University of Central Florida
Department of Electrical & Computer Engineering

EZ-Bike
Smart Electric Bicycle

Senior Design 1: Divide & Conquer
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I. Project Narrative

A. Motivation:

Nowadays, millions of people depend on motor vehicles as a source of daily transportation. Unfortunately, owning one can be expensive and not good for the environment as it depends on fossil fuel and emits carbon dioxide. Currently, countries are shifting to be more eco-friendly in order to protect the planet for future generations and they have policies in place, like the Paris Agreement which is “a legally binding international treaty on climate change” (United Nations), to hold countries accountable[1]. The United States, in the past years, has encouraged society to be less dependent on fossil fuels in order to achieve this goal. Bicycles are a great alternative to motor vehicles but in cities like Orlando there may be a great distance between point A to point B and a bicycle may not be as efficient as a car. Using a rechargeable battery combined with a solar panel to power a bicycle makes the commute easier and more efficient. An electric bicycle also promotes a cleaner environment and makes us less dependable on fossil fuel.

B. Project description:

The electric bike is not a new concept. Electric bikes serve many purposes such as a mode of transportation, to make a living, or just simply as recreational purposes, but it can be expensive for the consumer. We want to create a system that not only is beneficial to the environment, but to the consumer by being less expensive than the ones that already exist in the market. It will run on electric power with the option of self-pedaling or by activating a motor that will turn on the accelerator. It will also have the ability of self-charging. The bike will have a motor on the rear wheel, a battery with a solar charging system as well as a wall charger, regenerative braking, a LCD display, some sensors to determine when to switch to the motor when going uphill and switch to generate power when going downhill and a head light. The feature of the self-charging comes from the photovoltaic solar panel and the regenerative brake. The solar panel desired is to be lightweight and smaller in size with a good output voltage and watts. To be realistic, the solar panel is not to fully charge the battery, its primary function is to provide a longer life cycle for the battery and to provide some charge when an outlet is not available. The regenerative brake will convert some of the kinetic energy into useful energy to supply it back to the power source.

C. Goals:

- Reduce the commute time.
- Reduce the amount of energy used by the rider.
- Reduce carbon dioxide emissions.
- Promote physical activity by allowing the rider to charge the battery while pedaling.
- Make travel easier in incline roads and rough terrain.
- Maximize efficiency.

D. Objectives:
- Build a low cost electric bicycle.
- Incorporate a rechargeable battery that charges by pedaling.
- Attach a portable solar panel as a secondary form of charge.
- Include LCD screen.
- Install Bluetooth to pair a cell phone.

II. Requirements & Specifications

Requirements
Motor capable of both power output and generation
Can automatically switch motor between output and generation
Regenerative braking & coasting
Capable of varying motor output
Integrated solar panel
Detects both light levels and bike incline
Bluetooth capable
Automatic head and tail lights
Battery level monitor to prevent overcharging

Specifications	
Unloaded weight	< 25 kg
Max loaded speed	> 15 mph
Battery capacity	2600mAh
Headlight brightness	100 lux
Lux reading precision	+/- 1 lux
Solar power	~ 6 W
Motor power	>=250 W

- Motor capable of both power output and generation: this means the motor should be a direct drive hub motor and effectively precludes the use of a geared motor due to the added complexity that would entail.

- Can automatically switch motor between output and generation: the bike will use several tilt sensors to determine when to switch between motor output (going uphill) and motor power generation (going downhill).

- Regenerative braking & coasting: the means by which the motor acts as a power generator while going downhill will be applied to braking, regardless of the tilt of the bike.

- Capable of varying motor output: a speed controller will be implemented to regulator power being delivered to the motor.

- Integrated solar panel: a solar panel will be integrated into the bike to provide supplemental charging.

- Detects both light levels and bike incline: light and tilt sensors will be included to facilitate the automatic motor and light control

- Bluetooth capable: capable of Bluetooth pairing to personal devices for navigation purposes.

