
Glove Based WheelChair Navigation

Team 40 - ECE445 Proposal
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1.0 Introduction

1.1 Objective

Individuals with disabilities like paralysis or cerebral palsy find it hard to navigate a wheelchair using a joystick on the arm of the chair, considering limited hand control and movement. This is the inspiration to create a pair of gloves which can facilitate the maneuvering of the wheelchair with limited arm movement.

The device (i.e. pair of gloves) would consist of two hand gloves; one with flex sensors to control the acceleration and speed of the motors. This is not accounting for the direction. We utilize a ball tilt sensor or an accelerometer in order to allow the user to accurately control the direction of the wheelchair, forward, back, left and right. The data from the sensors is fed into a microcontroller (we are using Arduino) which transmits the information of motion and acceleration/deceleration to the motors (glove is wired to the chair). We will have one PCB that will encompass the data from the two sensors and relay the information to the motors. We will implement certain bandwidth filters that won't allow faulty data, essentially a threshold to make sure readings are appropriate. There will also be an emergency fail safe switch that decelerates and stops the wheelchair if needed.

1.2 Background

As mentioned in the objective, the importance of the solution taps into the user base of individuals with nervous system diseases that can impair mobility (including cerebral palsy, multiple sclerosis, and Parkinson disease) or those facing musculoskeletal disorders. Our device aims at a means to help these individuals by allowing them to maneuver a wheelchair through gloves in a stable stationary position.

There have been a plethora of companies attempting to create devices which can help perform daily tasks they otherwise could not do on their own such as the NeoMano wearable robotic glove. '*With the NeoMano, patients and others with limited hand mobility can hold a cup of coffee, grip and twist a doorknob, use a toothbrush or comb, manipulate shirt buttons and zippers, and perform other basic tasks, enabling them to more fully participate in social activities (1)*'. Our solution proposes a similar though specific platform to prompt movement independence.

1.3 High-level Requirements List

- Hardware - The flex sensors and accelerometer must be able to accurately collect data from the user's movements and within a certain threshold of error (~5%), be able to guide the maneuvering of the wheelchair as desired in terms of direction and speed
- Software - The software module should efficiently be processing and analysing this data, removing outliers (such as extreme pressure on the flex sensors) and relaying the desired action back to the motors through the microcontroller
- Latency time - There must not be more than 2s of latency between the user's movement and the interpreted command, to allow for smooth and lag-free navigation of the wheelchair
- Emergency Response - Once the emergency button is pressed, the wheelchair must decelerate and come to a stop within 3s. If there are extreme readings recorded by the software module consistently for over 10s, then also the wheelchair must decelerate and come to a stop.

