before recommended charge, electricity remaining, and charging indicator. For displaying electricity remaining, and charging indicator, we will use a rectangle diagram with several black blocks to display these information like mobile phone. This information will be put on the corner of screen and take up one row to display. The rest of information will take up three rows separately. Thus, the LCD2004 that has four rows meet the requirement very well. The layout of information's on LCD screen is shown as follows.

	Model:	Level 1	
	Speed:	19 M/Hrs	
	Miles Remaining:	30 Miles	

OSOYOO 12864 LCD is a very powerful LCD displayer and has many functions. However, we do not use it because there are many functions we do not need and it is more difficult to code. Besides, the price of OSOYOO 12864 LCD is twice than LCD 2004.

To sum up, we decide to use Sun Founder LCD2004 to be our displayer. It is cheap and can display all information's we need. Besides, it is easy to achieve display function for coding especially with Arduino Uno microcontroller. Thus, we decide to connect Arduino microcontroller and sensors to LCD2004. The speed sensor will transmit the information of rotation speed to microcontroller. The microcontroller collects and process the information's. Then the LCD will collect the information's processed from microcontroller and display them.



Requirements and specifications

Electrical

Electrical category is the most complicated requirement for this project. The marketing requirements are wants and needs and constraints. First, the major parts related to power are the energy source (electrical or gas) will provide the exact power that motor need. And we have to make the right calculation to feed the motor and use regenerative braking system to recharge the battery. Moreover, we have to make sure the electrical connections between the electrical parts must connected perfectly to improve the accuracy of power feeding and improve the whole system efficiency. Also, the bicycle must have easy interfacing and showing all data that related to electrical and mechanical parts such as data on battery usage, speed, and range left. Indeed, The Bicycle does not need high power because it works by (Pedal-assist system). So, we will use maximum 25323.2 J/s. For now, we will focus on power, accuracy, sensors, and interfacing.

Electrical	
Power	• Battery: 36V • Controller: 12A • (36V x 12A = 432W) This amount of power enough for this kind of bicycles
Accuracy	• Power output from energy source • Power input to motor from energy source • Power input to battery from regenerative braking system • Sensors calibration • electronic cords • Adjust levels of assist • Pick an appropriate type of motor
Sensors	• Virtualized torque sensor • Cadence speed sensor • Temp sensor
Interfacing	• On-board computer based on Arduino

Environmental

The project is going in different weather condition. So, we are going to make it ready for all kinds of weather could be facing. The bike will be waterproof, so all wires and sensors will be covered. As well as, the bike will won't be rust since it's all made from aluminum. So, the bike will be ready to face all kinds of weather condition and it will give the user reach any place want.

Environmental	
· Temperature	The e-bike will be water resistant, so all wires, battery and motor will be cover. So, the user can use in different condition weather. Such as, using the e-bike in the rainy or snowy weather.
· Humidity	Since we choose our bike frame to be made from aluminum. The user can use it in sunny and rainy weather condition.
· Vibration, Shock	The bike will have less vibration, since it has a good shape aluminum frame.
· Environmentally Friendly	E- bike will be fully electrical power, so it won't create air pollution.

Mechanical

We need to make sure that our additions to the bike will not be too large or heavy on the bike. If the bike exceeds either of these it could cause more strain on the motor reducing the life of the motor. The system created should be compact and not cause the rider any interference. We need to make sure that the system works properly and will not cause any problems that could cause damage to the rider or bicycle. The system created should be able to withstand normal conditions for a bicycle.

Mechanical	

· Size	Must be on a three-wheeled bicycle. Should be able to fit in a location on the bike that does not affect the rider and does not take up a large amount of space.
· Weight	Weight must be minimized to reduce stress on the motor. Should not add more than 25 pounds excluding the weight of the frame.
· Organization	Must be compact and neatly stored on the bike to reduce errors. Could be on the rear of the bike in a container that is on the rear rack.
· Interconnect	Pedal assist system must be integrated into a standard bicycle. Must be able to calculate the rider's cadence to properly give assistance.
· Protection	Must be able to withstand normal wear and tear on a bicycle.

Software

We are planning to create our code that will be implemented on the control system. It will take in all the information from each of the sensors and use that to provide efficient power output from the motor. We plan to use multiple sensors to read all the information that will be inputted into our code.

Software/GUI	
· Language	C language
· Software required to use	Code Composer Studio、Altium Designer
· Hardware to use	MSP430G2211 Signal Chip Microprocessor
· etc.	LCD1602

The bike should be in high quality and ready to use. All wires will be covered effectively, which will protect the wires from being damaged. The device will provide enough power to the bike, and this will make the assistant ready to work. The power provided will be enough to run all parts in the bike. Such as, sensors and platform. All works must be in high quality, since it's going to be our final project. Moreover, the bike will have all maintenance scheduled. In addition, the bike weight should be distributed equally. so, the group is going to place all parts in the correct place, which will give the user the control of the bike. the interfacing system must be in perfect condition. so, it will work without any errors.

General

General	
Reliability	• Energy source, motor, controller, and electrical circuits must be fit with each other and for the needed force • The bicycle must be in good quality • Sensors, cords, and interfacing should be in good quality. • Maintenance

Documentation is important because it's going to give an overview of the bike to the user. The documentation will provide all instruction for the user. The user will find the enough information to run the bike, and the description of all parts. Moreover, the documentation will provide the process of the building the project, and include all contact information for any help. Also, it will include maintains and user guides. Which will help the user to fully understand the bike, and that's including the platform instructions. The user needs to be able to use the device in easy way, the team will test it to make sure that the user will not encounter any errors.

Documentation

Documentation	
· Operator's Manual	The team will provide a manual for the project to the users, include instructions.
· Maintenance Manual	The team will provide a maintenance manual, and it include all the services the e-bike needs.
· User's Guide	The team will create a user's guide to give the user all the information needs. So, the user may get to it if some technical problems happened.

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