- Automatic head and tail lights: head and tail lights will be incorporated with the aforementioned sensors to allow for automatic light control

- Battery level monitor to prevent overcharging: charging capabilities will be disabled if battery levels reach an unsafe threshold

Constraints	
Man-hours	Motor power
Costs	Battery capacity
Weight	Power generation
Dimensions	Safety

- Man-hours: our team is constrained by our available man-hours and the labor that man-hours represent. Firstly, we are limited in the number of man-hours that we are able to put into this project. This limitation is due to other responsibilities that we must divide our attention among (i.e. family, work, other classes, etc). Secondly, the labor that a man-hour represents is another dimension of this constraint. This is because the circumstances surrounding our work impacts it's quality and quantity. For example, spending 30 man-hours over the course of one week towards our project would likely result in a greater quantity and quality of work when compared to working 30 consecutive hours. Thus we must balance this constraint in order to ensure that we are consistently making progress on our project while also maintaining our mental and physical wellbeing.

- Cost: because this project is being funded at the expense of it's group members, cost is a very important constraint to keep in mind. We must make sure that our project incorporates parts that have the required functionality while also minimizing cost. This is a constraint that is connected to the man-hour restraint because oftentimes cost and labor required to implement are inversely related. Discounting the cost of parts already owned by team members we will attempt to keep the project cost below $500.

- Weight: a very important restraint for the majority of devices, especially those which require acceleration such as in our project is weight. However, this constraint doesn't only impact acceleration, it also impacts the battery range. This is a constraint that we were especially mindful of while selecting our heaviest components, where even a slight percentage difference between similar components had a large impact. We will continue to remain mindful of this constraint as we continue to add auxiliary/miscellaneous parts to integrate our components.

- Dimensions: the dimension constraint was very important to be mindful of while selecting our components. This is important for a number of reasons. Firstly, because available space on the bike is limited and we have to make sure we have adequate space to mount and install all components. Secondly, the dimensions of several of the components have an impact on speed and maneuverability of the bike, chiefly the solar panel and motor.

- Motor power: our device will be constrained by it’s available motor power because commercially available direct drive hub motors have a limited range of output power. Additionally, there is interplay between this constraint with the weight and cost constraints. This connection comes from the fact that a greater load will require a more powerful motor to reach comparable speeds, which usually means acquiring a motor at greater cost. Motor power will be constraint to 250-350W

- Battery capacity: the capacity of the rechargeable battery pack places a constraint on the implementable power consumption of our device if we want to maintain a desirable range per charge. Battery capacity will be limited to about 2600mAh

- Power generation: we are constrained in the amount of mileage that power generation can extend our range. Additionally, we are constrained by the available power generation options. This is due to the generation needing to be easily controllable to not interfere with Motor output.

- Safety: we are constrained by safety in the sense that safety must always be taken into account at every point in the project's design and execution. Furthermore, just because we might be able to be more aggressive in our design to boost performance, safety must always be paramount.

Related Standards	
CPSC	Consumer Product Safety Commission
DMV	Department of Motor Vehicles
FDOT	Florida Department of Transportation
SIG	Bluetooth Special Interest Group
IEC	International Electrotechnical Commission

CPSC:
Is a governmental agency which is responsible for the safety of consumer products, which includes e-bikes. They promote safety by developing uniform safety standards and examining possible product-related safety concerns.

DMV:
Is a governmental agency which is responsible for the registration of vehicles and licensing of drivers. They provide guidelines as to what is considered an e-bike and what thresholds a license is required to operate a given bike.

