Project Proposal for ECE 445
Spring 2019

Project Title : Safe-Walk Hat for people with visually impaired

Team # 72
Woo Young Choi (wchoi19) / Yong Jun Lee (ylee168)/Tae Hwa Kim(tkim142)
Assigned TA : Dongwei shi
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1. Introduction

1.1 Objective

There is a high chance that people with vision impairment or blindness would get involved with traffic accidents including collision accidents with bicycles. According to a research, Are Normally Sighted, Visually Impaired, and Blind Pedestrians Accurate and Reliable at Making Street Crossing Decisions written by Shirin E. Hassan, there are two decision variables to consider in order to cross a street safely; the time that it will take them to cross the street; the time available before the next vehicle reaches them[1]. Compared to people with normal vision, visually impaired people or people with blind disability recognized 12% fewer crossable gaps, and made 23% more errors by estimating a gap as crossable[2].

The chance that people with blind disability get involved with accidents has been increased since electric automotives, which does not make any noise even on the road, started to draw people's attention because global warming is one of biggest problems needed to be solved around the world. People with vision trouble will have more difficult time to safely cross a street as the number of electric automotive keeps increasing. For example, the number of electric automotive increased from 160,000 in 2016 to 280,000 in 2017 in the united states, and is estimated to keep increasing in the future[3]. Furthermore, the number of people using bicycles which poses a danger to people with blind disability in the U.S has been also increasing from 36 million to approximately 48 million since 2006[4].

1.2 Background

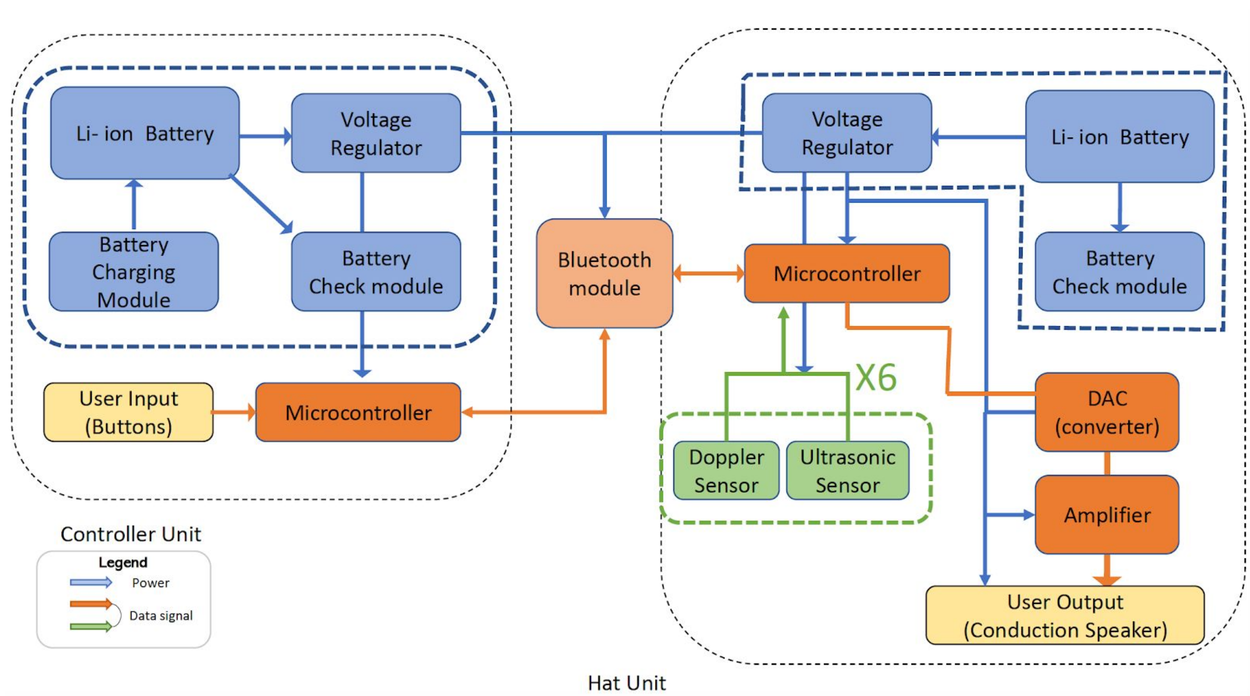
There are several ways to support people with vision trouble walking; First, a cane; Second, a guide dog and a cane. Of course, those two methods are also effective to walk around the outside, but the problem is that both of methods are just to detect unknown objects near a person who uses them. Both methods do not have an ability to prevent accidents from happening. There are many products of comfortable canes or of training a service dog, but there is no such products on the market that protect people with vision trouble from accidents and allow visually impaired people to cross a street safely and to walk around without exposing themselves to a danger. To protect people with visually impairment from any accident, we thought of a device that notifies people with visual impairment when an object with higher speed than people is approaching. Here is a brief explanation of the solution. The solution includes two components. First component is a hat integrated with six doppler radar sensors and six ultrasonic sensors, and facing six different direction, so that sensors can cover 360 degree. Second component is a bone conducting speaker located in the device. If an object with higher speed than people is coming behind toward people with visual impairment, the device calculates the speed and direction of the object coming, determines level of danger, and sends a signal to the speaker to notify users.

