Final Report

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Introduction

- Problem Description

Even though we have achieved an autonomous control of the car using two physical switch sensors on its sides in lab8, this method is not efficient and also not practical in real life design. Therefore, I intend to replace them with ultrasonic sensors to detect the distance. The car should automatically take a turn when its distance from the wall is less than 5cms. Also, I will add flex sensors to the car which allows me to control it simply by showing different gestures.

- Design concept

The entire design consists of several components: **Distance Detecting, Motor Driving, Finger Motion Sensing, Central Processing, Battery**. The distance detecting and finger motion parts send input signals to the central processing component, which then decides output signals to the Motor Driving part. The car takes different actions accordingly.

Even though the toy car is used as a key component of this design, many other devices, such as electronic skateboards, robot arms, even toy helicopter, could also be used.

Analysis of Components

- Characterization of sensors

There are mainly two type of sensors used in this design: Ultrasonic sensor and Flex sensor.

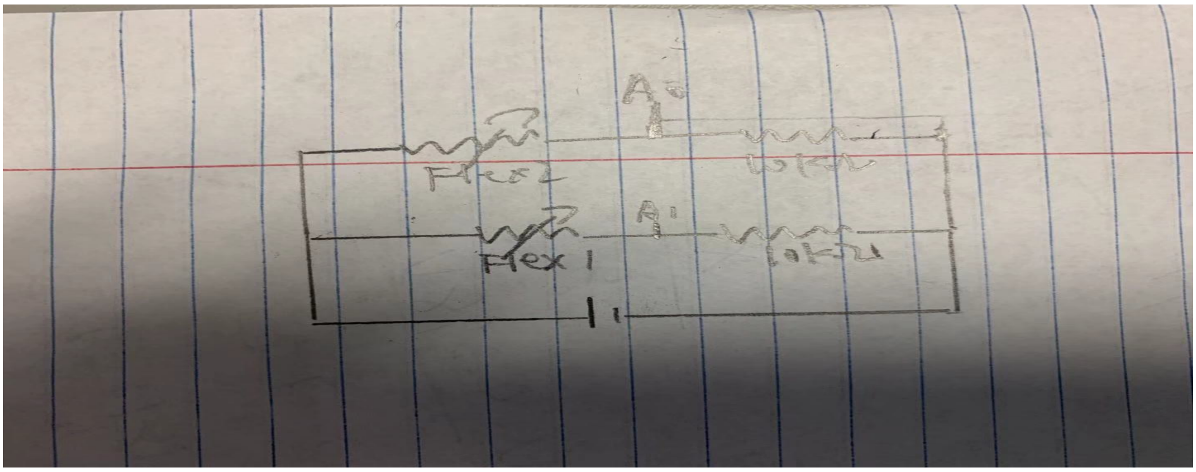
1). Ultrasonic

I use three HC-SR04 ultrasonic sensors as the distance detecting component of the entire design. Three sensors are placed on the front, left, and right side of the car. The setup of component is not difficult. Three ultrasonic sensors are connected in parallel and powered up by the Arduino 5V voltage. All of the sensors collect data concurrently. No voltage measurement or testing is made in Ultrasonic sensors' setting up in that the process is very straightforward and self-explanatory. However, we do need to test the car in different environments to observe the performances of sensors, based on which we set a turning distance threshold (the distance at which the car takes a turn). The conclusion is that the HC-SR04 sensor does poorly when it faces a curvy or fluffy surface. We might want to take different sensors with higher precision to use in environment which involves some fluffy surface. Moreover, based on my trials, the car works best when the turning distance threshold is **5cm or so (+-0.5cm)**, as the car gets stuck in cramped environment if the threshold is large and might crash into a wall due to inertia if the threshold is small.

2). Flex

I use two SEN-08606 Flex sensors as the finger motion component of the entire design. Two sensors are adhered tightly on two of my fingers to mimic my finger movements. Designers also have the choice to make a "control glove" and stick the flex sensors on it, which can make the testing part and adding more flex sensors a lot more convenient.

