Intelligent Control System using Gesture Sensing

Naveen Kumar Toshawar, Chandni Jain

Abstract— **With the rapid Increase in the technologies as well as in the Science, it has become a major concern for every individual to be updated in the latest inventions and the software's. In the present era, we have noticed that there are numerous applications as well as software's has been introduced in the markets which are totally controlled by our Body Gestures or we can say that these applications are fully gesture based applications.**

Generally, Gestures are one of the most intuitive ways of interacting with an application. There are lots of application software which senses our body movement, matches with the particular pixels range which is stored in the database prior to the software being developed and delivered to the client side. This phenomenon or we can say, these types of technologies can be made by several software's.

Gesture Recognition means identification and recognition of gestures originates from any type of body motion but commonly originate from face or hand. The latest invention in this field includes Emotion recognition from the face and hand gesture recognition. Gesture recognition enables humans to interface with the machine (HMI) and interact naturally without any mechanical devices.

Index Terms — **Intelligent Control, Picture Processing, Pattern Recognition, Gesture.**

I. INTRODUCTION

Gesture Recognition Phenomena:—

In this technology, a camera reads the movements of the human body, sends the data to a computer that uses the gestures as input to control devices or applications.

For example, we can make a certain body gesture to switch on/off any of our home electronic appliances such as Fan, A.C. and many more.

In One way gesture recognition is being used to help the physically impaired/ handicapped people to interact with computers, such as playing with numbers or studying. The Gesture technology also has the prospective to change the way users interact with machines by eliminating input devices such as mouse, keyboard and joysticks allowing the unfettered body to give signals to the computer through gestures such as pointing to the screen.

II. GESTURE RECOGNITION

Gesture recognition is the process by which gestures made by the end user are used to fetch the information from the device which is pre-installed. The term "Gesture" is nothing but particular body actions shown to the computer to get the desired output. In everyday life, physical gestures are a powerful means of communication. "Body Language" plays a very vital role in the Inter personal communication. Gesture-based control generally wants to utilize this channel for human-machine interaction. Because traditional input devices constrain the expressive power of the human hand, researchers are developing an in numerous techniques to read hand and body movements directly. For example, most currently available interfaces make use of that particular data which can produce some results made by the user's movements.

This sometimes stems from the use of inherently discrete input devices, such as a keyboard or mouse. Even with uninterrupted input devices, such as mouse, only specific events and data points (e.g., the co-ordinates of the pointer when the user clicks) are taken into account by most applications. This interaction attempts to take the profit of the continuity and dynamics of the end user's movements, instead of simply drawing discrete information from these particular movements.

In gesture recognition technology, a camera detects the gestures made by the human body and sends the data to a computer that uses the gestures as an input to perform the operation.

Gesture recognition is a very vast topic in computer science with the aim of interpreting human body gestures via mathematical calculations as well as algorithms. Gestures can be originated from body's motion or state but it is generally originated from the face or hand. Current focuses in the field include eye's recognition from the face and gesture made by the hands. Many approaches have been made using cameras and computer vision algorithms to understand sign language. However, the classification and recognition of position, step and human behaviour is also the subject of gesture recognition techniques. The main objective of Gesture Recognition Review is:

- Study of body gestures.
- Study of various Gesture Recognition engines.
- Applications of Gesture Recognition.

Gesture Recognition is the act of interpreting motions to determine such intent. The specific human gestures can identify using the gesture recognition technology and used to convey the various information or for various applications by controlling devices. There are various Body gestures available from which we can get the particular output. Among all of them, the ones which are the most common are:

- Face Recognition
- Hand Recognition
- Body Recognition

The general block diagram of it is depicted in the below figure:

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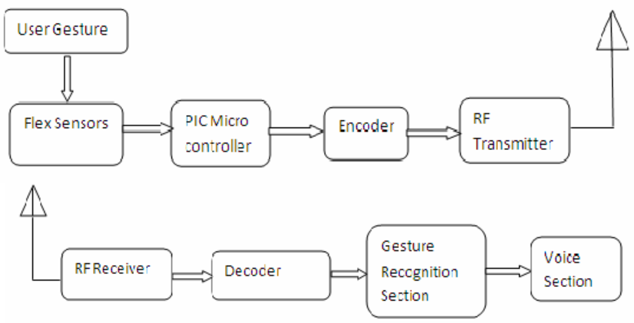
Gesture is a very natural human communication principle by which any human can make his life more comfortable. Therefore, it should lend itself to easily erudite interaction techniques. An uncommon feature of the gesture communication channel is that it allows one to act on one's environment which means it is unique to every individual. So, as far as the security point of it is concerned, a user should not worry about it. Some typical gesture commands are concise and commanding. A single gesture can include a command as well as its arguments.
For example, one gesture can be used to combine the point and click operations of a mouse. Taking into account the user's movements, in all their continuity and dynamics, can provide more information than current interfaces and improve the interaction. For instance, while drawing a program, a linear path can be interpreted as a line-drawing command, while a curled trajectory would start the drawing of a circle. More conceptually, a cross drawn on an object can be a command for deletion; this would be an excellent and iconic use of the gesture. This can provide for more natural control of a system at a lower cost. As a matter of fact, in the upcoming few years, the hand can become the actual input device being used for the gesture.