1.3 High-Level Requirement List

- The range of detection component, including doppler radar sensors and ultrasonic sensors, will be approximately 4 meters.
- Six of the doppler radar sensors and six of the ultrasonic sensors must be able to detect an object in 360 degree.
- The doppler radar sensors must be able to detect a speed of an object from 5 m/s to 60 km/h

2. Design

2.1 Block Diagram



2.2 Block Description

2.2.1 Component description, requirements and verifications

a hat unit manages the battery storage, checks the remaining battery, receives the data input from the Bluetooth module, and alerts the user by calculating speed and distance of an approaching object.

- **Microcontroller** : a microcontroller, chosen to be ESP 32, communicates with cell phone using the bluetooth module integrated in the microcontroller. One of the reasons, that ESP 32 is chosen, is the number of GPIO pins. To detect an approaching object toward a user correctly, the product might need some more sensors to enhance accuracy, or to add extra features later. This micro controller operates at voltage from 2.3 V to 3.6 V. Its recommended current is 500 mA.

Microcontroller	Requirement : - The microcontroller must be able to output 5 V ± 5% and 15 ~ 30 mA - The microcontroller must have at least 12 GIPO pins to support all of our sensors - The microcontroller must be integrated with Bluetooth module in order to communicate with any android cell phone.
	Verification : - Connect the sensors to the microcontroller, and measure the output voltage and current using a multimeter to make sure that the sensors get enough voltage and current to operate - Check the datasheet of the microcontroller so that it has enough GIPO pins to support at least 12 sensors - Check the functionality of the Bluetooth module by connecting an android cell phone

- **Doppler radar sensor** : Six HB100 has been chosen for doppler radar sensor. The doppler radar sensors detects the speed of an object approaching, and sends the data to the microcontroller.

Doppler radar Sensor	Requirement : - The microwave sensor should detect an object at least 3 meters away - The microwave sensor must be able to detect an object that is moving from 1.4 km/hour to 60 km/hour
	Verification : - Connect the ultrasonic sensor to the power source, then measure the velocity of an moving object that is at least 3 meters away from the sensor. Vehicle is going to be used as an moving object in order to test the measuring functionality of the sensor, because it is equipped with a speedometer.

- **Ultrasonic sensor** : a ultrasonic sensor, chosen to be HC-SR04, detects the distance of an approaching object, and sends the data to the microcontroller. This sensor is able to measure the distance from 2 cm to 4m. The measuring degree of HC-SR04 is 30 degree, but the effectual measuring degree of the sensor is less than 15 degree.