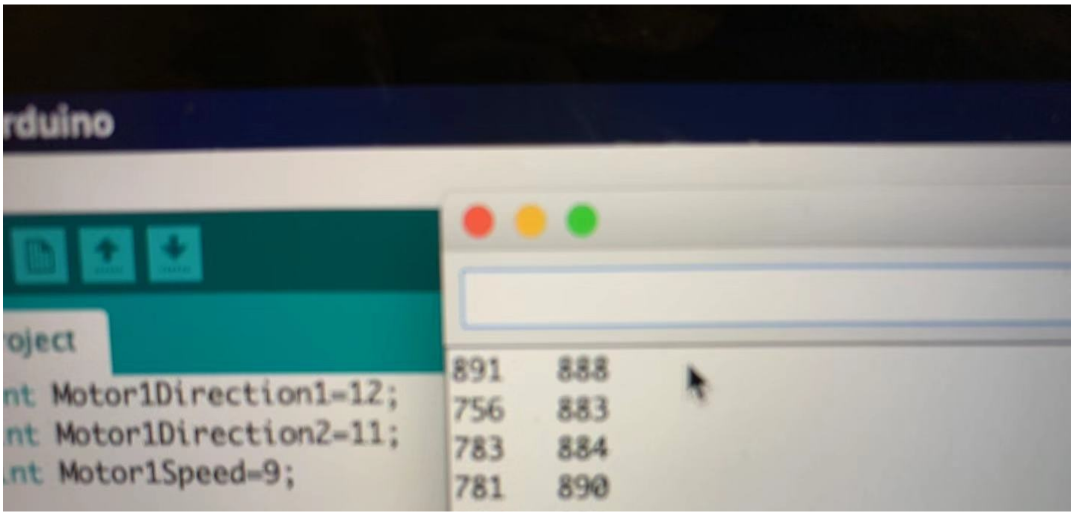
I use a voltage divider circuit and the ADC ability of the Arduino to make two sensors act like two switches in the circuit. A thorough test of different voltages and resistances taken by flex sensors in different bending angles was conducted by me to set a threshold voltage value and the resistor resistance value in the voltage divider circuit.



Any resistance value between the minimum resistance value and the maximum resistance value taken by the flex sensor should be considered a good choice.

https://cdn.sparkfun.com/datasheets/Sensors/ForceFlex/FLEXSENSORREVA1.pdf

Referring to the data sheet, we can see that the range of resistance taken by the flex sensor is from 10k ohms to 110k ohms. Due to limited types of resistors provided in the lab kit, I chose 10k ohms resistor as the voltage divider. However, if designers have access to more resistors, a resistance value around 50k ohms should be a very good choice.



Analog values read by Arduino. Left column data is the analog value in the subcircuit with the bended flex sensor. Right column data is the analog value in the subcircuit with natural stretch sensor.

As we can see from the above data, when there’s a bending, the analog value read at the positions indicated as A1 and A0 in the circuit diagram shown above drop below 800, which corresponds to 5*(800/1023) =3.91 volts.

Analog values read by Arduino. Data of both columns are taken when the flex sensors are perfectly straight.

As we can see from the above data, when the flex sensor is perfectly straight. The analog value is 900 or so which corresponds to 5*(900/1023) =4.39 volts.

Thus, the threshold value is set as 800. When the analog read value drops below 800, the finger associated with it is considered to be bent.

With two flex sensors acting like switches, we have four (2^2) different combinations or patterns to use. For simplicity reason, I will take bent finger as “1” and stretched finger as “0”. In my design, I assign “00” as “moving”, “11” as “halt”. For the patterns “01” and “10”, I assign two special movements to them. For “01”, the car starts to spin clockwise. For “10”, the car starts to spin counterclockwise.