2.1 Different ways of Gesture Recognition:
There are several ways of gesture recognition such as Hand, Face and Body Gesture Recognition explained below.

1. Hand Gesture Recognition:

Hand gesture can be best operated by wearing a glove. A glove-based system makes the user to be connected to the computer. Even wireless systems currently offered in the market makes the user to compulsory wear a glove. Moreover, accurate devices are expensive and hard to calibrate.



Block Diagram of Glove based Hand Gesture Recognition.

* User Gesture: Data glove is used to capture the hand gestures made by the user.
* Flex Sensor: The data glove is fitted with flex sensors on the top of each finger and the thumb. The flex sensor outputs a stream of data that varies with degree of bend. The analog output which is generated from the sensors are then send over to the PIC microcontroller.
* PIC microcontroller: It processes the input signals and then perform the analog to digital signal conversion (ADC).
* Encoder and RF Transmitter: The desired digital signal is then encoded and transmitted through RF system.
* RF Receiver and Decoder: RF receivers receive the signal and fed to the gesture recognition section through the decoder.
* Gesture Recognition Section: In this section the gesture is recognized and the corresponding information is identified and dealt with.
* Voice Section: In this section, the Text to Speech conversion takes place and is being played out through the speaker.

2.1.1 Flex Sensors:

The Flex sensors are normally glued to the glove using either a needle or a thread. It generally requires a 5-volt Input power supply and Output between 0 and 5 V, the resistivity altering with the sensor's degree of bend and the voltage output changing consequently. The sensors are usually connected to the device via three pin connectors namely ground, live, and output. The device can turn on the sensor from off mode, enabling it to power down when not in use and greatly decreasing power consumption. The flex sensor Photograph shown changes resistance when twisted. It will only change resistance in single direction. The unflexed sensor has a resistance of near about 10,000 ohms. As the flex sensor is turned, the resistance rises upto 30- 40 kilo ohms at approximately 90 degrees. The dimensions of the sensor are ¼ inch wide, 4-1/2 inches long and 0.19 inches thick.

Fig. Flex Sensor

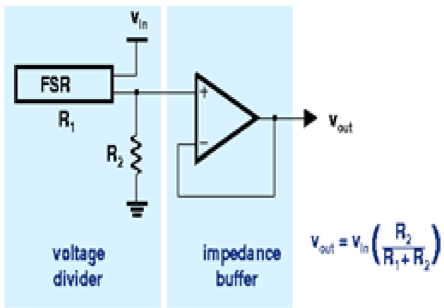


Fig. Basic Flex Sensor Circuit

As seen in the above diagram that two or three sensors are connected serially and the output from the sensors is sent to the Analog to digital converter(ADC) in the controller. The outputs from the sensors are sent to LM258/LM358 op-amps and used as a non-inverted style setup to amplify their voltage. The more the degree of bending, the least will be the output voltage. The output voltage is unwavering based on the equation Vin * R1 / (R1 + R2), where R1 is the other input resistor to the non-inverting terminal. Using the voltage divider concept the output voltage is determined and it ranges from 1.30V to 2.8V.

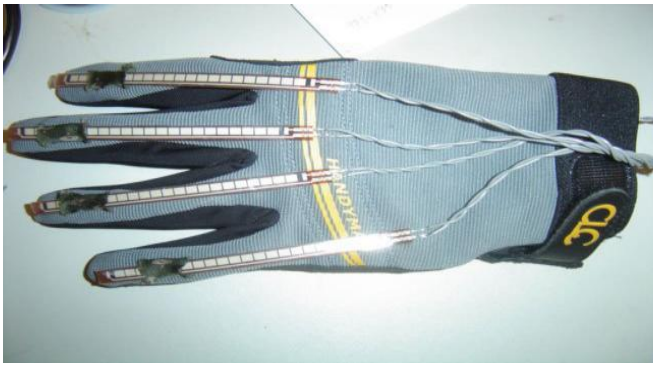


Fig. Glove with Flex Sensor

Characteristics:

