DU Journal of Undergraduate Research and Innovation
Volume 3, Issue 2, pp 01-11

Gesture Recognizing Smart System

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ABSTRACT

For differently abled people like deaf or dumb, communication is a challenge. They make use of sign language which is not easily understandable by others and hence poses severe challenges and inconveniences for them in carrying out their day to day task. This work attempts to bridge the communication gap by designing a device that can convert the user's sign language gestures to visual form. The primary focus of the work is to design a portable, intelligent, smart, and cost-effective system using flex sensors and accelerometer which identifies the extensive hand movements of the differently abled person while communicating using sign language and in effect can facilitate him/her in communicating with others. The portable device can capture the user's sign language gestures, convert it to text and outputs the translated text to PC serial monitor, which can easily be understood and can also be converted to voice to be heard by the normal audience. The work also encompasses the design of mobile application for further assistance to differently abled persons.

Keywords: Arduino, Flex Sensors, Gesture Recognition, Sign Language

INTRODUCTION

A gesture is a form of non-verbal communication in which the visible bodily actions communicate messages either in place of speech or in conjunction with speech (1). Sign language is a means of communication which, instead of acoustically conveyed sound patterns, uses manual communication and body language, mainly hand movements, to convey the message. The message conveyed by differently abled people through sign language cannot be easily understood by common people. To understand them, one should be able to understand their language i.e. sign language. But it is not possible for everyone to learn sign language. So, sign language translating equipment, which can translate sign language messages to normal understandable text or voice form, can be used to bridge this gap.

Science and technological advancements has taken a leap towards bridging the communication gap between the normal community of the society and the differently abled people. Many commercial products are also available in the market that can help differently abled people but they are costly and cannot be used in everyday situations because the necessary use of PCs limits their portability (2). The prototype designed here overcomes these issues by providing a smart glove which can be efficiently used without the need of PCs, by providing audio and visual output of the recognized gestures on the Android devices and the use of PCs thus becomes optional, thereby providing portability to the device at a lower cost.

LITERATURE REVIEW

Several projects have been carried out in this field which incorporated the gesture recognition technique. The first glove prototype to emerge included the Sayre Glove, the Massachusetts Institute of Technology (MIT)-LED glove and the Digital Entry Data Glove [3]. It used different touch or proximity sensors mounted on a cloth for determining the user's thumb movements and other parts of the hand or fingers. The first commercially available Data Glove appeared in 1987, (3) and since then different designs have been projected for this gesture recognition glove technology. Various types of machine learning algorithms have been used to implement gesture recognition that could learn from or make predictions based on data and can be further supervised for system taming. Supervised machine learning algorithms usually involved data sets that were used for further training the machine or system to learn or recognize the pattern of data that it had been monitoring so that the machine could apply these patterns to new data sets (4).

A number of approaches within the field of Artificial Intelligence (AI) such as Artificial Neural Networks (ANN), Artificial Vision, Virtual Reality and motion capture using data gloves or Electromyography (EMG) sensors, (5) have also been used to effectively recognize and translate sign language. Thus, in general there are two main approaches for recognizing hand gestures: one was based on motion capture of the user's hand, while the other was based on artificial vision to determine the gestures made in a specific time. Both the approaches have their pros and cons (6).

Vision-based gesture recognition relies on image capture by one or more cameras and apply algorithms to extract visual features, in order to recognize the gestures made. The problem of gesture recognition in real time is worked upon by Digital Image Processing using Color Segmentation, Skin Detection, Image Segmentation, Image Filtering and Template Matching techniques. The purpose of these applications is to recognize hand gesture with very simple design where the signer doesn't need to wear any type of hand gloves and is thus totally independent of the system. The fact that the person making the gesture is totally detached from the system is one of the most important benefit in working with visual recognition (4).

In this work, an effort is made to provide a portable, intelligent, smart and cost-effective system for helping the hearing impaired and mute person to have usual communication with others. The system identify the extensive hand movements of the differently abled person while communicating using sign language and this in turn, can facilitate him/her in communicating with others. To further assist the differently abled people, our work also aimed to develop a mobile application which will perform the task of text-to-speech conversion for conveying the desired information in audible form and will also act as a learning tool to help the interested ones in learning sign language.

HARDWARE USED

The basic prototype of this work consists of a gesture recognizing glove, fitted with flex sensors and accelerometer and the Arduino MEGA ADK for signal processing. Arduino MEGA ADK is a microcontroller board based on the ATmega2560. The prototype uses the android's TTS feature for providing better sound quality without the use of expensive voice modules.

FLEX SENSORS

Flex sensors, used to detect bending, are passive resistive devices made up of carbon strips having metal pads inside it, as can be seen in figure I. It is a variable resistor, which upon bending produces a change in value. The sensor produces a resistance output corresponding to the bend radius where; the smaller the radius, the higher the resistance value. Straight (un-flexed) resistance is 25 kilo ohms and 90 degree bend resistance is 75 kilo ohms. This resistance varies with the sensor's degree of bend and the voltage output changes according to the bend. They require a 5-volt input and provide analog output between 0 and 5V. The sensors are connected to the device via three pin connectors (ground, live and output). Table I gives the pin configuration of the flex sensor used.

Figure I: Flex Sensor

Table I: Flex Sensor Pin Configuration

Pin	Name	Details
1	GND	Power Supply Ground
2	+5V	Power Supply Positive Input
3	OUT	Analog Output

ACCELEROMETER

The accelerometer-ADXL335 is used in the design. It is a low power 3-axis accelerometer with input voltage of 5V and produces signal conditioned voltage outputs of 3.3V. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The measured analog output is ratio metric with a minimum full-scale range of ±3 g where 0 g measurement lies in the middle of 3.3V output.

ARDUINO MEGA ADK

The Arduino MEGA ADK is a board comprising of microcontroller ATmega2560 and has 54 digital input/output pins. It consists of a USB host interface, which enables it to connect to Android phones, based on the MAX3421e IC. Out of 54 digital pins, 15 pins can be used as PWM outputs, 16 pins as analog inputs and 4 pins as UARTs (hardware serial ports). There is an onboard 16 MHz crystal oscillator, a power jack, an ICSP header, and a reset button.

The gesture recognizing glove used in this work is a normal fabric glove fitted with five flex sensors in proper orientation and accelerometer as can be seen in figure II, to detect the accurate bending of each finger which is then recorded using programmable Arduino Mega ADK interface. The project code has been written in Arduino's IDE programming environment in simple C++ language. The length of the flex sensors used in this work is 2.7 inches and each sensor has been adjusted over the knuckle without getting slipped over. To keep the sensors in place, they have been stitched over the fingers of the gloves. The output terminal pins of the flex sensors placed on adjacent fingers have been properly insulated from each other to avoid any kind of short-circuiting which can cause variation in the resistance from the actual value. Each of the flex sensor terminals is connected to jumper wires for further connections. For calibration of flex sensors, voltage divider network has been used which is soldered on a PCB to which the sensors are connected for proper biasing. The bending of the fingers is then detected by recording the resistance of the flex sensors. The readings thus obtained are used to determine the corresponding message which is later displayed on PC serial monitor.

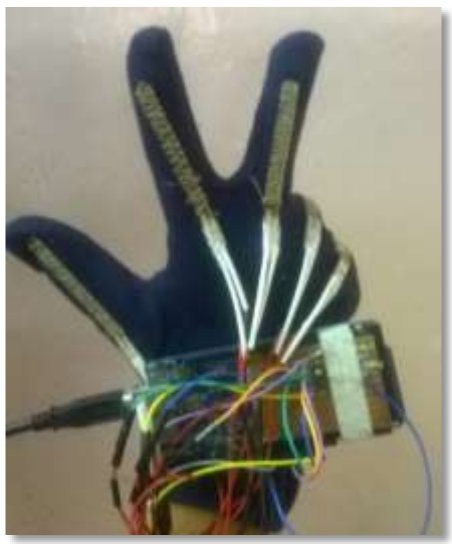

Figure II: Proposed Prototype

The accelerometer is also fitted on the palm of the hand that detects the hand orientations in different directions and the recorded value is then transmitted directly to the analog pins of Arduino microcontroller. The Arduino continuously scans its 8 analog channels at the rate of 10 kbps with resolution of 14 bits. The successive approximation type scanning method is used. The microcontroller receives the data from ADC which is then used for comparison and processing. For each character, the output from ADC is checked to get the voltage drop across the flex sensor and those voltage values are then mapped to get the corresponding resistance of the tilted flex sensor.

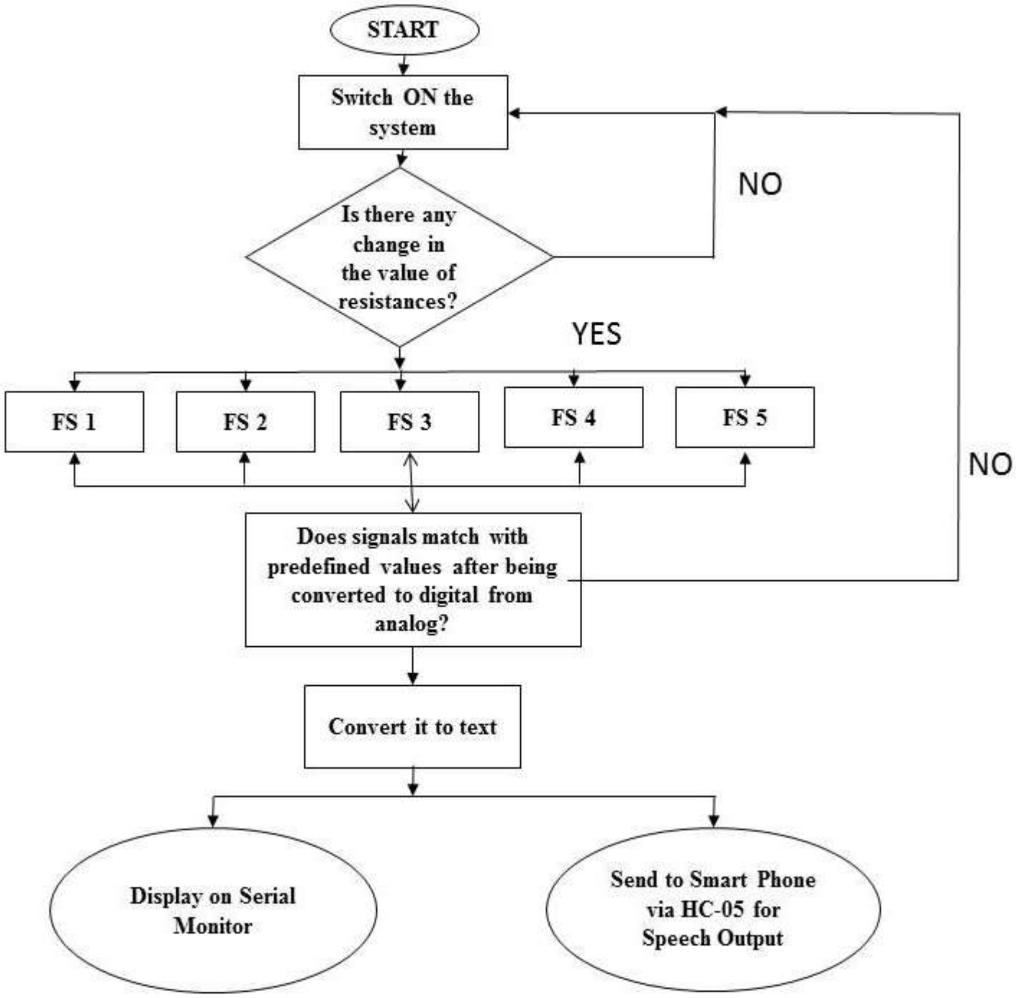

Figure III: Flow chart explaining gesture recognition system

A look-up table is created for every gesture based on the finalized resistance and accelerometer values and these values obtained from them are then compared with the tabulated values. The corresponding characters are recognized after a comparison from the look-up table entries. This information is then conveyed to other users either in the form of a text output for visual insemination or in the form of speech output for audio insemination of information. The converted text is transmitted to Android device using Bluetooth Module HC-05 and the speech output is provided by the use of Android's TTS feature. The entire technique was repeated till the complete information was converted to text and speech for the normal person to ease out the communication with the differently abled person. Figure III shows the flow of control of the work done.

Before defining the sensors values for a gesture, a number of readings are recorded until a stability and similarity in the recordings is obtained. The system is calibrated under different temperatures to incorporate the effect of temperature variations on the flex sensor readings. Few similar gestures need more number of samples but on an average, the various gestures are defined by taking two consecutive samples each from three different users wearing the glove. The accuracy of the prototype also depends on the size of user's hand. Smaller hands will provide comparatively large degree of bend, which leads to small differences between gestures getting unnoticed and may provide incorrect results.

