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Sign Language Interpreter Using A Smart Glove

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Abstract— **Sign language is the communication medium for the deaf and the mute people. It uses hand gestures along with the facial expressions and the body language to convey the intended message. This paper proposes a novel approach of interpreting the sign language using the portable smart glove. LED-LDR pair on each finger senses the signing gesture and couples the analog voltage to the microcontroller. The microcontroller MSP430G2553 converts these analog voltage values to digital samples and the ASCII code of the letter gestured is wirelessly transmitted using the ZigBee. Upon reception, the letter corresponding to the received ASCII code is displayed on the computer and the corresponding audio is played.**

Keywords—*Sensor, Microcontroller, Wireless communication, Display and Audio.*

I. Introduction

About nine billion people in this world are either deaf or mute or both. The deaf communities use the sign language as a communication medium. Sign language uses manual communication and the body language to convey the intended message unlike acoustically conveyed sound patterns. Communication between the deaf and the mute with the normal people is a greater challenge than communication between the blind with the normal people. When the deaf or the mute communicate with the normal people, they often encounter couple of major problems. First of all, there is no universal standard in the sign language. Each country possesses its own sign language. Secondly, the person who has no knowledge of the sign language will not be able to understand the message being conveyed by the deaf or the mute. In some cases, misinterpretation of the signing gesture may also cause problems. Hence, it can be concluded that there exists a barrier in the communication using sign language. To remove this barrier, the sign language interpreter device is used. American Sign Language (ASL) is chosen for interpretation as it is the most widely used sign language across the world. Like any spoken language, ASL is a language with its own unique rules

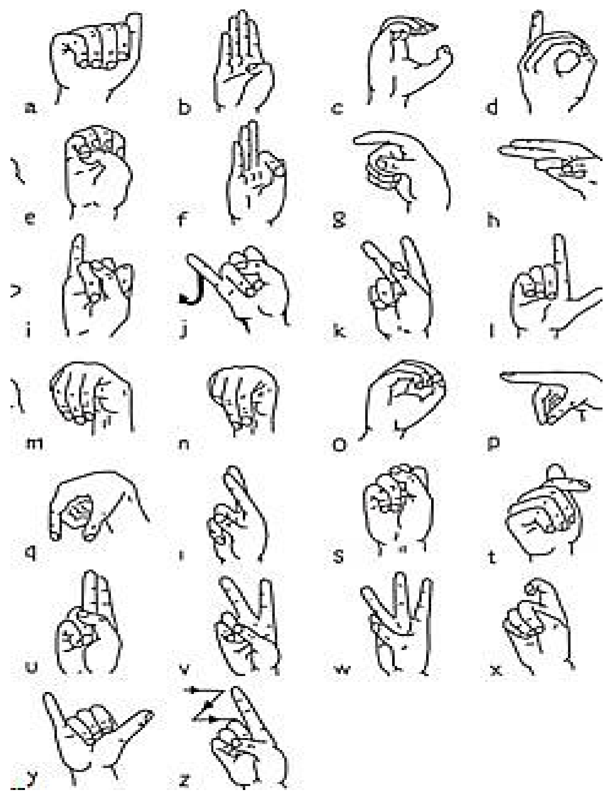

Fig.1 The letters of the English alphabet in ASL

of grammar and syntax. ASL is used predominantly in the United States and in many parts of Canada. It is accepted by many high schools, colleges, and universities in fulfillment of modern and "foreign" language academic degree requirements. The letters of English alphabet in American Sign Language is as shown in fig 1.

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Sign language interpretation is classified into two main categories i.e., vision based [1][2] and sensor based[3][4][5]. The disadvantage of vision based techniques includes complex algorithms for data processing. Another challenge in image and video processing includes variant lighting conditions, backgrounds and field of view constraints and occlusion. The sensor based technique offers greater mobility. The sign language interpreter proposed in this paper uses a glove fitted with sensors that can interpret the ten English letters in American Sign Language. The glove uses LED-LDR pair to gather data on each finger's position to differentiate the letters. The translation is transmitted to the computer, which displays as well as pronounces the letter. This is a very fast and effective way of converting Sign language into text. The block diagram of the sign language interpreter is as shown in fig 2.

Sensor is placed on each and every finger of the hand. Five sensors are thus used to detect the signing gesture. The analog signals from the sensors are given to the ADC10 of MSP430G2553. MSP430G2553 has an 8-channel-10-bit ADC of which 5 channels are used. ADC converts the analog signal from the sensors into the digital data.

These digital samples are encoded to respective ASCII code and given to ZigBee module for transmission. ZigBee transmitter module transmits the encoded data wirelessly. At the receiver end, the receiver receives the ASCII code. The ASCII code is forwarded to the computer where the corresponding character is displayed. In the end, the audio of the displayed alphabet is played.

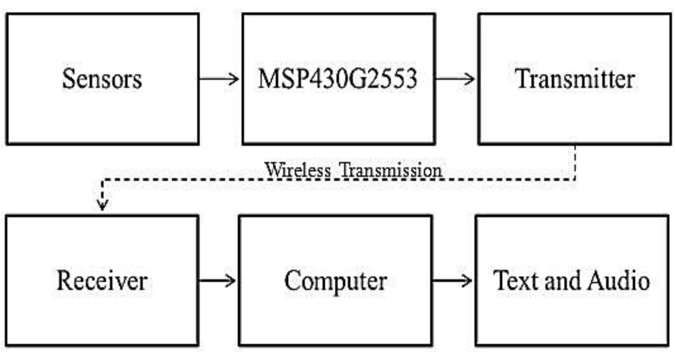

Fig 2 : Sign Language interpreter

II. SENSOR

A sensor is a transducer that measures a physical quantity and converts it into a signal which can be read by an electronic instrument. The sensor used in the smart glove to detect the sign language gesture is the LED-LDR pair. The circuit diagram of the same can be seen in the figure below.

LDR is the abbreviation for Light Dependent Resistor. The resistance of a LDR decreases with increasing incident light intensity and vice versa. LED and LDR is placed in the line of sight using a sleeve. This is necessary in order to prevent any outside light source influence the sensing process. The sleeve containing LED at one end and LDR at the other is placed along the finger. When the finger is kept straight, most of the light from the LED fall on the LDR. The resistance of the LDR is low and the voltage across the LDR is thus less. When the finger is bent, intensity of light falling on the LDR is low. The resistance of the LDR increases and the voltage across the LDR is higher than earlier. This signifies that the finger is bent. The same circuit is replicated for all the five fingers. The analog voltage across the LDR is coupled to the microcontroller.

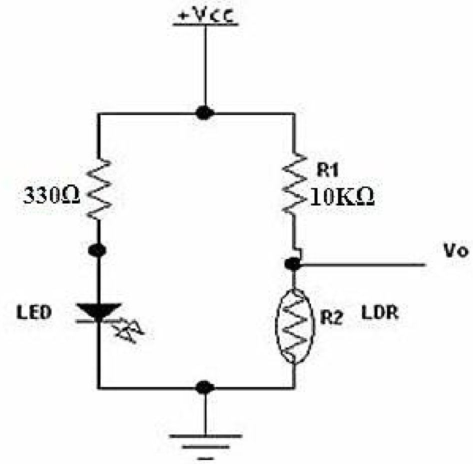

Fig 3 : Sensing circuit

III. MICROCONTROLLER

To convert the analog voltage from the sensors to the digital samples, an Analog to Digital converter is required. To transmit the gestured letter, UART is necessary. A device that possesses both these features is microcontroller MSP430G2553. The MSP430G2x53 series are ultra-low-power mixed signal microcontrollers with built-in 16-bit timers, up to 24 I/O touch-sense-enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. MSP430G2553 has a 10-bit analog-to-digital (A/D) converter, 8 ADC channels along with 512 bytes SRAM and 16kB Flash. Only five of the ADC channels are required to convert the analog voltages from the five sensing elements to the digital values. In ADC10 of MSP430G2553, sequence of channel conversion mode is selected. The flowchart of the same is shown in fig 4. [7]

The ADC10 core is configured by two control registers, ADC10CTL0 and ADC10CTL1. The core is enabled with the ADC10ON bit. With few exceptions the ADC10 control bits can only be modified when ENC = 0. ENC must be set to 1 before any conversion can take place. A sequence of channels is sampled and converted once. The sequence begins with the channel selected by INCHx and decrements to channel A0. In this case INCHx is selected to be 7. Each ADC result is written to ADC10MEM. The sequence stops after conversion of channel A0. When ADC10SC triggers a sequence, successive sequences can be triggered by the ADC10SC bit. When any other trigger source is used, ENC must be toggled between each sequence. The ADC10 includes a data transfer controller (DTC) to automatically transfer conversion results from ADC10MEM to other on-chip memory locations. It is enabled by setting the ADC10DTC1 register to a nonzero value. When the DTC is enabled, each time the ADC10 completes a conversion and loads the result to ADC10MEM, a data transfer is triggered. The one-block mode is selected if

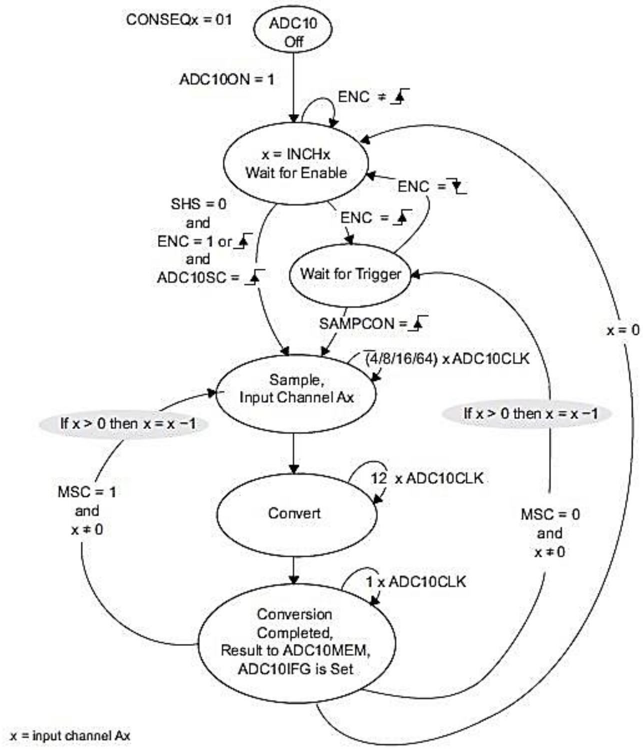

Fig 4: Flowchart of sequence of channel conversion mode

the ADC10TB is reset. The value n in ADC10DTC1 defines the total number of transfers for a block. The block start address is defined anywhere in the MSP430 address range using the 16-bit register ADC10SA. The block ends at ADC10SA + 2n – 2. [7]

Once the digital values of the analog voltage of each of the five fingers are obtained, the encoding of these values is done.

The encoding procedure for the digital value obtained for one finger is as given below.

- If the digital value is less than half of the maximum value that can be represented by the ADC, encode it as ‘1’. This signifies that the finger is straight.
- If the digital value is more than half of the maximum value that can be represented by the ADC, encode it as ‘0’. This signifies that the finger is bent.

If the above procedure is carried out for all the digital values obtained after conversion, then an array of ones and zeroes are obtained. Each bit in an array signifies if that particular finger is bent or not. Once the encoded array is obtained, comparison with the similar predefined array of ASL alphabets is done. Based on the match, the ASCII code of the matched letter is transmitted.

IV. WIRELESS COMMUNICATION

For transmission and reception, ZigBee is used. ZigBee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low- power digital radios. ZigBee is based on an IEEE 802.15 standard with a data transmission rate of 250 kbps in 2.4GHz frequency band. In the microcontroller MSP430G2553, Universal Serial Communication Interface (USCI) in UART mode is used in order to send the ASCII character of the letter to the ZigBee transmitter module. Control registers of UART are initialized, baud rate is set to 9600 and the ASCII character of the letter to be sent is put into the transmission buffer of the UART. The transmission and receive buffer of UART contains a shift register; when a byte is placed in this register it transmits the individual bits in a sequential fashion. At the destination, receive buffer re-assembles the bits into complete bytes. The ASCII character in the transmission buffer is serially sent to ZigBee transmitter module which is then wirelessly communicated to the ZigBee receiver module. When ASCII character is received by the ZigBee receiver module it is then serially forwarded to the computer. The letter corresponding to the received ASCII character is displayed and the audio output of the displayed letter is obtained.

V. DISPLAY AND AUDIO

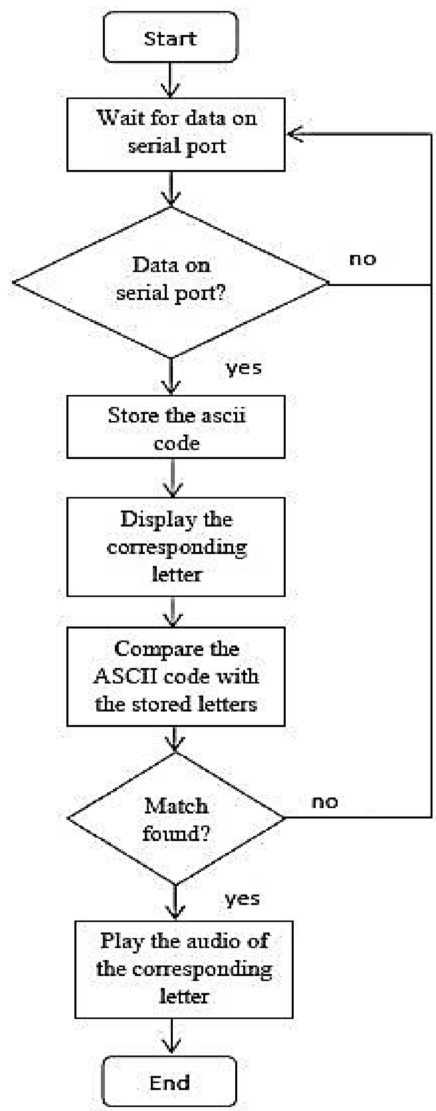

Fig 5: Flowchart for displaying and audio output of the letter

Character corresponding to the received ASCII code must be displayed on the computer screen as well as its audio output must be obtained. In order to accomplish this task, a tool called Processing is used.

Processing is an open source programming language and integrated development environment (IDE) built for the electronic arts, new media art, and visual design communities with the purpose of teaching the fundamentals of computer programming in a visual context, and to serve as the foundation for electronic sketchbooks. The flowchart of the display and audio process is as given in fig 4. Serial, one of the libraries in Processing2.0, is used to read the serial port and display the character corresponding to the ASCII code read. Minim, one of the libraries in processing2.0, is used to include the audio file of the letters and to give an audio output based on the character being displayed.

VI. EXPERIMENTAL RESULTS

The smart glove developed to interpret the sign language was tested thoroughly for the 10 English alphabet characters. The 10 English alphabet characters that can be interpreted using the glove are as given below.

CHARACTER	PROBABILITY
A	0.081
B	0.014
D	0.037
E	0.131
F	0.029
I	0.063
K	0.004
L	0.033
W	0.015
Y	0.019

Fig 6 : Table of letters and their probability of occurrence

As can be seen from the fig 6, the smart glove was designed to interpret the sign of the above stated English alphabet characters. These 10 characters are chosen as they are among the frequently occurring characters in English language. Moreover, the gestures for these 10 letters neither involve the movement of wrist nor the contact between the any two fingers.

The experimental results of two of the characters interpreted by the smart glove among those mentioned in the fig 5 can be seen in the following subsections.

A. *CHARACTER 'a'*

When the user does sign 'a' as shown in the fig 7, the values from the sensors are sent to the microcontroller through the ADC ports. The microcontroller receives these analog values and converts them to the corresponding digital values. These digital values are then encoded to ones and zeros. For 'a', the value in terms of ones and zeros is [1 0 0 0 0] and this can be seen in the fig 8.Comparison of this encoded value is done and the corresponding ASCII code is put into the transmission buffer of UART for serial transmission. It is transmitted serially to the ZigBee transmitter module, which is then wirelessly transmitted to the ZigBee receiver module. The received ASCII value forwarded to the computer. The character corresponding to the ASCII code is then displayed in processing as shown in the fig 9.When the letter 'a' is displayed in processing the corresponding letter is pronounced.

Fig7: Sign gesture for 'a' in ASL

Expression	Type	Value
f	unsigned int[5]	0x020A
[0]	unsigned int	1
[1]	unsigned int	0
[2]	unsigned int	0
[3]	unsigned int	0
[4]	unsigned int	0

Fig 8: Encoded values

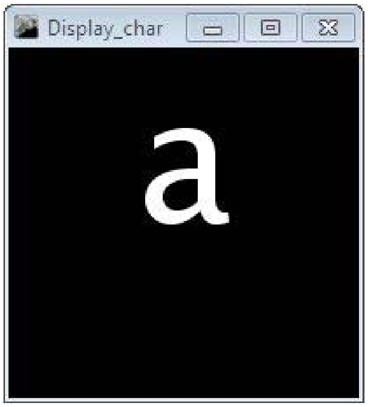

Fig 9: Display as seen on Processing2.0

B. *CHARACTER ‘b’*

Sign gesture for character ‘b’ can be seen from fig 10. Fig 11 and fig 12 shows the encoded values for the character ‘b’ and the corresponding display on Processing2.0 respectively. A similar explanation as given to character ‘a’ implies to character ‘b’ and every other character that can be interpreted using the smart glove.

Fig 10: Sign gesture for ‘b’ in ASL

Expression	Type	Value
f	unsigned int[5]	0x020A
[0]	unsigned int	0
[1]	unsigned int	1
[2]	unsigned int	1
[3]	unsigned int	1
[4]	unsigned int	1

Fig 11: Encoded values

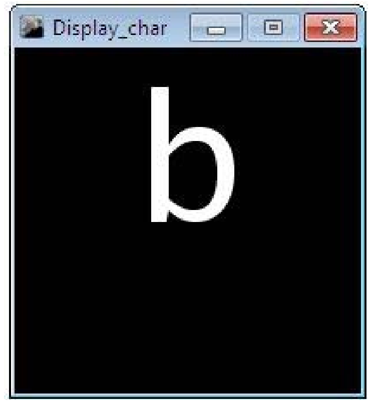

Fig 12: Display as seen on Processing2.0

VII. CONCLUSION

In this paper, the smart glove approach proposed is meant to be a prototype to check the feasibility of recognizing sign languages using smart gloves. The completion of this prototype suggests that smart gloves can be used for partial sign language recognition. The system is composed of two main components. First is a sign language recognition part, which has the smart glove to recognize the signing gesture and create text representation of the signed gesture. Second is a translation part which converts text to audio output. With the ability to recognize sign languages especially natural forms, the deaf community will not be left behind as the industry moves away from the standard text inputs.

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