2.0 Design

2.1 Block Diagram

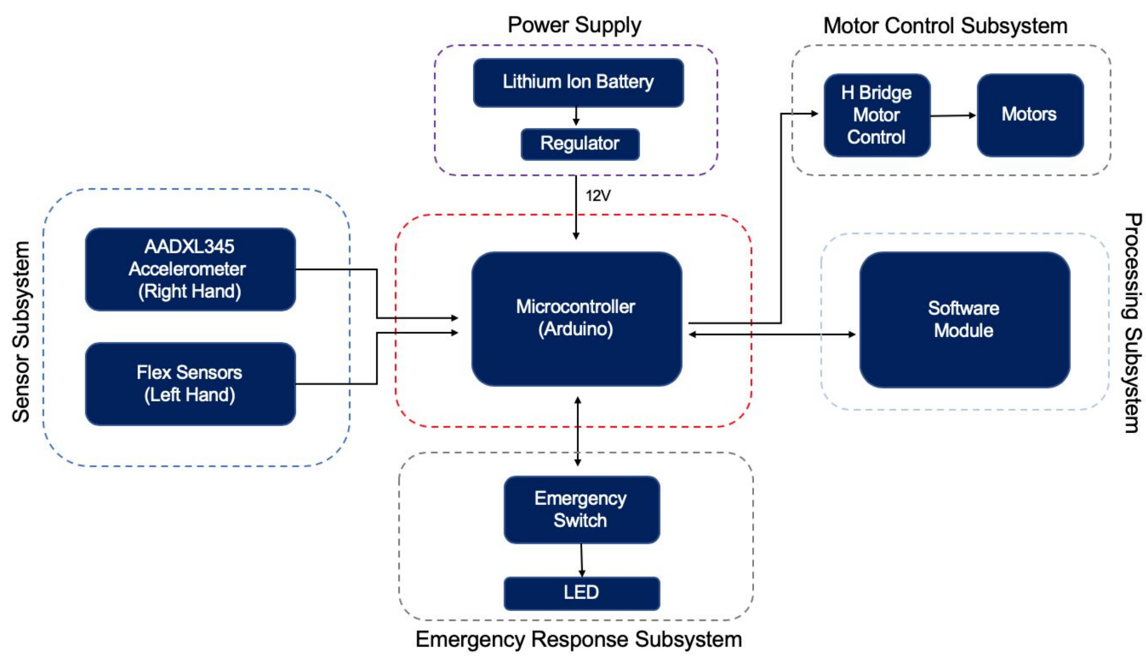

Figure 1: Block Diagram

2.2 Physical Design

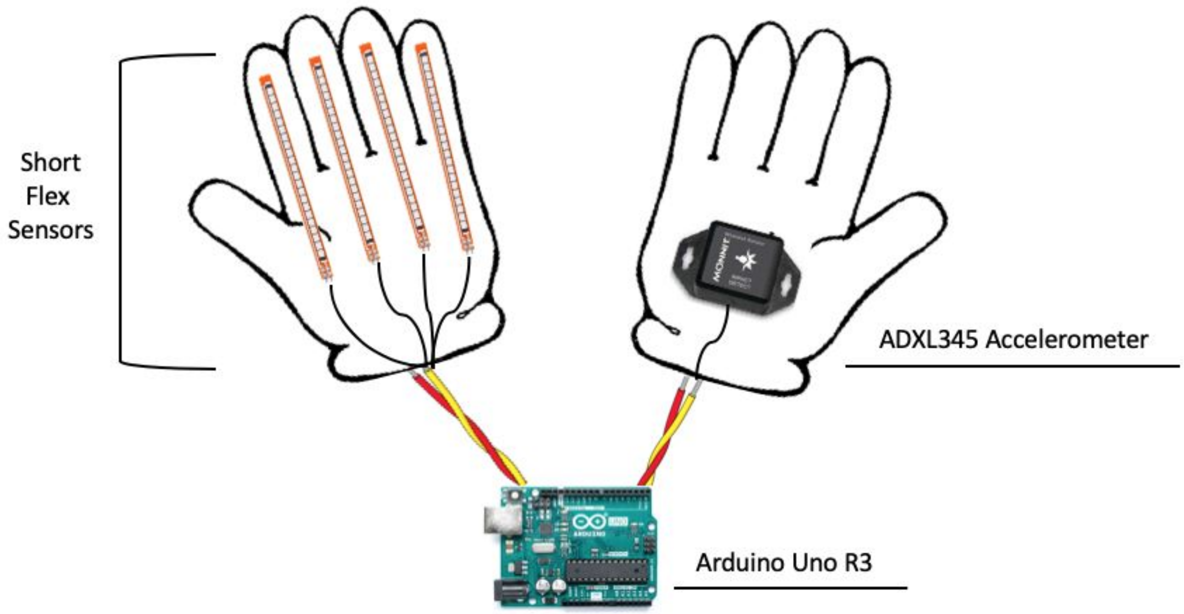

Figure 2: Physical Design

The physical component of our system involves two gloves. The left glove will have flex sensors attached along the fingers. This will help in detecting the bending of the fingers and clenching of the fist to change speeds. The left hand glove will have an ADXL345 accelerometer attached to it to detect tilt movements of the hand for direction detection. Wires from these sensors will go into the Arduino which will be placed on top of a motorized toy car. This motorized toy car essentially acts as a representation of a motorized wheelchair.

2.3 Functional Overview

The functionality of the device follows a sequence of events starting with the user's hand movement through the gloves. On the left hand, the flex sensors measure the pressure applied by folding of the fingers and on the right hand, the accelerometer detects left, right, forward and backward movements of the hand. Both of these then relay to the Arduino which draws power from the lithium ion battery with an input voltage of ~7-12V and communicates the information to the software module.

The software module is designed to intake the sensor data, process it while removing extreme outliers and with a margin of error of 5%, transmit the information back to the microcontroller. The Arduino then controls the motors of the wheelchair and guides the maneuvering accordingly. In the case of extreme movement of the arm, that would constitute an emergency and bring the wheelchair to a stop within 3s. Similarly, if needed, the user can press the emergency switch button. This will light up the LED next to the button and transmit the information to the microcontroller which will decelerate and stop the wheelchair.

2.4 Block Requirements

<u>Sensor Subsystem</u>

- Consists of the Flex Sensors and the ADXL345 Accelerometer
- The flex sensors (installed in the left-hand glove) are responsible for detecting the clenching of the hand and relaying this sensor data to the Microcontroller/Arduino
- The accelerometer will detect hand tilt movements and send the corresponding data to the microcontroller

  Requirement:
  1. Clearly be able to detect left, right, forward and backward movements of the hand and relay this information.
  2. The sensors should have an error margin of less than 10% in collecting the desired data

<u>Power Subsystem</u>

- Consists of batteries for voltage supply
- Voltage regulator to modulate voltage values

  Requirement:
  1. Input Voltage must be within 7-12V
  2. Operating voltage for the system is ~5V

<u>Control Subsystem</u>

- Consists of a Microcontroller unit (Arduino). This block is responsible for reading in the input sensor data from the sensor subsystem.