Ultrasonic Sensor	Requirement : - The ultrasonic sensor should detect an object at least 3 meters away from the sensor - The sensor must accurately detect an object within range of 50 ~ 60 degrees
	Verification : - Connect the ultrasonic sensor to the power supply, and measure the distance of an object using ultrasonic sensor - Measure the actual effectual angle of the ultrasonic sensor

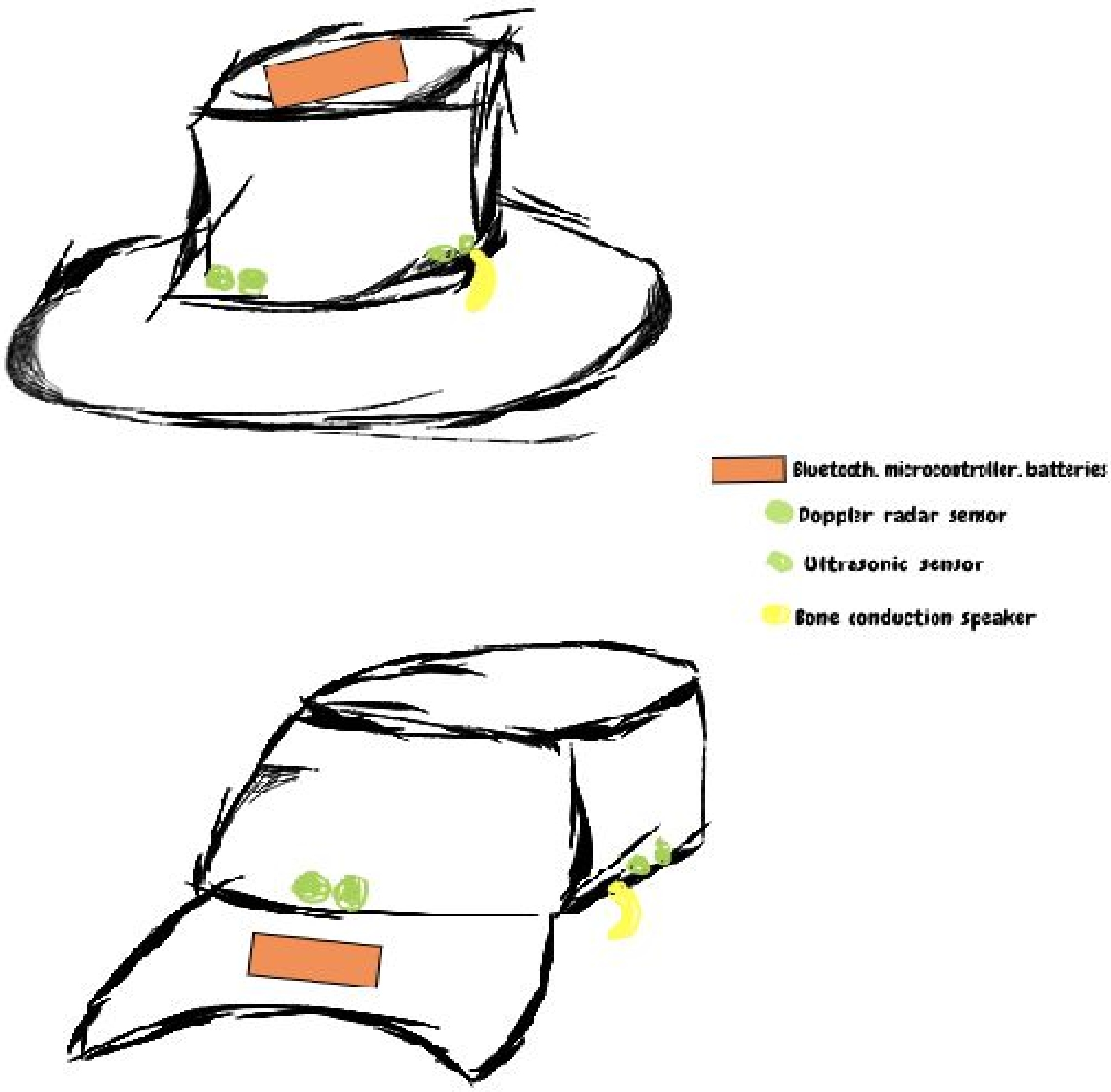
- **Power supply module** :The power supply module must include a rechargeable battery that supplies power to the microcontroller. The power source must be able to supply power over 6 hours. That is why 5 V Li ion battery is chosen. And the Buck-Boost converter, included in the power supply module, must be able to convert 5 V to 3.3 V± 5% to run the microcontroller.