RESULTS AND DISCUSSION

The prototype proposed in this work explores the use of glove for deaf, dumb, and physically impaired people, converting their hand gestures to desired actions, text and speech output. The android's TTS feature provided better sound quality without the use of costly voice modules. The development of mobile application further offers a learning platform for the learners of sign language by providing both audio and visual output simultaneously. The prototype can be used without a computer, thereby providing portability to the design.

I. GLOVE OPERATION

A. SWITCHING BETWEEN MODES

The bend of the fingers was recorded using flex sensors. The flex sensors provide a range of values for a bend angle rather than providing a single value. The resistance values of all the gestures of sign language are compared with the previously defined values and accordingly the various gestures are recognized. Accelerometer is also incorporated to record proper hand orientation along with finger bend. The module worked in two modes i.e. Alphabet mode and the General mode. In Alphabet mode, alphabets are defined and in General mode, numeric characters and few common gestures are defined. The switching between these two modes is also implemented using gestures. Table II shows the resistance values obtained after calibrating the different flex sensors on the glove for mode switching. These resistance values correspond to the gestures that are defined for the entry in the two modes. The accelerometer readings for the two mode switching gestures are almost same as there is little change in the orientation of hand in generating the two gestures. Only the fingers' bent are different. Figure IV shows the gestures that are used to specify the alphabet mode and general mode. The system is so designed that exiting from one mode results in entering the other.

Table II: Flex sensor reading for mode switching

MODES	FLEX SENSOR RESISTANCE RANGE (in kΩ)				
	THUMB	INDEX FINGER	MIDDLE FINGER	RING FINGER	PINKEY FINGER
ALPHABET	110-160	145-190	60-85	50-85	80-110
GENERAL	120-155	145-185	155-190	130-180	35-65

B. ALPHABET MODE AND GENERAL MODE

Table III and Table IV summarizes the range of resistance and voltage values obtained after successful calibration of flex sensors and accelerometer respectively, in alphabet mode, for recognizing various alphabets and for converting them to text, in the gesture to text conversion function of the system. The flex sensor and accelerometer readings in this mode for various alphabets are found to be same due to similar hand orientations. To deal with similar types of gestures, in case of flex sensors the amount of bend of finger is modified by bending the finger more than necessary at few places and less at the other. This bring out some substantial amount of difference in the flex sensor readings and hence make every gesture unique. For example, consider the signs “M”, “N” and “S”. In all the three gestures, all five fingers are bent, and the only difference is the amount of bend. In “M” the thumb is bent more (purposefully) and since it is resting on the pinky finger, the amount of bend in the pinky finger is also increased (more than needed) as compared to “N”. In case of “S”, there is slightly more flex compared to other two. So, by modifying the amount of bend, some difference is created in all the gestures. Figure V shows the gesture and corresponding readings for alphabet ‘A’.

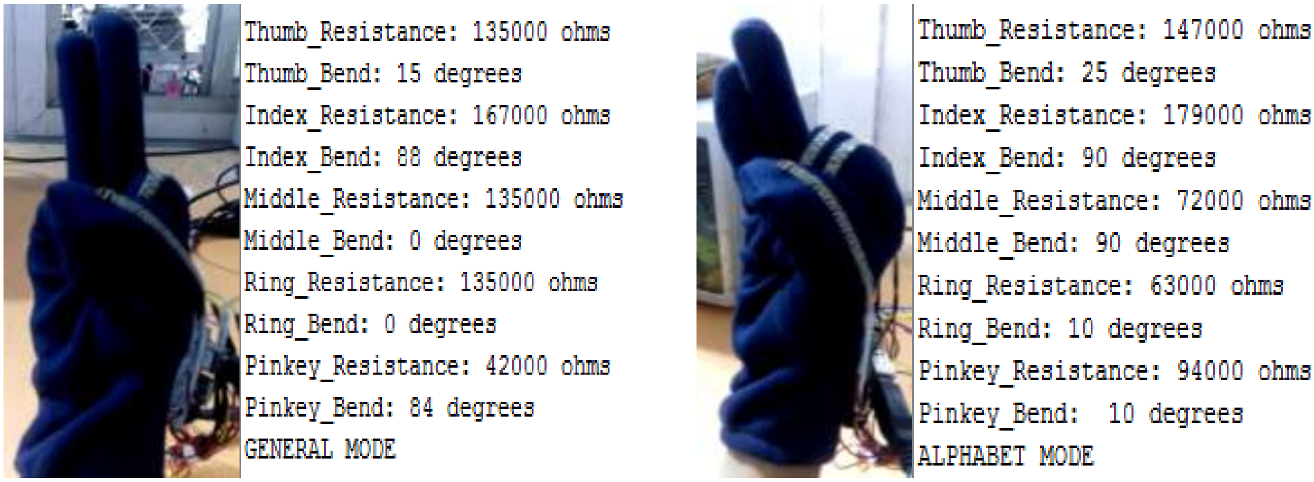

Figure IV: Gesture and corresponding readings for Mode Switching

Table III: Flex sensor readings in alphabet mode

ALPHABETS	**ACCELEROMETER RANGE (mV)**	
	X-VALUE	**Y-VALUE**
A,B,D,E,F	320-338	320-340
C,O	350-380	320-345
G,H	330-355	260-280
P	390-415	320-345

Flex sensor reading for some common gesture in general mode is given in table V. Figure VI shows the gesture and corresponding readings for message ‘NO’. In a similar manner, most of the alphabets and numeric characters are defined.

Table IV: Accelerometer readings in alphabet mode

ALPHABETS	FLEX SENSOR RESISTANCE RANGE (kΩ)				
	THUMB	INDEX FINGER	MIDDLE FINGER	RING FINGER	PINKEY FINGER
A	70-93	125-165	140-182	125-165	85-120
B	95-135	65-85	60-85	65-85	40-65
C	70-130	95-130	100-140	95-130	40-85
D	110-150	55-85	120-155	120-155	70-120
E	100-145	120-175	110-155	120-175	70-105

Figure V: Gesture and corresponding readings for alphabet ‘A’

Table V: Flex sensor readings for some common gestures

COMMON GESTURES	FLEX SENSOR RESISTANCE RANGE (in kΩ)				
	THUMB	INDEX FINGER	MIDDLE FINGER	RING FINGER	PINKEY FINGER
HELLO	95-135	65-85	60-85	125-165	40-65
YES	100-141	140-190	155-190	120-175	90-125
NO	75-105	60-95	80-105	125-170	85-115
SORRY	70-93	125-160	130-162	120-175	85-115
WELCOME	50-93	80-120	80-120	125-165	45-85

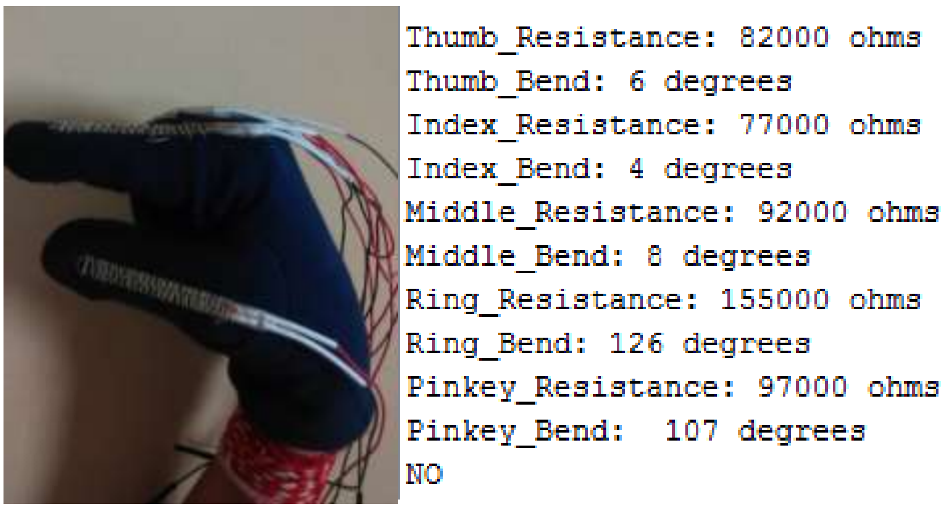

Figure VI: Gesture and corresponding readings for message 'NO'

II. MOBILE APPLICATION

A. TEXT-TO-SPEECH CONVERSION FEATURE

It is used as an alternative to Arduino text-to-speech module/shield, which is very expensive. This feature makes use of Bluetooth technology to receive text sent from the Arduino via Bluetooth module HC-05. HC-05 is a Bluetooth SPP (Serial Port Protocol) module providing transparent wireless serial connection with any Bluetooth enabled device. The communication between the glove and the android system is through Bluetooth V2.0+EDR (Enhanced Data Rate), a specification for short-range wireless data exchange.

Arduino converts the recognized hand gesture to text and this text is transmitted via Bluetooth IC to android phones. In the Android device, text-to-speech conversion is carried out. So, the Arduino enables the gesture recognized to be spoken aloud by the phone. Figure VII shows the preview of mobile application developed, where Screen 1 provides the platform to connect to the Bluetooth device (BT module) and screen 2 provides the platform to display the text message received via Bluetooth module and provide the feature of text-to-speech conversion.

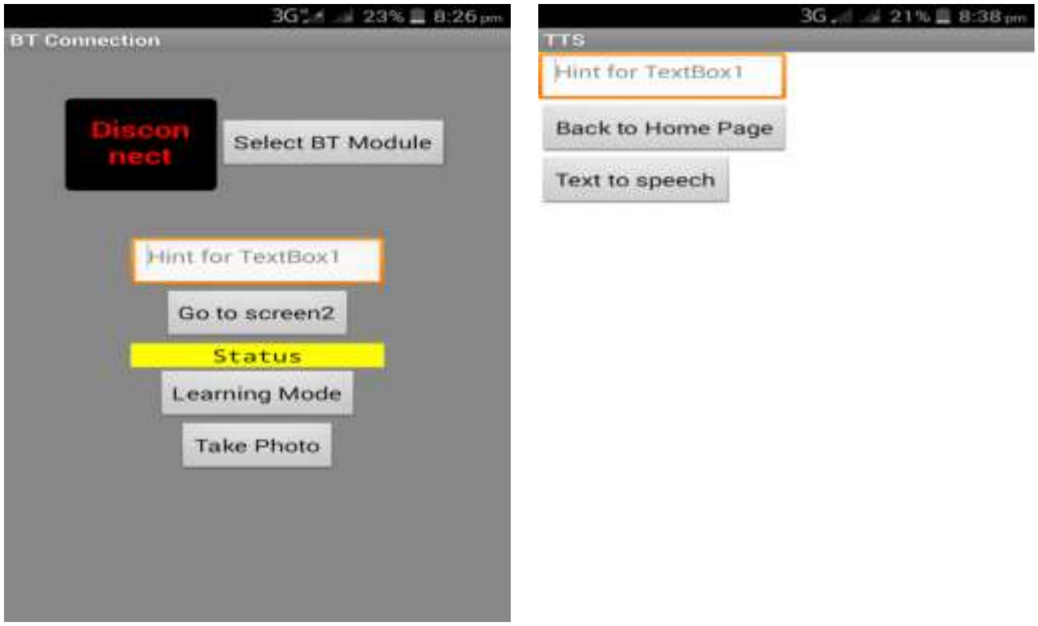

Figure VII: Preview of Mobile App developed

B. LEARNING MODE

In the learning mode, various sign language gestures are displayed and are also spoken aloud, thereby providing ease and assistance to sign language learners. Figure VIII shows the preview of mobile application developed in this work in Learning Mode.

Figure VIII: Preview of Mobile App in Learning Mode

CONCLUSIONS

The flex sensors, placed on the knuckles of the hand, can monitor the user's gestures and are thus capable of working as a gesture recognition system, which further has many uses including the communication of differently abled people.

The mobile app developed in this study provides additional assistance to its user and makes the device portable. Using the proposed technology, communication can be eased between the speakers and non-speakers of sign language. To detect the motion of the hands more efficiently, along with flex sensors and accelerometer, contact sensors can also be placed on the glove, thereby making the design more efficient. The Smart Glove can be used in gaming applications where the hand movement can control the moves of the gamer. The glove can also be used for home automation, where the gestures of the hand will control the switching of the devices. The prototype also finds its applications in other fields such as military and rescue operations.

ACKNOWLEDGEMENTS

Authors are grateful to the Department of Electronics, Acharya Narendra Dev College, University of Delhi for providing necessary conceptual understanding and financial assistance to carry out this work. The authors also express their gratitude to the Principal, Acharya Narendra Dev College for motivation and constant guidance.

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