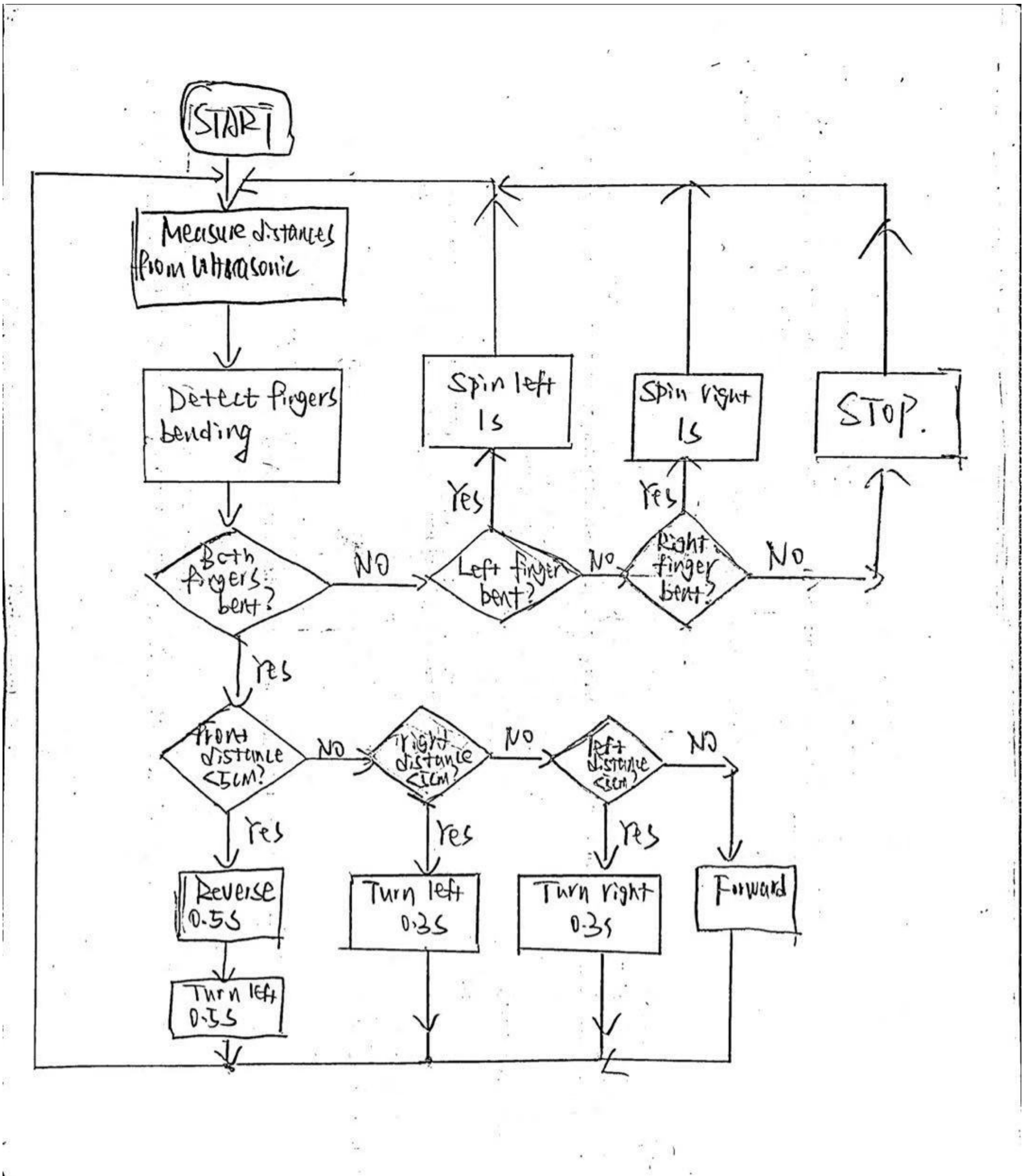
Designers can also add more flex sensors to it. For example, if we use one flex sensor for each finger with a total of 5 sensors. Then we can have 32(2^5) different combinations to use and 32 special actions associated with them.

