Bluetooth Enabled E-Walker

ECE 445 Project Proposal

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1 Introduction

1.1 Problem

Walkers are primarily used by people over 65 years old with musculoskeletal or neurological problems. Some conditions that require a person to use a walker include arthritis and Parkinson's disease. When a person uses a walker, one or both hands are occupied supporting themselves with the walker which makes it more difficult to access smartphone features in times of emergency. In recent years, more devices have become smart devices paired with our smartphones for additional features, but walkers and walking canes have been left behind. When looking for existing solutions, we have found some canes that support lighting and charging, but none with IoT. We believe this is the next logical step in innovation to support people with conditions that struggle to interface with touch screen displays.

1.2 Solution

Our solution is to bridge the gap between features that would be used on a smartphone in times of emergency and walker aids themselves. We will be implementing an easily accessible contact system on the walker that can be used in an emergency situation where time is of the essence and the user might struggle to use their smartphone. This includes a connection between the walker and a smartphone via bluetooth allowing for a 911 call as well as texts and calls with two specific contacts. These will be prompted through push buttons and when the walker detects a fall or emergency situation.

1.3 Solution Visual Aid

Figure 1: Bluetooth Enabled eWalker Visual

1.4 High-Level Requirements List

Button Functionality

Our push buttons must be able to initiate calls and texts to two configured contacts as well as calls to emergency services such as 911. There will be one isolated button for emergency services and four other buttons organized in sets of two buttons per contact for calling and texting each configured contact.

Messaging System

Our messaging system must be able to send different text messages based on the severity of the situation. For example, if the walker is in a fallen orientation, an automated text would indicate a fall and request urgent help. If the walker is in an upright orientation, the text will be less severe and request a call or assistance when available.

Power Unit

The power unit of our design will be capable of charging up to two devices through a USB Port in addition to the battery, and providing power to the control unit of the design which handles the interface between systems as well as communication in emergency situations.

Location Services (Time Permitting)

If time is available while working through the design, GPS location services will be utilized to send a location through our text messaging system.