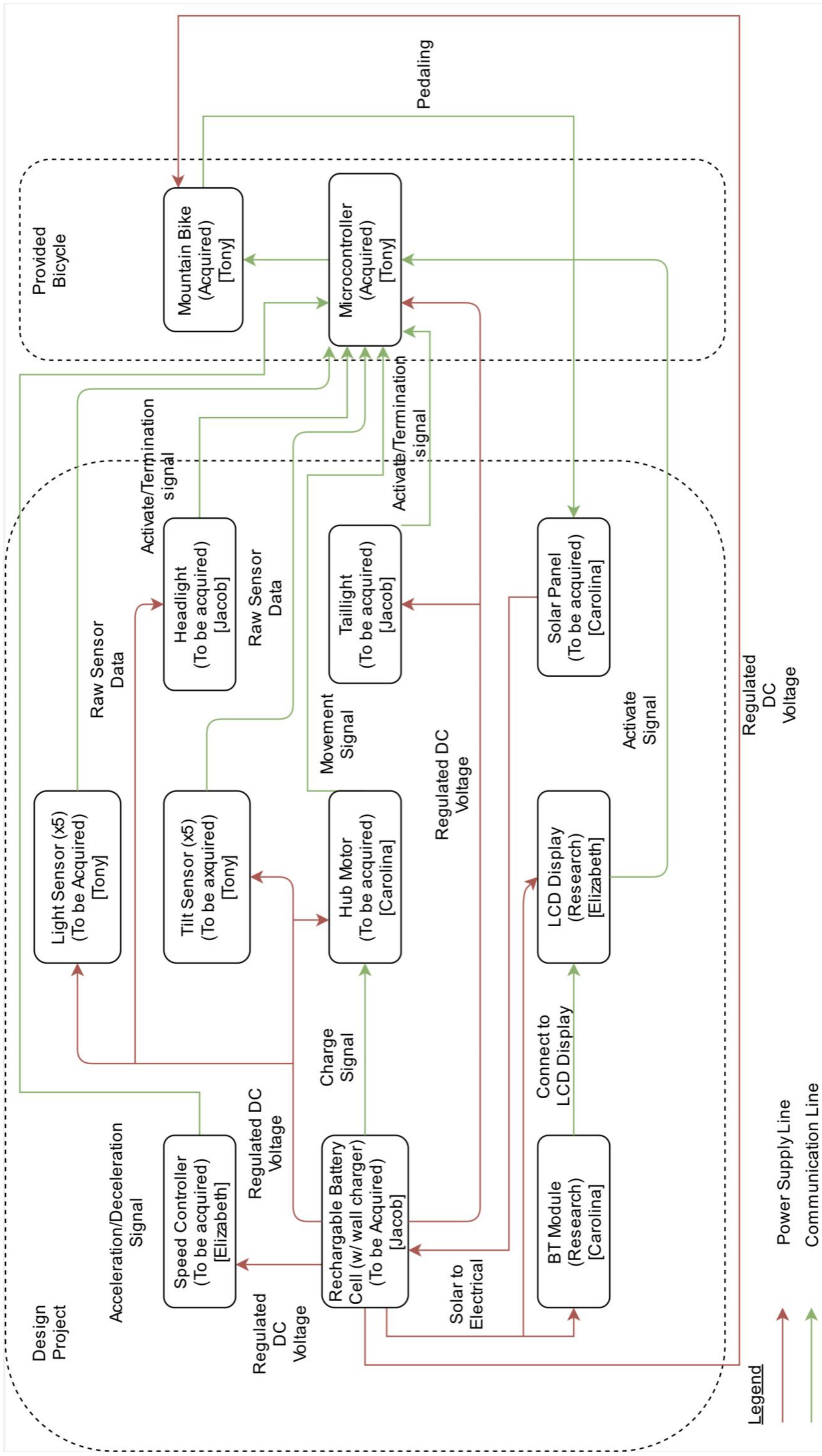
FDOT:

Is an agency which is responsible for the public transportation of florida, and the regulations surrounding transportation in the form of traffic laws.

SIG:
Is a non-profit organization that is responsible for the development of bluetooth standards and licensing of bluetooth technologies.