- Other components in the design

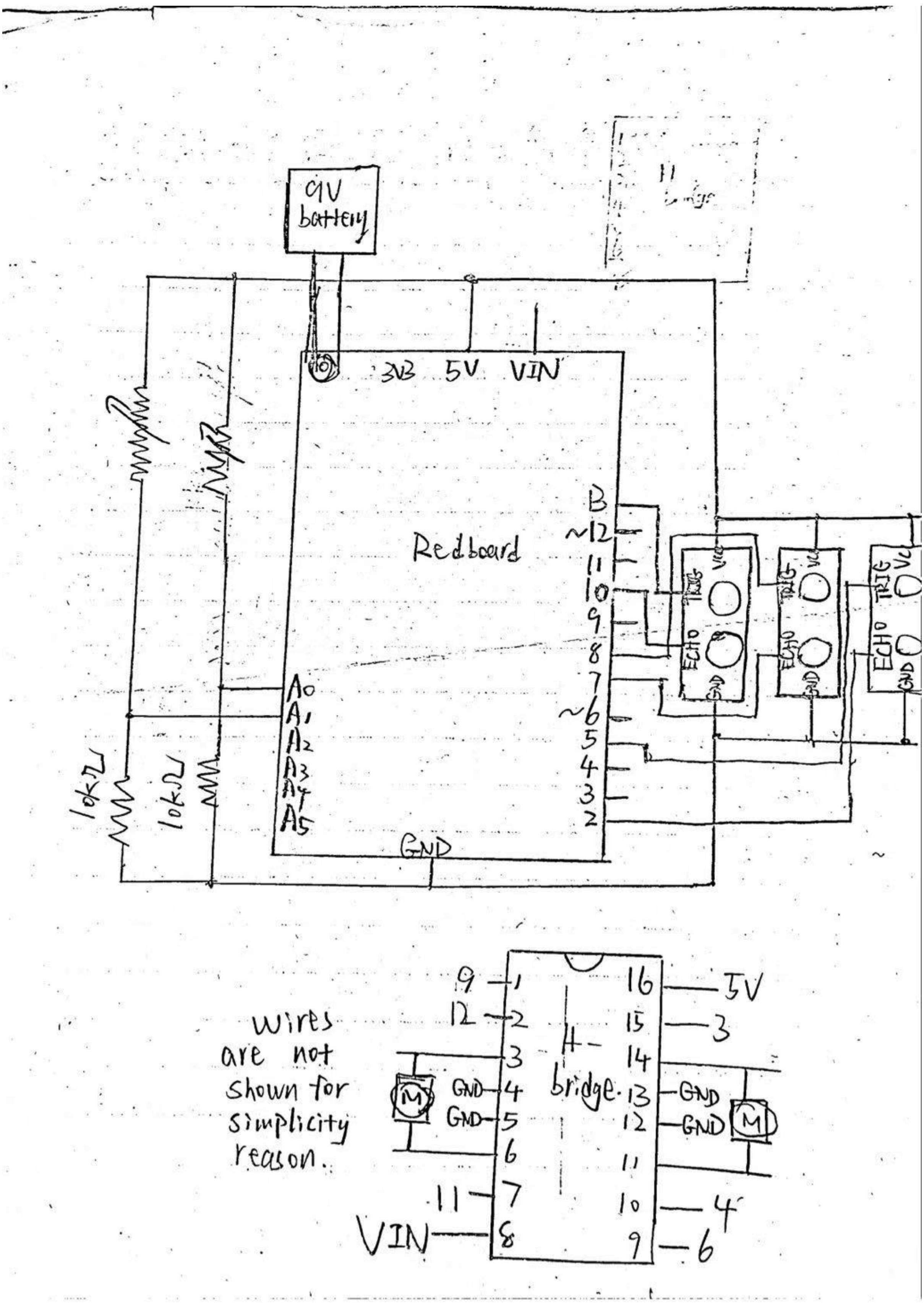
1). Motor Driving Component
I use the H-bridge SN754410 as the motor driving component of the entire design. There are three control pins on the H bridge for each motor, which are two direction pins and one speed pin. We can change the rotation direction of motors by changing the direction pins and the speed of the motor by changing the duty cycle of the PWM signals sent into the speed control pin (also the motor ENABLE PIN).
2). Central Processing
I use Redboard as the micro processing unit.
3). Battery
I use 9v lithium battery to power the Arduino, which then powers the motor, H-bridge, and other components in the circuit.

Design Description

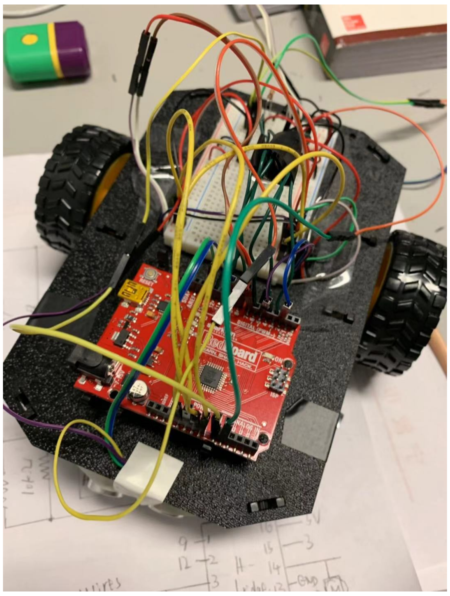
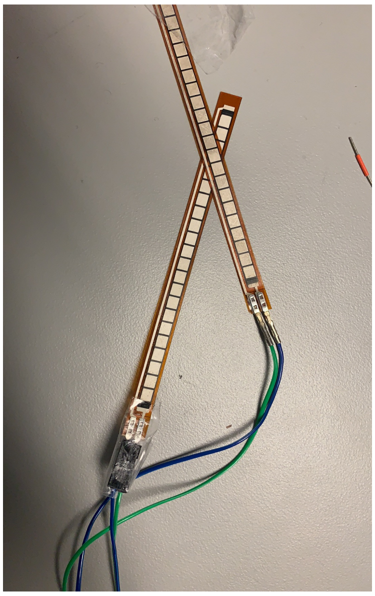
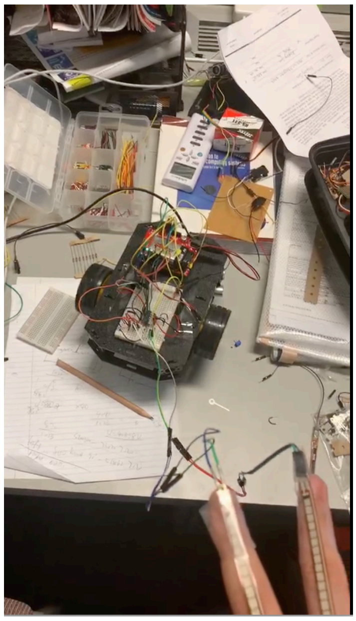
- Flowchart