Power Supply Module	Requirement : - The Buck-Boost converter must be able to supply 3.3 V± 5% and 500 mA ± 5% - The battery must last over 6 hours
	Verification : - Measure the voltage and current of the battery using a multimeter to ensure the output voltage and current are not over 3.6 V and 550 mA - Connect the all the microcontroller and sensors, then measure time of operation until battery dies

- Speaker : a bone conduction speaker that can fit inside of the product. That is why Bone Conductor Transducer with wires is chosen. The dimension of the speaker is 14 mm x 21.5 mm. This speaker consumes 1 watt.

Speaker	Requirement : - The speaker should be able to conduct the vibration that is equivalent to loudness of 60~65 decibel.
	Verification : - Check the loudness of the speaker by using it. Loudness of normal conversation (60~65 decibel) is good enough.

2.3 Physical Design of the product



Physical design sketch

The physical design, shown above, will consist of a hat, a bone conduction speaker, 4 doppler radar sensors, 4 ultrasonic sensors, bluetooth module, battery, and a microcontroller. The speaker, sensors, battery, microcontroller and a bluetooth module would be protected from water and dust. Bluetooth, battery and a microcontroller would be placed beneath the top part of the hat if we go with the first sketch and they would be placed under the brim of a cap if we go with the second sketch.

2.4 Risk Analysis

There are two blocks that pose the greatest difficulty to implement this project. First is finding an perfect angle in order to detect 360 degree. Second is a way to identifying joggers from bicycles and automotives.

Appropriate angle : it will be difficult to define perfect angles of doppler radar sensors and ultrasonic sensors that detect an approaching object toward users with minimum error.

Identification : it will be difficult to distinguish joggers from bicycles, automotives and bikes. Of course, average people walking pace is 1.4 m/s, but there is a special situation that some people sprint or run. Changing a range of speed detection of doppler radar sensors can solve the problem; there, however, is a case that a car, bicycle or bike is moving slowly.

3. Ethics

We, the members of IEEE, acknowledged the 7.8 IEEE code of ethics, and are not going to do any acts that violate the ethics code. The project is to protect visually impaired people from accidents occurring, to provide more safety to people with vision trouble, and to give them more mobility outside. We believe that out product is designed “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger” the people with visual disability. (IEEE Code of ethics, #1) “To avoid injuring others, their property, reputation, or employment by false or malicious action,” we will definitely address any possible risks, harms, or dangers to end users in details, so that our product does not put any people with visual disability in a harm’s way. (IEEE Code of ethics, #9) In order to act in accordance with IEEE Code of ethics, #7, our team is also going to take notes thoroughly on the procedure of the development and implementation “to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.” Furthermore, to be more adhered to IEEE ethics code, every team members are willingly going to help each other even if it is not his own task to work on. For these reasons, we believe that there is no ethical concerns.

4. Safety Issue

Our project has few risks needed to be taken care of. The device is designed to be a outdoor-purpose device, dust and moisture could damage the device, which is consisted with microcontroller, several sensors, batteries, and a small circuit. In other words, the device for our project has to be dust and waterproof. That is the reason that the device will be designed under IP64 guideline, which is protected from total dust and protected from water spray from any direction.   (source : http://www.dsmt.com/resources/ip-rating-chart/)

Another safety issue is concerned with rechargeable Li-ion batteries. Li-ion batteries may explode and cause fire if mishandled. If the batteries are mishandled when it is being used or being charged, internal short circuit can cause enough heat to damage the components around and even hurt users. To prevent possible safety hazards, batteries will thoroughly be checked and tested in the manufacturing process.

