ECE 388: Embedded Systems Design Project
Wheelchair Control and Safety

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Abstract

This report consists of the breakdown of wheelchair control and safety project. It highlights the progress that has been made since the start date, as well as gives an overview of the requirements, components, and goals of the system. Test plans for each of the components at hand have been included along with a compilation of each team member's contributions to the project.

1 Introduction

Prototyping is a major and very important aspect of every major project or any project for the matter. It is an import step in ensuring the success and the completion of the project. This specific project is designed to amplify the safety of a wheelchair, and to do so many outside components have to be implemented in the chair. These components include several sensors as well as a Joystick, an H-Bridge, Digital Accelerometer, as well as a Voice Recognition. Each component will play a key part in ensuring the maximum level of safety for the chair, which is the main goal of the project. During the prototyping stage, each of these components will be tested separately as well as in conjunction with each other to see the outcome of each as well as how each component reacts and works with each other. The data collected will be compared with the expected results gathered from each components data sheet.

2 Concept of Operation

This wheelchair should be able to operate and do all the functions that a regular electric wheelchair should be able to do. In this design, the wheelchair has two forms of operation. The main operation is through a joystick which allows the user to turn in any direction the joystick is pushed. The second operation is through voice commands that allow the user to speak to wheelchair to execute movement and other commands. The wheelchair also contains advanced safety features through sensors. There is a pressure sensor that detects the weight of the user on the chair and acts accordingly if the user is suddenly ejected from the chair. There are proximity sensors at two different angles. These sensors are on the front and back of the wheelchair. One is angled 90 degrees to detect anything directly in front or behind the wheelchair. The other's angle has yet to be determined and will be determined through trial and error. However, the sensor will be pointed roughly around 20 degrees so the wheelchair can detect cliffs and any ground obstacles. There is also an accelerometer on the wheelchair. This is done so that if the wheelchair is accelerating at too fast of a pace the motor can be throttled so that the user does not lose control of the wheelchair. The wheelchair also features toggle-able LEDs on the side as a safety feature for night time use.

2.1 Hardware

This project requires the use of a variety of components including three different types of sensors that are crucial to the project's main goal of safety. The components that have been gathered so far include:

- Digital Accelerometer (ADXL345)
- Joystick (B1033810)
- H-Bridge (L298N)
- Pressure Sensor (FR 402)
- Ultra-sonic Proximity Sensor (HC-SR04)
- Infra-red Proximity Sensor (GP2Y0A41SK0F)
- Voice Recognition (EasyVR Shield 2.0)

Along with the components listed above, a cart powered by two DC motors was supplied to act as the scaled wheelchair. A to-scale chair will be constructed out of Styrofoam to allow for the system to be mounted. The accelerometer will be used to detect if the wheelchair is either going too fast, or accelerating too quickly. If this is the case the chair will throttle it's speed to a safe pace. The joystick's purpose is to pair up with h-bridge to control the movement of the wheelchair as well as control the speed at which the chair moves. The plan for the pressure sensor is to place it on the seat of the wheelchair to detect whether or not the user is seated. If there is no weight detected while the chair is moving, i.e the user fell out of the chair, the chair should stop and play an alert through the speaker. Both the ultra-sonic and infra-red proximity sensor will be used to detect obstacles in front and behind the chair. At the time of this report, the placement of these sensors and which type of sensor that is going to be used is still unknown, but this will come with testing the capabilities and reliability of each type. As for the voice recognition through the EasyVR Shield, it will be used to turn on LEDs on the wheels for night-time usage, and potentially move the wheelchair. Though it is not a top priority at this time, the voice recognition is expected to be a feature in the final design. These components along with the scaled down wheelchair that was given will be used to prototype and test.

2.2 Software and Firmware

In this project it is predicted that two different processors will be used. Both processors will be the ATMEGA328P but one CPU will be used just to function the EasyVR Shield Voice Recognition module while the others will deal with the inputs and outputs of the wheelchair. The EasyVR Shield will be using Arduino libraries that are provided with the Shield. The coding language, whether assembly or C,has not been decided at this time. However, C is most likely going to be the coding language in the final design.

2.2.1 General Control

The general control of the wheelchair is done through a joystick. This joystick works in conjunction with a H-Bridge that is supplies current to drive the motors. The code converts the resistance that the joystick gives when pushed a certain direction into actual directional movement with the wheelchair.

2.2.2 Park Mode

Park Mode is a setting that is toggle-able through a button on the left arm of the wheelchair. When Park Mode is on, a blue LED will be lit on the left arm of the wheelchair indicating that Park Mode is engaged. When Park Mode is off, this LED will be off and the wheelchair will work as expected. Park Mode locks the motor in place so the wheelchair can not move in this setting. If the user gets off of the chair at this time, the pressure sensor will not sound an alarm.

2.2.3 EasyVR Shield 2.0

This component should make the wheelchair be controlled with voice recognition. The plan is to have a list of commands that will react with the wheelchair through code to do the given command. To initiate a command the user must say ”Sally” before their command for the wheelchair to listen. The commands should be able to be chained together. For example, ”SALLY TURN LEFT THEN STOP”. This will execute the turn left command and immediately stop after this command. The commands are listed below:

- SALLY STOP: Stops the wheelchair.
- SALLY FORWARD: Advances the wheelchair until a stop command is given or sensors engage breaks.
- SALLY REVERSE: Reverses the wheelchair until a stop command is given or sensors engage breaks.
- SALLY TURN LEFT: Turns the wheelchair left then halts.
- SALLY TURN RIGHT: Turns the wheelchair right then halts.
- SALLY TURN ON WHEEL LIGHTS: Turns the safety LEDs on.
- SALLY PARK: Engages the Park Mode.
- SALLY TURN AROUND: Turns the wheelchair 180 degrees.

2.2.4 Sensors

The sensors will be communicating with motors and encoder in order to provide safety features for the wheelchair. When the sensor reads an obstacle ahead that is deemed a hazard (edge, wall, person, etc.) the sensors will lock stop the wheelchair. The pressure sensor will read if there is weight on the wheelchair, if weight is detected then the wheelchair will work as expected. When weight is taken off of the sensor without engaging "Park Mode" an alarm will sound to alert that the user may be in trouble and fallen out of the chair. If "Park Mode" is engaged this sensor will be turned off and the alarm will not sound. The proximity sensors' set distance has not been determined yet, but with trial and error a set distance will be made in the code where it is deemed unsafe and will automatically stop the wheelchair heading towards a hazard.

3 Test Plans

The following subsections test plans for each component that is currently being used in the wheel chair. Each table includes a variety of tests that will ensure the components are working properly. The procedure portion of the table explains how the specific test was performed and the expected results of the test will be listed in the next column. Components that have been tested will include the actual results of the test along with the calculated percentage error. Some components have not been tested yet and those will become a top priority to verify their performance.

When the final product is completed the object should satisfy the following table.

Final Test Plan		
Circuit Testing	Test	Results
Joystick w/ Motors	Left: Right motor full throttle, Left motor half throttle Right: Left motor full throttle, right motor half throttle Forward: Both motors full throttle Reverse: Both motors full throttle backwards.	
EasyVR Shield w/ Output	Run through all commands. The Shield should execute each command with a .2 second response time.	
Park Mode	Attempt to move the wheelchair when in park mode. Blue LED should turn on. Remove weight alarm should not sound.	
Pressure Sensor	Remove weight. Alarm should sound	
Proximity Sensor w/ motors	Drive wheelchair towards an edge. Wheelchair should override user and stop. Slide object in front of wheelchair while in motion. Wheelchair should stop. Repeat above test for backwards motion. Should have same result.	
Accelerometer w/ motors	Drive wheelchair down a steep hill. The wheelchair should throttle down due to high acceleration.	

3.1 Motors

Servo DC Motor					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Working Current:	Supply current until it reaches moderate speed	Part scratched off and unknown	1 to 2 A	N/A	At 1 amp the device went a moderate speed. At 2 amps the device went considerably faster.
Working Voltage:	Supply voltage until it reaches moderate speed.	Part scratched off and unknown	5 to 14 V	N/A	At 5 volts the device went moderate speed at 12 volts the device went considerably faster and 14 was deemed unsafe.
Reversing:	Supply negative voltage until it reaches slow reverse speed.	Part scratched off and unknown	Under Test	N/A	This was done and it has gone in reverse, but one of the motors ceased working before further testing could be done.

3.2 Encoders

HEDS-9140					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Working Voltage:	Supply voltage until it powers on.	5 V	Under Test	Under Test	Under Test
Accuracy:	Monitor the rotary encoders output with an oscilloscope by hooking the oscilloscope to the information port	The oscilloscope should result in a square wave with little to no noise.	Under Test	Under Test	Under Test

3.3 Digital Accelerometer

ADXL345					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Working Current:	Measure the current consumption when in idle and working mode while powered.	0.1 μA to 23 μA	Under Test	Under Test	Under Test
Working Voltage:	Measure the voltage consumption when in idle and working mode while powered.	2.0 V to 3.6 V	Under Test	Under Test	Under Test
Accuracy:	Vary the speeds given to the accelerometer to ensure it detects acceleration.	+- 2g	Under Test	Under Test	Under Test

3.4 Joystick

B1033810					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
X-Axis	Moving the joystick to left and the value should be bellow 470. Moving the joystick to the right, the value should go above 550.	Range from 470-0 for left movement. Range from 550-1023 for right movement.	Under Test	Under Test	Under Test
Y-Axis	Moving the joystick backwards and the value should be bellow 470. Moving the joystick forward and the value goes above 550.	Range from 470-0 for backwards movement. Range from 550-1023 for forward movement.	Under Test	Under Test	Under Test
Center Position	Move the joystick in several directions and release to center position,and observe it it returns to the range of 470-550	Range value from 470-550	Under Test	Under Test	Under Test

3.5 Pressure Sensor

FR 402					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Weight to Resistance Ratio:	Take different size weights and place them on the pressure and note the corresponding resistance.	Each weight should decrease the resistance.	Under Test	Under Test	Under Test
Non-actuated Resistance:	Measure resistance with no weight	$> 10\mathrm{M}\Omega$	Under Test	Under Test	Under Test

3.6 H-Bridge

H-Bridge					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Current flow	Giving the H-Bridge Current (2A) and measuring the output current.	The output current should be the same as the input current (2A)	Under Test	Under Test	Under Test
Inverted current flow	Giving the H-Bridge Current (2A) and measuring the output current.	The output current should be the inverse of the input current (-2A)	Under Test	Under Test	Under Test

3.7 Proximity Sensors

3.7.1 Ultra-sonic

HC-SR04					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Vertical	Using a measuring tape and an object in the vertical direction to see how far out the sensors can still detect the object	Refer to Data Sheet for the sensors range	Under Test	Under Test	Under Test
Horizontal	Using a measuring tape and an object in the Horizontal direction to see how far to the right and left the sensors can still detect the object	Refer to Data Sheet for the sensors range	Under Test	Under Test	Under Test

3.7.2 Infra-red

GP2Y0A41SK0F					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Vertical	Using a measuring tape and an object in the vertical direction to see how far out the sensors can still detect the object	Refer to Data Sheet for the sensors range	Under Test	Under Test	Under Test
Horizontal	Using a measuring tape and an object in the Horizontal direction to see how far to the right and left the sensors can still detect the object	Refer to Data Sheet for the sensors range	Under Test	Under Test	Under Test

3.8 Voice Recognition

EasyVR Shield 2.0					
Test	Procedure	Expected Results	Actual Results	Percentage Error	Notes
Working Current:	Drive less than the operation current and see when the component turns on.	12 mA to 180 mA	Under Test	Under Test	Under Test
Working Voltage:	Drive 3-5 Volts to the chip and see when it turns on.	5 V	Under Test	Under Test	Under Test
Voice Recognition Accuracy:	Use different peoples voice and accents to command the chip.	All different ranges of voices should work.	Under Test	Under Test	Under Test
Command Recognition Accuracy:	Go through the range of given commands and assure the chip understand the difference between the commands and executes them properly.	All commands will work when said and execute probably.	Under Test	Under Test	Under Test

4 Contributions

Team Member Contributions		
Joao Alves	Kevin Prairie	Zachary Taylor
Currently working in making the Chair move using the joystick in conjunction with the H-Bridge	Gathered data-sheets for the Team Github.	Gathered data-sheets for Team Github.
Built a casing to enclose three 3.7V li-ion batteries	LaTeX formatting for Lab One and Project Progress Report.	Soldered accelerometer for test
Wrote test plans for Joystick, H-Bridge, and the two proximity sensors (Ultra-sonic and Infra-red)	Wrote test plans for HEDS-9140 encoder, h-bridge, and assisted with DC motor test plan.	Wrote test plans for pressure sensor, accelerometer, and EasyVR Shield
Assisted in gathering results for all the components	Gathered voltage and current ratings for all components.	Currently researching EasyVR Shield 2.0 further
	Currently learning the fundamentals of Eagle software for PCB.	Created chassis for current prototype.

5 Laboratory Reflection

Thus far, there have been issues occasionally happening. One of the biggest halts in the progression of this design is that the left side motor has failed and is currently undergoing repair. This slowed the testing of the motors. The hardest component to work with thus far is the EasyVR Shield. There are many external program required for the EasyVR shield that has become an entirely new learning curve. The availability of the parts have been sporatic as well which resulted in a slow testing process. All the sensors other than the pressure sensor and accelerometer have been received last lab session, which made prototyping the sensors very difficult in order to make the timing of this report. The encoder has not been tested due to there being nothing that the encoder currently has to read, thus it has been put near the bottom of the priority list. The joystick, H-Bridge, and motors were wired together to make the chassis move in each direction. The problem lied with the unresponsive motor as the joystick worked with one motor but not the other. This is going to be tested again after the repair of the motor. Otherwise, the high-level design and final desired operation has been designed.