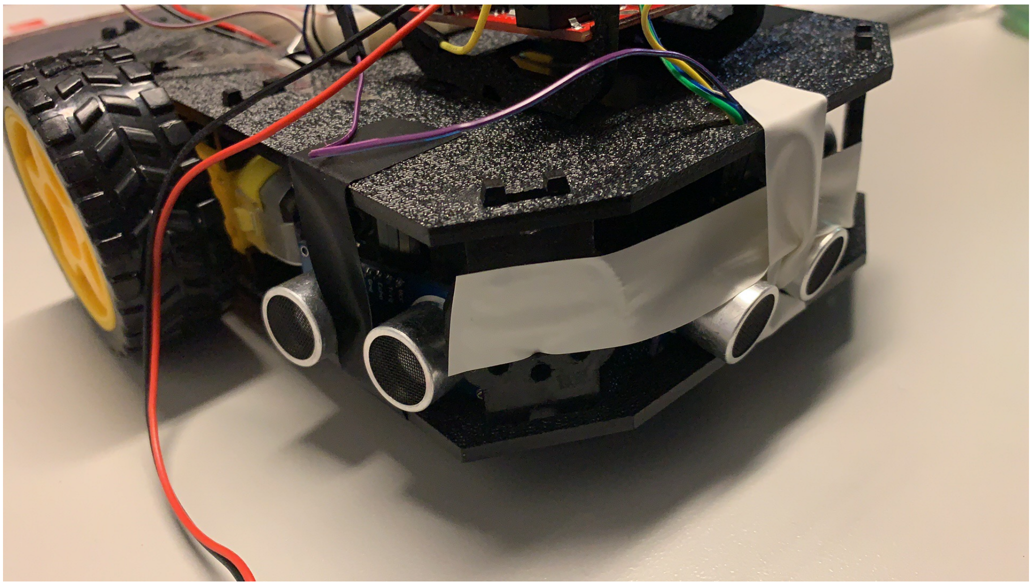


- Circuit Schematics



- Physical Construction



Three ultrasonic sensors are immobilized at the positions as shown using duct tapes. Two flex sensors are stuck on my fingers with very long jumper wires connecting the ends of them to the breadboard. The other components are placed on top of the car.

Conclusion and Prospect

The project has been successfully completed. The car's performances were quite decent during my test using different obstacles in different environments. However, there's still a lot to improve on. The following points are my prospects for this project and its possible applications:

1. As I mentioned above, we can make a control glove if we can access to more resources. We can also increase the number of flex sensors used to obtain more

combinations and patterns. Currently, the flex sensors are connected to the remaining part of circuit using jumper wires. However, we can make use of the RFID or some other wireless modules and Arduino Nano to send the control signals wirelessly. Also, the improved design can incorporate the Gyro Sensor to it, which can directly sense the bending angle of hands. This will have more precise control over the car.

2. There are several possible applications of this project. For example, we can use the same control idea on the wheel chair for the disabled. Furthermore, it'd be a great idea if we can make some programmable toys for kids. Instead of making some predefined assignments of patterns, we can make a simple programming interface and allow the users to associate different "flex sensor patterns" with different actions and behaviors according to their will. In other words, they can make their own control glove.

3. However, the flex sensors are expensive, which are not good for mass production. Therefore, figuring out methods to replace the flex sensors and reducing the cost is also a small potential future project to work on.

Reference and Help:

https://learn.sparkfun.com/tutorials/flex-sensor-hookup-guide/all
https://learn.sparkfun.com/tutorials/analog-to-digital-conversion