5. Cost and Schedule

5.a Cost

Labor

We consider the University of Illinois at Urbana Champaign ECE graduate average starting salary is $45/hour. We have three group members in total and we estimated 10 hours/week as a weekly time effort.

$$3 \ * 2.5 \ * \ \$45/hour \ * 10 \ hour/ \ week \ * \ 12 \ weeks \ = \ \$ \ 40,500$$

Parts

Part	Cost
Microcrontroller x 2 : ESP 32 (3.3 V, 500mA, *Espressif Systems)*	$\$3.96 * 2 = \$7.92$
Doppler radar sensor x 6 : HB100 (1.2mA~4mA with 3 to 10% duty cycle pulse at 5v, *ST Electronics*)	$\$5.83 * 6 = \$34.98$
Ultrasonic sensor x 6: HC-SR04 (5V and current 15mA, *Sparkfun*)	$\$1.93 * 6 = \$11.58$
Li-ion Battery x 4 : (<5V and 100mA, last over 6 hours, rechargeable, LiFePO4 3.2V 1500mAh, *AA Portable Power Corp*)	$\$3.75 * 6 = \$22.5$
Speaker (Bone Conductor Transducer with Wires - 8 Ohm 1 Watt, *adafruit*)	$8.95
Total	$85.93

The total development cost becomes $\$40,500 + \$85.93 = \$40,585.93$.

5.b Schedule

<table>
<tr><th>Week</th><th>TaeHwa Kim</th><th>YongJun Lee</th><th>WooYoung Choi</th></tr>
<tr><td>2/11</td><td colspan="3">Research on the project</td></tr>
<tr><td>2/18</td><td>Power test for sensors</td><td colspan="2">Research on Bluetooth module and modify design</td></tr>
<tr><td>2/25</td><td colspan="2">Begin schematic design</td><td>Research on bluetooth API</td></tr>
<tr><td>3/4</td><td colspan="2">Finish schematic design and order PCB</td><td>Research on bluetooth API</td></tr>
<tr><td>3/11</td><td></td><td>First round PCB order</td><td>Start programming for bluetooth module</td></tr>
<tr><td>3/18</td><td colspan="2">Second schematic design (if needed) & work on building up the device</td><td>Continue on programming and debugging</td></tr>
<tr><td>3/25</td><td>Final PCB order</td><td>Continue on building up the device</td><td rowspan="2">Programming and merge the circuit with software</td></tr>
<tr><td>4/1</td><td colspan="2">Work on finalizing circuit and sensors</td></tr>
<tr><td>4/8</td><td colspan="3">Mock demo prep/ debug</td></tr>
<tr><td>4/15</td><td colspan="3">Mock demo/ Bug fix</td></tr>
<tr><td>4/22</td><td colspan="3">Prepare for the presentation and write final report</td></tr>
<tr><td>4/29</td><td colspan="3">Final presentation/Final report</td></tr>
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6. Citations and References

1. Shirin E. Hassan, “Are Normally Sighted, Visually Impaired, and Blind Pedestrians Accurate and Reliable at Making Street Crossing Decisions?,” 2012. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3358127/#i1552-5783-53-6-2593-b04

2. Wilmer Eye Institute, “Traffic gap judgment in people with significant peripheral field loss,” 2008. https://www.ncbi.nlm.nih.gov/pubmed/18174838

3. Matt Pressman, “Over 3 Million Electric Cars On The Road — You Driving One Yet?,” 2018.https://cleantechnica.com/2018/07/03/over-3-million-electric-cars-on-the-road-you-driving-one-yet/

4. Statista, “Number of participants in bicycling in the United States from 2006 to 2017 (in millions),” 2017. https://www.statista.com/statistics/191204/participants-in-bicycling-in-the-us-since-2006/

5. Theorycircuit, 2018. http://www.theorycircuit.com/hb100-microwave-motion-sensor-interfacing-arduino/

6. https://www.youtube.com/watch?v=H9TdEP94LeI

7. ST Electronics, “X-abnd Microwave Motion Sensor Module,” https://www.limpkin.fr/public/HB100/HB100_Microwave_Sensor_Application_Note.pdf

8.https://www.amazon.com/Generic-Surface-Conductor-Transducer-Exciter/dp/B00Y8ISYHG

9. Espressif Systems, 2019, https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf