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Sign Language Glove using Arduino

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Abstract*: Communication between speakers and non-speakers of American Sign Language can be problematic, inconvenient, and expensive. This project attempts to bridge the communication gap by designing a portable glove that captures the user's American Sign Language gestures and outputs the translated text on a laptop or a personal computer. The glove is equipped with flex sensors, contact sensors, and an accelerometer to measure the flexion of the fingers, the contact between fingers, and the rotation of the hand. The glove's Arduino microcontroller analyses the sensor readings to identify the gesture. Using this device, one day speakers of American Sign Language may be able to communicate with others in an affordable and convenient way.
***Keywords*: Arduino, American Sign Language, Flex Sensor, Accelerometer, Contact Sensor.**

I. INTRODUCTION

Communication is of paramount importance in today's data driven society. Shopping at a supermarket, asking for directions, event planning, or even national security depend on reliable communication. To the average person, everyday routines such as dentist appointments or having dinner with a friend would be difficult without the ability of speaking in order to convey ideas.

Speakers of American Sign Language (ASL) have to face this reality and all the challenges associated with the inability to communicate verbally. This population includes people who are deaf, hard of hearing, and children of deaf parents (CODAs). American Sign Language (ASL) is a complex visual-spatial language primarily used by the deaf community. The origins of ASL trace back to the nineteenth century deaf communities. Due to a high rate of intermarriage, deafness was a common trait found among the people in these communities. Though these people, and others across the country, had their own varied ways of using hand signs to communicate, the development of ASL is attributed to the establishment of the School for the Deaf.

Today, it is estimated that the number of users of American Sign Language falls between 250,000 and 500,000. On a large scale, a truly international American Sign Language does not exist; however, ASL is one of the most popular American Sign Languages in the world. Despite such a large population of people who speak ASL there are few people outside of native speakers who can understand it. The ASL community not only shares a common signed language, but also its own unique culture. Unfortunately, this language and culture often do not transcend into the hearing world, causing a lack of deeper communication and understanding between ASL users and non-users.

II. ADVANTAGES AND DISADVANTAGES

A. *Advantages are as Follows*

1) Any complications in its user interface would inhibit the glove's use in everyday life. The user should be able to begin translation without much difficulty or delusory. Each translation should be done without any unnecessary button-pressing or other interfacing.

2) Not financial aid is available for assistive devices. This device should be accessible by the average person by practical and affordable means.

3) There is a certain degree of accuracy that the device should maintain. This threshold has been decided by our team to be of about 90% accuracy. If the device does not accurately and consistently translate signs, then the user will resort to time consuming alternatives such as writing on pen and paper and the device will have no use.

4) For marketability purposes, the device shall be aesthetically pleasing and easily wearable without any factors that hinder convenience during extended periods of time. This includes a smooth, professional appearance without any components that irritate, cut, bruise, or otherwise cause discomfort for the user.

B. *Disadvantages*

The main disadvantage of American Sign Language translator glove using Arduino is that it can only convert the sign gestures into text format only.

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III. HARDWARE

A. Arduino Board

Arduino is an open source platform based on simple microcontroller board. The controller used in the device is Arduino duemilanove with inbuilt Atmega328P in it. Atmega328P has 32KB on-chip flash memory for storing codes of which 2KB used for boot loader. It also includes a 2KB of SRAM and 1KB of EEPROM. The program that is developed is to be stored on the flash memory of the controller. The Arduino software also includes a serial monitor which allows data to be sent to or from the Arduino board.

B. Flex Sensors

Flex sensors are resistive carbon elements. When bent, the sensor produces a resistance output correlated to the bend radius. The variation in resistance is approximately 10 to 30 KOhm's. An unflexed sensor has 10Kohm resistance and when bent the resistance increases to 30Kohm at 90o. The sensor is about ¼ inch wide, 4-1/2 inches long.

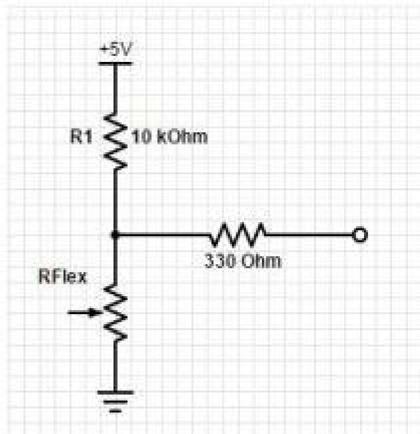

Figure 1 : Voltage divider circuit diagram

The sensor is incorporated in device using a voltage divider network. Voltage divider is used to determine the output voltage across two resistances connected in series i.e. basically resistance to voltage converter. The resistor and flex forms a voltage divider, which divides the input voltage by a ratio, determined by the variable and fixed resistors.

C. Accelerometer

Accelerometers are used for tilt sensing. They measure both static and dynamic acceleration. The sensor has a g-select input which switches the accelerometer between ± 1.5g and ±6g measurement ranges. It has a signal conditioning unit with a 1-pole low pass filter, temperature compensation, self-test, and 0g-detect which detects linear free fall.

D. Contact Sensors

The contact sensors are designed in such a way that copper tape is taped on the top of the fingers and at the sides. The copper tape is wired to the digital inputs on the microcontroller, with pull up resistors. The output on the microcontroller is high when there is no contact between two copper tapes. Whereas when two copper tapes are in contact with each other, the inputs on the microcontroller are pulled to ground, giving out an active low signal, which is very stable. Contact sensors signify which fingers are touching each other. They do not give us any information of the relative position between fingers except for whether they are together or apart. Contact sensors instead of Hall Effect sensors are used because Hall Effect sensors are expensive whereas contact sensors can be created using copper tape and wires.

E. MCP3008

The MCP3008 is a 10 bit analog to digital convertor equipped with sample and hold circuitry. It can be used to provide 4 input pairs or 8 single ended inputs. This device is capable of conversion rates of 200 kbps and operates over a large voltage range of 2.7V - 5.5V. The MCP3008 is designed with 16 pin PDIP and SOIC packages.

F. Bluetooth Module

The first prototype of the glove was connected to the PC via a USB cable. Once the prototype was in working condition, a Bluetooth

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module replaced the USB cable. This module transmits the ASL gestures to a PC via Bluetooth. These gestures are raw text, which will be recognized by an Android smartphone application and is connected wirelessly to the glove. This smartphone application will display as well as speak the English translations to the gestures being assigned to it.

IV. BLOCK DIAGRAM DESCRIPTION

There are very subtle differences in the gestures between similar signs. The mechanics of ASL make it challenging to distinguish and capture differences between signs. The team considered these challenges by making sure the sensors had the desired sensitivity and linearity as well as developing a software algorithm that detects these subtle changes. Flex sensors were used to measure the flexion of fingers, force-sensitive resistors were used to measure contact between the fingers, and a gyroscope was used to capture the motion and the position of the hands.

Flex sensors are sensors which measure the degree by which an object is bent. They are chosen for this project (and previous projects) because when they are fixed to each finger of the hand, they can be used as a measure of finger position. In addition, if contact sensors are affixed to the tips of the fingers, they can provide information about whether each finger is pressed against the palm or perhaps the other hand, which is common in ASL. To quantify and measure motion, specifically rotation of the hand, this project uses a gyroscope.

An ATMEGA 328P microcontroller was chosen for processing the sensor input, distinguishing between different gestures, and producing the output. This choice was based primarily on the number of analog and digital pins of the microcontroller, the reliable online support community, and cost. Arduino software was used to configure input and output pins for each sensor, setup a clock speed, implement the machine learning, and send the data to LCD monitor. Various types of algorithms can be used to implement the gesture recognitions. One algorithm that is accurate in nearest neighbor classification is called the Nearest-Neighbor algorithm. After training, to decide which class a data point belongs to, the algorithm chooses the class which is nearest to the data point. After the microcontroller decides which ASL sign has been gestured, it can send the name of the gesture to a LCD monitor.

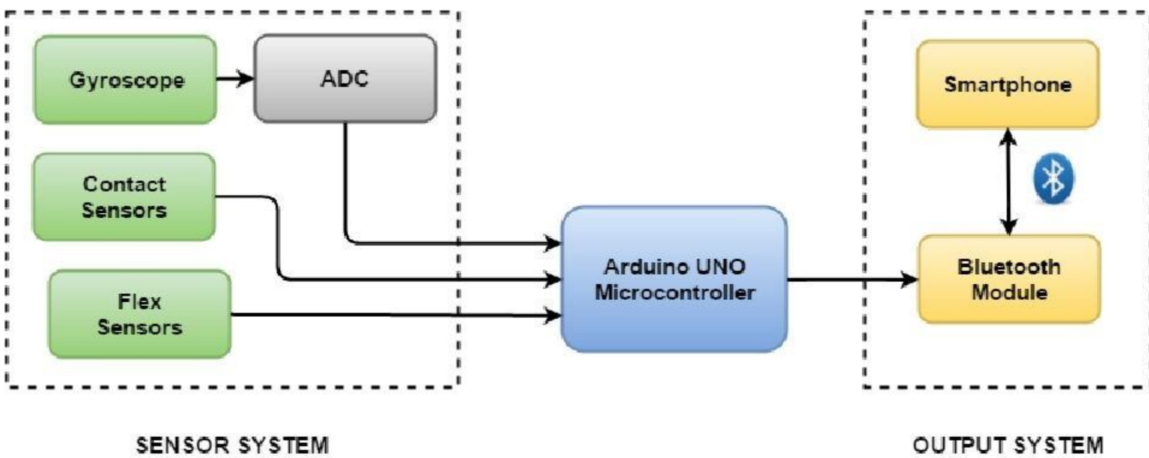

Figure 2 : Proposed block diagram of Sign Language Glove using Arduino

Based on preliminary research and testing, the team was able to discern that developing the American Sign Language glove was going to be a multifaceted process. The team developed a sensor network that differentiates various types of hand movement used in American Sign Language (ASL), interfaced the sensor network with a microcontroller, designed a Printed Circuit Board (PCB) that serves as the bridge between hardware and software components, developed a program that recognizes sensor signals and stores those that correspond to a designated ASL sign into a code library, and successfully outputted two ASL signs through a Bluetooth module to a smartphone.

After having completed the design of the glove, the team ran performance tests to ensure that it met our preliminary design specifications and development objectives. The average runtime of the classification algorithm is calculated to be 0.506 milliseconds. The final text output is displayed Bluetooth to a smartphone application, making the glove portable and not dependent on any external devices. This realization accomplishes one of the project's primary goals, which is to design a portable and compact glove that can be used on a daily basis. All essential components to both signal communication and sign translation are part of the glove itself.

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Once the Arduino software and glove hardware were able to communicate and exhibit the desired functionality, the team was able to test them for accuracy. The test involved alternating between the resting position and the ASL sign being tested. The team observed how often the program accurately translated them.

V. CONCLUSIONS

The software used in the algorithm has not been finely tuned. There are many optimizations, which may be possible. An even greater improvement in its function may be iterative debugging using ASL signs, which will be possible once the new prototype is steadily constructed. The current software does not use real tolerances or multiple samples per gesture. In addition, the gyroscope data is not used in the classification. Implementing gyroscope data introduces memory and algorithmic challenges but will yield greater accuracy in movement-related gestures than what has been seen in other ASL-translating devices. Testing with actual ASL users to determine how well the user requirements and design specifications were followed would allow for a more accurate library of gestures and a more practical product.

As a final remark, the team is excited about the progress made in the development of the glove prototype. Although it is not a finished product, it shows that using a glove outfitted with sensors, a microcontroller, and wireless communications can be used to translate ASL signs. It satisfies all of the major requirements put forth by the team, and it may lead to further developments in translation devices.

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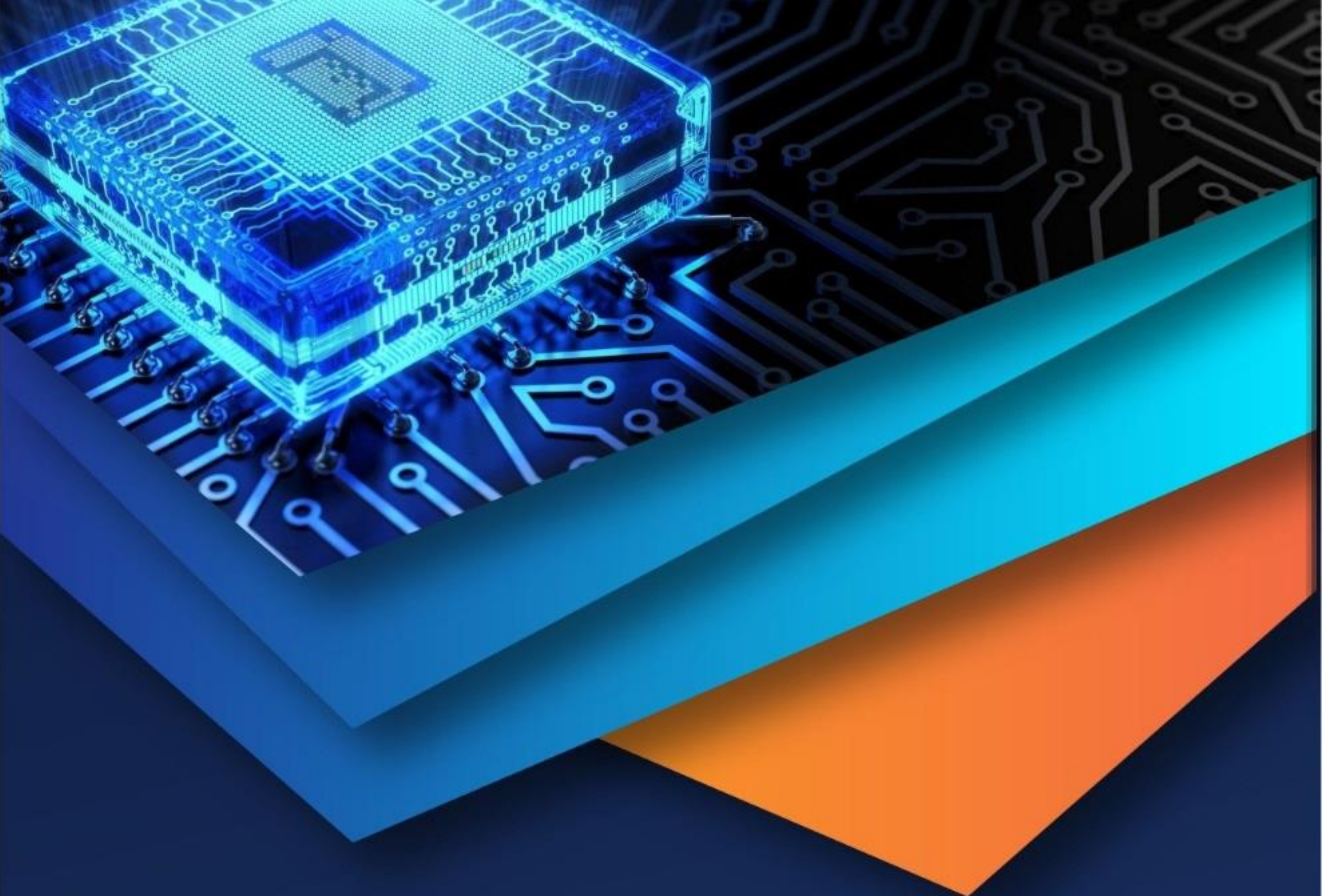

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