- These values are then outputted to the Processing subsystem for further analysis.

Requirement:

1. Must read in the input data from the two sensors
2. Accurately receives, processes and outputs data for ensuring proper functionality of the entire system
3. Should be correctly programmed to analyse input data and relay commands to the motor drivers

Processing Subsystem

- This system inputs the sensor data values from the Microcontroller. These sensor signals are then processed and analysed to conclude a desired action.
- The data from the flex sensors will determine what the speed of the motors should be and the data from the accelerometer determines whether the wheelchair should move to the right, left, forward or backwards.
- In case the subsystem identifies the analysed data as extreme or out of safe bounds, it sends an emergency signal causing the motors to come to a safe stop

Requirement:

1. Speeds greater than 7mph must be correctly identified as dangerous/out of bounds and emergency response should be initiated
2. Accurately differentiate between left, right, forward and backward commands, with an error margin of <10%

Emergency Response Subsystem

- A switch system to cut the power to the motor when pressed.
- Automatic cut-off of power if the voltage values are detected to go above/ beyond certain thresholds.
- An LED light to indicate that the motors have stopped due to malfunction.

Requirement:

1. The wheelchair must decelerate and come to a stop within 3s when the emergency switch is pressed
2. System must declare an emergency if faulty data is read continuously for t>10s
3. LED must be lit when emergency state is recognised by the system

<u>Motor Control Subsystem</u>

- Consists of an H-bridge that will essentially act as motor drivers. These are responsible for driving the wheels of the wheelchair

  Requirement:
  1. The speed of the motors must not exceed 7mph
  2. Motor drivers must come to a stop when an emergency situation arises

2.5 Risk Analysis

- Processing Subsystem poses the greatest risk factor in our project. It is critical that we evaluate all the data correctly otherwise it will lead to an uncomfortable experience and the user can tend towards dangerous outcomes.
- The data from the accelerometer must be read correctly to sense the appropriate direction for the wheelchair to move in.
- Data from the flex sensor must be correctly mapped in the appropriate range to guarantee a comfortable experience.
- In the end, the motive of this project is to make sure that the person using this can comfortably navigate their way on a wheelchair and getting this subsystem to function correctly is critical to the overall experience.

3.0 Ethics and Safety

There are various concerns and things we need to keep in mind when we build this device from a safety standpoint, few of which have been elaborated:

- Individuals using this will mostly be differently abled and hence there are risks that those individuals face if they don't understand the sensitivity of the control they have. To tackle this, we suggest having a caretaker around when the individual learns how to use the device to prevent accidents. Gradually, the individual will get accustomed to the sensitivity and will be more confident operating it.

- Wheelchairs have the ability to go at speeds that may cause discomfort to these individuals. Also, accidents are more frequent at high speeds and we need to address this issue. We researched the average speed of a motorized wheelchair and have a system in place to cut-off power to the motor if the speeds start going beyond that limit.

- Temperature has an impact on the sensitivity of the sensors we are using and faulty data can put the individual at high risk. To make sure this doesn't become a threatening issue, we will be using filters to keep the data in appropriate working range. Any change in sensitivity of sensors should be reported immediately to get it replaced.

- We will comply with the design requirements, test procedures and performance requirements as mentioned in the WC19 Safety Standard for Wheelchairs.

Our project also challenges some ethical issues that differently abled people have to face when going about their routine :

- The standard wheelchair design requiring manual effort for navigation is not comfortable for all individuals. These challenges rarely get attention and our project is attending to the needs of those people in accordance with the rule stated in IEEE that tell us about our responsibility to improve understanding of people about the societal impacts of modern technology [2].

- Since a very small subset of people face the challenge we are tackling, not enough people are working towards improving their lives. This project is an attempt to popularize the various disabilities in humans that make completing everyday tasks a challenge.

- There are also concerns about someone maliciously trying to rupture the system. To counter this, we will try to create all the components such that it is not very accessible from the exteriors, giving only the user the control of the wheelchair.

We acknowledge the challenges we face ahead of us to make this project as safe for the user as is possible while also complying with the code of ethics specified by IEEE. We have procedures in place to help us achieve both such that we can guarantee the best experience for the individual.

4.0 Citations

[1] *Robotic Glove Helps People with Hand Paralysis Regain Independence*. (2018). *AP NEWS*. Retrieved from https://apnews.com/BusinessWire/a72eb0a3c46444709a522ebf48c86555

[2] *IEEE Code of Ethics.* Institute of Electrical and Electronics Engineers. (2020). Retrieved from https://www.ieee.org/about/corporate/governance/p7-8.html