2 Design

2.1 Block Diagram

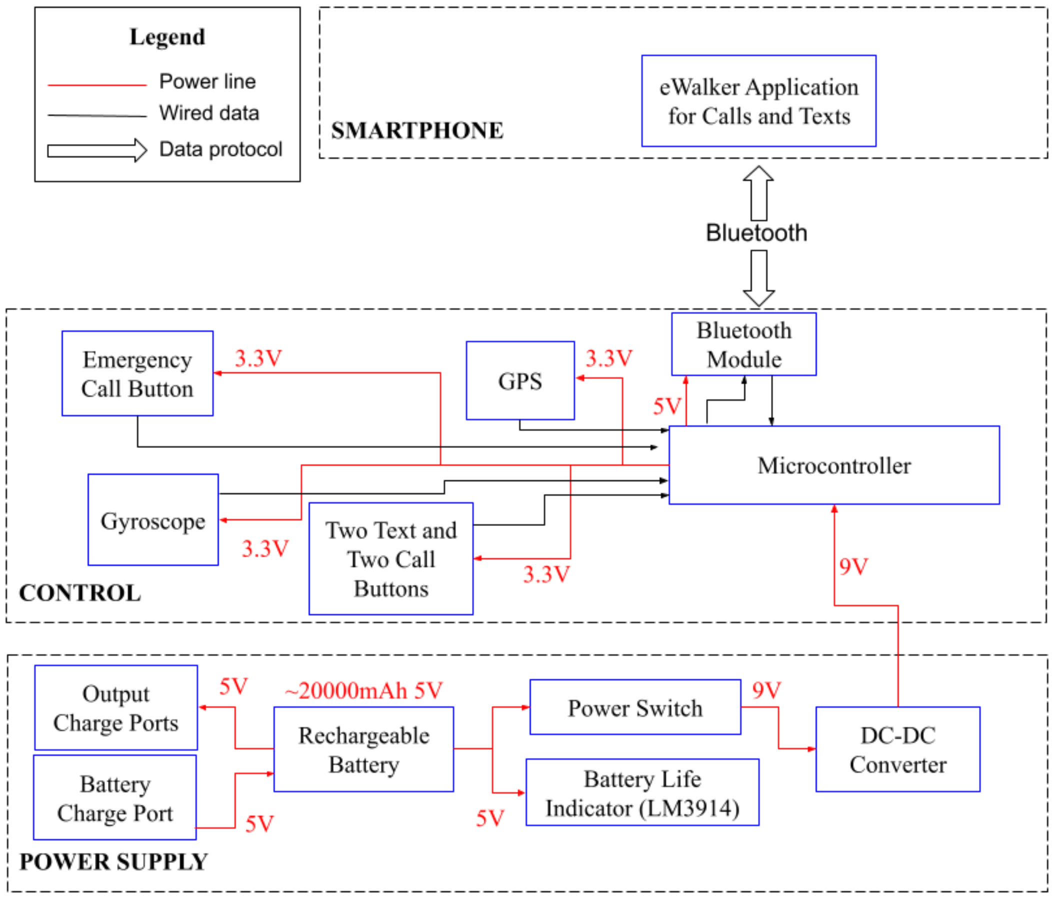

Figure 2: Block Diagram

2.2 Subsystem Overview

2.2.1 Smartphone (Physical Components Out of Scope)

- The smartphone pairs with the Bluetooth module that is part of the control system so data can be received and utilized to trigger calls or text messages on the smartphone. The smartphone must also send Bluetooth data so contacts can be configured on the control system.

Requirement 1: The smartphone must have Bluetooth connectivity and be able to pair to a Bluetooth device.
Requirement 2: The smartphone must have a SIM card that can access a cellular network.

2.2.1.1 eWalker Application for Calls and Texts

- When the Bluetooth module sends over the correct data indicating a text message or phone call should be made, the eWalker application will trigger text messages and phone calls through an external service with an API. Initiating a phone call or text message directly with the smartphone through Bluetooth requires special approved permissions with smartphone manufacturers that our team might not have access to, so we will likely be utilizing this alternative approach.
- *Requirement 1: The eWalker application must be able to read Bluetooth data sent from the paired Bluetooth module on the control system.*
- *Requirement 2: The eWalker application must be able to send Bluetooth data to the Bluetooth module on the control system.*
- *Requirement 3: The eWalker application must be able to process the Bluetooth data and upload this data to an external web service application that can trigger phone calls and text messages.*

2.2.2 Control

- The control unit collects data from sensors or inputs like the GPS, the gyroscope, and the five total input buttons and stores this data into the microcontroller where the data is processed. The processed data will first be formatted in the Bluetooth protocol in the microcontroller and then sent over to the smartphone with the Bluetooth module.
  Requirements: Requirements for control system are divided by sections below.

2.2.2.1 Microcontroller

- Arduino Uno

    - The Arduino Uno collects and processes data from the GPS, button PCB, and gyroscope. The Arduino Uno will also power the sensors and inputs that it collects data from and the Bluetooth module. The Arduino Uno will format the processed data into a serial packet that can be transmitted by the Bluetooth module.
      Requirement 1: Collect and store serial data from GPS, PCB, and gyroscope.
      Requirement 2: Take 9V input and provide 3.3V outputs to each sensor and input.
      Requirement 3: Compute a serial packet with proper heading and block information required for Bluetooth communication.

- PCB
    - The PCB will also act as a microcontroller. It will be specific to our power system and push buttons used for calling and texting. For the power system, it will help control the stability of our circuits in terms of overcurrent and overvoltage protection.
    - *Requirement 1: PCB will be able to detect instability in the power system to prevent any major damages and overcharging.*
    - *Requirement 2: PCB will be able to transmit the high signal from the push buttons to the Arduino Uno to signal call and text functions*

2.2.2.2 Bluetooth Module

- The HC-05 Bluetooth module allows for two way Bluetooth communication and is compatible with the Arduino Uno. The HC-05 Bluetooth module will read the prepared packet as serial data on Pin 5 which is the RX receiver. This pin allows serial data to be transmitted via Bluetooth. [1] The Bluetooth module will also receive transmitted data from the smartphone and send the serialized data to the microcontroller.
  Requirement 1: 5V Power requirement is fulfilled by the microcontroller.
  Requirement 2: Transmits packet received from microcontroller without packet loss.

Requirement 3: Successfully receives packet from smartphone that can be deciphered for contact information by the microcontroller.

2.2.2.3 GPS

- The GPS NEO-6M module will utilize satellite data to find its current position. The GPS module will be placed in a fixed position near the top of the enclosure so the data is accurate and the module can receive proper connection. Power for the GPS module will be supplied by the Arduino Uno. Data from the GPS will be sent to the Arduino Uno pin utilizing a USB-TTL cable.
  Requirement 1: Data must be successfully transferred from USB to TTL serial data so the Arduino Uno can accurately read the coordinates.
  Requirement 2: 5V must be supplied to the GPS NEO-6M module to successfully power the system.

2.2.2.4 Two Text and Two Call Buttons

- All four buttons will be the E-Switch TL1105AF100Q model. These buttons will be mounted on the horizontal bars directly below the handles of the walker. The two buttons on the left side will prompt a call and text for one configured contact, and the two buttons on the right will be for the other configured contact. These buttons will interface with PCB to prompt calls and customized text messages from the cellphone through the bluetooth module.
- *Requirement: Pressing these buttons should output a high signal that can be read by the microcontroller which would initiate the desired call or text function.*

2.2.2.5 Emergency Call Button

- This button will be used specifically to call an emergency contact such as 911. The emergency call button will be the Grayhill 4001 SPST normally open 1 Amp push button, and it will be mounted on the center rail of the walker to the left of the phone mount. This button will also interface with the PCB to prompt a call from the cellphone through the bluetooth module.
- *Requirement: Pressing this button should output a high signal that can be read by the microcontroller which would initiate the desired emergency call.*

2.2.2.6 Gyroscope

- In order to implement the gyroscope, we will be using the GY-521 MPU6050 model from HiLetGo. It is a 6-axis accelerometer gyroscope sensor (ie. 3 axes each for the accelerometer and gyroscope). This will be placed on a mounted breadboard within the enclosure shown on Figure 1 above in order to detect the orientation of the walker. It will interface with the microcontroller and bluetooth module to prompt an emergency call and text when necessary.
- *Requirement 1: The model should be able to detect orientations from straight and upright to horizontal on all sides.*
- *Requirement 2: The model should be able to withstand any sudden movements or collisions the walker may encounter.*

2.2.3 Power Supply

- The power supply consists of a rechargeable battery that is able to deliver power to the Arduino system and up to two external devices There are a total of three power ports: one charging input port to the battery, and two output charging ports to external devices. A power switch for the DC-DC converter is used as a way for the user to power on the Arduino system. Lastly, the battery is connected to a LM3914 to display the state of charge of the battery.

2.2.3.1 Rechargeable Battery

- To make a rechargeable battery pack that is at least 20000mAh, we will make use of eight 18650 lithium 3.7V 2600mAh batteries in parallel. The 18650 batteries have a nominal voltage of 3.60V so a voltage regulator will be used to output 5V for the entire pack. The voltage regulator in use will be a L78S05CV, to step up the 3.6V voltage of the battery pack to 5V and output 2A.
- *Requirement 1: The 18650 8P battery pack must have 20,800 mAh +/- 5% capacity with a nominal voltage of 3.6V.*
- *Requirement 2: The battery pack must output 5V +/- 5% at 2A +/- 5% to account for fast charging.*

- *Requirement 3: The battery pack must have easily removable batteries in the case of cell or charging failure.*

2.2.3.2 Battery Charging Port

- To ensure that the lithium battery pack charges safely and efficiently, we will use one BQ2057 IC per lithium battery. Each IC, rated for max 15V input, is able to manage the voltage and current when each cell is being charged by the supply voltage, as well as battery temperature. The voltage input to the ICs will be supplied through a USB Type C port.
- *Requirement: The charging port must not operate or charge the battery pack when any of the lithium batteries are 4.2V.*

2.2.3.3 Output Charge Ports

- Having 5V and 2A for 10W charging, each of the two USB Type A ports will be built with overcurrent and overvoltage protection.
- *Requirement 1: The output charge port must not operate when any of the lithium batteries are below 3.2V.*
- *Requirement 2: The output charge port must be able to safely charge various smartphones while maintaining device functionality.*

2.2.3.4 Power Switch

- To turn on the system, we will use an SPST illuminated rocker switch that has the light on when the system is powered, and off when the system is disconnected. For added safety, we will also use a 5V 2A fuse if the voltage regulation is not correct to break the connection to the battery pack to protect the DC-DC converter, control system, and the battery pack itself.
- *Requirement 1: The power switch safely disconnects the battery from the DC-DC converter.*
- *Requirement 2: The fuse will blow if the battery pack malfunctions and provides a current beyond the specified rating.*

2.2.3.5 DC-DC Converter

- To power the Arduino, we will use the LM2734 DC-DC switching regulator for the voltage regulated 5V output from the lithium battery pack to become 9V with a max current draw of 1A. The 9V supply allows use of the Arduino's onboard features as most of the control unit uses the 3.3V from the Arduino board itself. When components are used with the Arduino, the maximum draw is rated to be 1A. We want to have sufficient input voltage and current to the Arduino for various loads.

- *Requirement: The DC-DC switching regulator must provide 9V +/- 5% with maximum 1A draw from the Arduino using the 5V regulated battery pack output.*

2.2.3.6 Battery Life Indicator

- To display the current charge of the battery, we will use a LM3914 paired with a 10 segment LED bar graph display.
- *Requirement: The SoC of the entire lithium battery pack is displayed with each LED representing 10% charge.*

2.3 Tolerance Analysis

The main constraints of our design will be the battery life and battery sizing. We will have to ensure our battery will be able to supply enough power to all of our subsystems as well as last for at least one day. We want to minimize the possibility of having to charge the walker during the day while the user may be away from outlets or away from their charger in general. The calculations for ensuring the correct battery size and desired battery life are shown below. The main components drawing power from our battery will be the output charging ports, the battery life indicator LEDs, and our microcontrollers which are powering the rest of the control system. The walker will have a power switch which will help to save battery, but we will be analyzing how long a fully charged walker can be functional without being turned off.

Table 1: Power Draw Calculation Table

Components	Arduino Board	Charging Ports	Bluetooth	GPS	Gyroscope	LED Bar Graph
Current Draw (A)	25m	2000m(2A) per port	30m <100m	100m	3.6m	300m
Voltage Draw (V)	9	5	5	5	3.3	2.1
Power Draw	0.225W	10W per port	.15W min .5W max	0.5W	0.01287W	0.63W

The 18650 3.6V 6P battery pack has 20800 mAh capacity and full state of charge is at 4.2V. This results in 87360Wh capacity.

- With no charge ports active, the power draw ranges from 1.52Wh to 1.86Wh.
- With one charge port active, the power draw ranges from 11.52Wh to 11.86Wh.
- With two charge ports active, the power draw ranges from 21.52Wh to 21.86Wh.

Using no charging ports yields a very long running time for the walker system. The total current draw ranges from 458.6mA to 558.6mA, and with a battery capacity of 20800mAh, the system is able to continuously operate between 37 and 45 hours, which is approximately almost 2 days.

- In the scenario of continuous one port charging, the total current draw ranges from 2458.6mA to 2558.6mA, resulting in system operation that is approximately 8 hours.
- In the scenario of continuous dual port charging, the total current draw ranges from 4458.6mA to 4558.6mA, resulting in a system operation that is approximately 4.7 hours.

3 Ethics and Safety

We plan to be very diligent in following the IEEE and ACM Code of Ethics throughout the creation of our Bluetooth Enabled eWalker. Safety is of the utmost importance in creating a new design without much precedence as there are many unexpected dangers that can occur. As a result, we will follow IEEE I.1 which references the safety, health, and welfare of the public. [2] The privacy of users and possible test subjects will be protected as we will not be storing any user contact information for any intention outside of the purpose of emergency calls. Unsolicited phone calls and text messages using user information will also not be made.

Proper precautions will be taken with wiring as well as voltage and current analysis of the power system. This will also follow the ACM Code of Ethics section 2.9 which requires the design and implementation of products that are secure and robust. [3] Our batteries will be analyzed intently to ensure safe working voltages and currents, and they will be tested with care to prevent any explosions and leakages that can endanger the public.

We will also be sure to seek and accept constructive criticism during the design and construction process while also awarding the proper credit to those involved as outlined in IEEE I.5. [2] Being honest and trustworthy with our TAs and professors both in our procedure and data acquisition is also a requirement for us following ACM Code of Ethics section 1.3. [3]

Finally, effective teamwork is paramount to the success of our Bluetooth Enabled eWalker, so we will ensure that we are not engaging in any discrimination of any type and treating all persons and parties fairly and with respect.[2]

References

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[7] Texas Instruments, “Advanced Linear Charge Management IC for Single and Two-cell Lithium-Ion and Polymer,” BQ2057 Datasheet, May 2001 [Revised July 2002].