IEC:
Is an international organization that develops and publishes standards in a wide range of technology fields. They relate to our project because of the published standards in the battery field.

III. Diagram


Provided Bicycle
Mountain Bike (Acquired) [Tony]
Microcontroller (Acquired) [Tony]
Pedaling
Design Project
Light Sensor (x5) (To be Acquired) [Tony]
Tilt Sensor (x5) (To be axquired) [Tony]
Hub Motor (To be acquired) [Carolina]
LCD Display (Research) [Elizabeth]
Headlight (To be acquired) [Jacob]
Taillight (To be acquired) [Jacob]
Solar Panel (To be acquired) [Carolina]
Speed Controller (To be acquired) [Elizabeth]
Rechargable Battery Cell (w/ wall charger) (To be Acquired) [Jacob]
BT Module (Research) [Carolina]
Raw Sensor Data
Raw Sensor Data
Activate/Termination signal
Activate/Termination signal
Movement Signal
Regulated DC Voltage
Regulated DC Voltage
Regulated DC Voltage
Regulated DC Voltage
Activate Signal
Charge Signal
Connect to LCD Display
Solar to Electrical
Acceleration/Deceleration Signal
Legend
Power Supply Line
Communication Line

IV. Budget

Parts:

- Alomejor 36V/48V 250W/350W Brushless Motor Controller LCD Panel Kit E-Bike Conversion for E-Bike Electric Bike E-Bike ($101)
  https://www.amazon.com/Alomejor-Brushless-Controller-Conversion-Electric/dp/B07PDSS3ZD?dchild=1&keywords=Alomejor+36V/48V+250W/350W+Brushless+Motor+Controller&qid=1621659088&sr=8-6&linkCode=sl1&tag=jag35com05-20&linkId=5276d75b103c7ffda805730a678d3e4b&language=en_US&ref_=as_li_ss_tl

- 26" BAFANG 36V DC ELECTRIC FRONT BIKE WHEEL & TIRE W/ MOTOR + TEKTRO DISK BRAKE FOR DIY ($45)
  https://jag35.com/products/26-bafang-36v-dc-electric-bike-wheel-tire-w-tektro-disk-break?_pos=4&_sid=d35dc209f&_ss=r&utm_source=ebikeVideo

- NEW 42V 1.7A BATTERY CHARGER + MU CABLE BY XIAOMI ($34)
  https://jag35.com/products/new-42v-1-7a-battery-charger-power-cable-genuine-xiaomi?_pos=5&_sid=f621b5bd2&_ss=r&utm_source=eBikeVideo

- 30-CELL 36V 8A, SCOOTER BATTERY PACKS ($45)
  https://jag35.com/products/30-cell-36v-10a-scooter-battery-packs-working?utm_source=eBikeVideo

- Bicycle
  https://www.rei.com/rei-garage/product/797365/scott-contessa-50-mountain-bike-womens

- HiLetgo HC-05 Wireless Bluetooth RF Transceiver Master Slave Integrated Bluetooth Module 6 Pin Wireless Serial Port Communication BT Module for Arduino ($9)
  https://www.amazon.com/HiLetgo-Wireless-Bluetooth-Transceiver-Arduino/dp/B071YJG8DR/ref=sr_1_1_sspa?keywords=bluetooth+module&qid=1643319593&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExUDFEMUU1MlJTRDlWJmVuY3J5cHRlZElkPUEwMDYzNzI0RDBZVzU0TDRXMk1VJmVuY3J5cHRlZEFkSWQ9QTA2ODEwNTEyOVdNT0gwQllPMzJTJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==

- 100 Watt 12 Volt Monocrystalline Solar Panel (Compact Design) ($100)
  https://www.renogy.com/100-watt-12-volt-monocrystalline-solar-panel-compact-design/?gclid=Cj0KCQiAosmPBhCPARIsAHOen-OjLKSYiPhNOgIutjv3nyEpwnIEGXGZot9KHxI5-kctSDW_ttdKBdkaAthTEALw_wcB

Description	Weight (kg)	Cost per	Status	Remaining Cost
Mountain Bike	14.5150	$399.93	Acquired	$0.00
LCD	0.2500	$9.19	Acquired	$0.00
Microcontroller	0.0250	$23.80	Acquired	$0.00
Speed Controller	0.5850	$39.99	Pending	$39.99
Rechargeable battery cell (w/ wall charger)	1.5876	$65.00	Pending	$65.00
Hub Motor	3.3000	$45.00	Pending	$45.00
Headlight	0.2000	$18.99	Pending	$18.99
Taillight	0.1200	$16.99	Pending	$16.99
Solar panel	0.2495	$13.99	Pending	$13.99
BT Module	0.0035	$8.59	Pending	$8.59
light sensor (x5)		$6.89	Pending	$6.89
tilt sensor (x5)	0.0357	$9.99	Pending	$9.99
Sums	**20.8713**			**$225.43**

V. Milestone Discussion

This section will illustrate the time and due dates from the initial stage of Senior Design 1 down to the final presentation time of Senior Design 2.

Semester	Task	Due Date
Senior Design 1		
	Idea	01/14/ 2022
	Project Selection	01/24/2022
	Research, Design, and Documentation	01/31/2022
	Initial Document Divide and Conquer 1.0	02/04/2022
	Review Document	02/11/2022
	Updated Divide and Conquer 2.0	02/18/2022
	Review Document	03/17/2022
	60 page Draft Document	03/25/2022
	Review Document	04/01/2022
	100 page Report Submission	04/08/2022
	Order Parts	04/08/2022
	Review Document	04/20/2022
	Final Document	04/26/2022
Senior Design 2		
	Assemble	May/2022
	Testing	May/2022
	Committee Selection	June/2022
	Final Presentation	June/2022

VI. Decision Matrix

When selecting our project idea, we had to evaluate different factors of each potential idea in order to pick the most suitable project. Some of the ideas we considered were smart e-bike, a sand-cleaning robot, and a smart home assistance system.

A. Time: one of the main elements we had to consider was the time it would take us to develop our project. We looked at the different components for each idea and we concluded that the smart e-bike could be done within the time frame given for our Senior Design 1 and 2 project.

B. Budget: since we are not looking for sponsorship, our project will be founded by the group members. Having this in mind, we had to look for ways to keep our costs low. After some research, we found that a lot of the parts required to build our smart e-bike can be refurbished since a lot of them already exist in the market.

C. Accessibility: after considering the possible parts that our ideas would require, acquiring the different parts for the smart e-bite turned out to be feasible compared to some of the parts we would need to develop our other ideas.

D. Motivation: one of our main goals for our idea was to work on a project that would help the environment. The sand-cleaning robot had good potential as it could be used to clean Florida beaches. The smart e-bike is also an eco-friendly project as we could achieve a reduction of carbon dioxide emissions.

Below we will find a decision matrix we used in order to pick the most suitable project idea. We ranked each fact from low to high:

Project Idea	Time	Budget	Accessibility	Motivation
	-	-	+	+
Smart e-bike	moderate	low	high	high
Sand-cleaning robot	high	moderate	moderate	high
Smart home assistance system	high	high	high	moderate

VII. Work Cited

1. “The Paris Agreement.” *Unfccc.int*, United Nations, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
2. MacArthur, John, Jennifer Dill, and Mark Person. "Electric bikes in North America: Results of an online survey." *Transportation Research Record* 2468.1 (2014): 123-130., https://journals.sagepub.com/doi/abs/10.3141/2468-14
3. Apostolou, Georgia, Angèle Reinders, and Karst Geurs. "An overview of existing experiences with solar-powered e-bikes." *Energies* 11.8 (2018): 2129., https://www.mdpi.com/1996-1073/11/8/2129