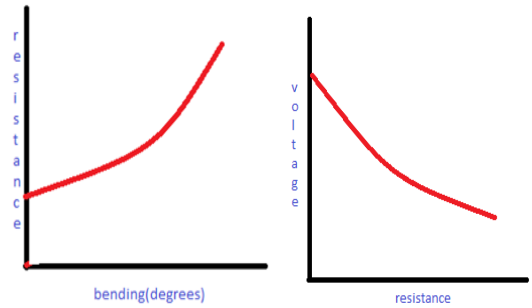


Fig. a) Bending Vs Resistance b) Resistance Vs Voltage

PIC Microcontroller:
All output signals generated from flex sensors are in analog form and these signals are required to be digitized before they can be sent/transmitted to encoder. Therefore, the basic microcontroller PIC16F877A is used as the main controller. It is comprised of inbuilt ADC module, which digitizes all analog signals from the sensors and inbuilt multiplexer for sensor signal selection. It deals with both serial and parallel communication facilities.
Encoder/Decoder:
The output from the microcontroller is prearranged by using HT12E-212 series of encoder. It is used to correct the error at the receiver end, if any error had occurred. While on the other end, it is decoded by using HTI2D212 series of decoder. The body movements involved in Gesture Communication can be a source of fatigue; thus it is important to use short and simple-to-execute gestures. High precision cannot be relied on over time, and therefore, it is very difficult for a human to maintain a static pose.
While the unusual sense gives one an indication of the position of the body and limbs, it is not sufficient to ensure that the desired gesture was effectively produced. Hence, feedback on gesture recognition is very important here.
Normally, Gesture is intentionally made more difficult in a lively environment as with head-based control, hand movements are impaired by G forces and by pulsation.
Hand gestures are a general means of communication, similar to speaking any particular language. The production and sensitivity of gestures can thus be described using a model commonly found in the field of spoken language recognition. An interpretation of this model, applied to gestures, is depicted in figure below.

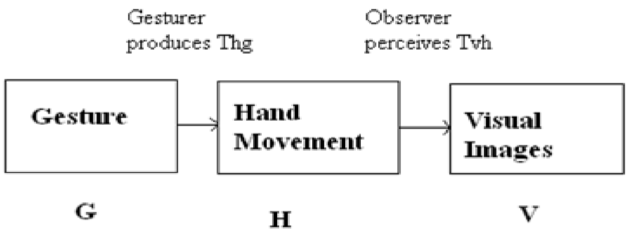


Fig. Production and Perception of Gesture

Hand gestures initiate a mental concept *G*, expressed as (*Lhg*) through arm and hand motion *H*, and are perceived (*Lvh*) as visual images *V*. According to the model, gestures originate as a gesturer's mental concept, possibly in combination with speech. They are articulated through the motion of wrist and hands, the same way speech is produced by air stream modulation through the human vocal region. Also, observers notice gestures as streams of visual images of gesturers which are acquired by one or more video cameras and recognize using the knowledge they possess about those gestures. The production and perception model of gestures can also be shortened in the following form:

H=LhgG …………………. (1)
V=LvhH …………………. (2)
V=Lvh(LhgG) = LvgG ….. (3)

Transformations *L* can be observed as different models: *Lhg* is a model of hand or arm motion given gesture *G*, *Lvh* is a model of visual images given hand or arm motion *H*, and *Lvg* describes how visual images *V* are formed given some gesture *G*. The plan of visual interpretation of hand gestures is to surmise gestures *G* from their visual images *V* using a suitable gesture model *Lvg*, or

G= LvgV …………………. (4)

Gesture Modelling Approaches:
→Appearance-based model: As far as the gesture production and perception model is considered, two possible approaches to gesture modelling may become evident. One approach may be to try to understand gestures directly from the visual images observed. This approach has been often used to model gestures, and is usually denoted as appearance- based modelling.
→3D-based Model: Another approach may result if the intermediate tool for gesture production is considered: the human hand and arm. In this case, a two step modelling process may be followed and the result will turn out to be:

H= LvhV …………………. (5)
G= LhgH …………………. (6)

In other words, one can first mould the motion and pose of the hand and arm $\hat{H}$ and then infer gesture $\hat{G}$ from the motion and posture model parameters. A group of models which follows this approach is known as 3D-model.

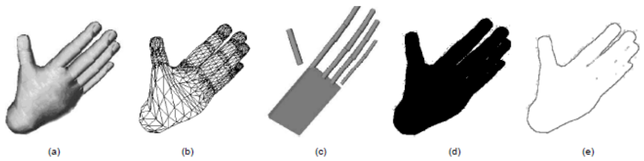


Fig. Hand Models: (a) 3D Textured Volumetric Model (b) 3D wire framed volumetric model (c) 3D Skeleton Model (d) Binary Silhouette (e) Contour

2) Face Gesture Recognition:

This way of Gesture Recognition consists of:

→OpenCV:

OpenCV stands for Free Open Source Computer Vision. It is a programming function library aimed at developing applications based on real time computer vision technologies. Some examples of OpenCV library are Object recognition, Segmentation and identification, Face Recognition, Gesture Recognition, Movement Tracking, Mobile Robotics etc.

→Visual Flow:

It uses the pixel movement of two consecutive images and delivers the result. This method takes two frames and specifies how much each image pixel has been moved and how much is unchanged.

Fig. Visual Flow Method

→Support Vector Machine:

This machine takes an ample amount of input data and guesses, for each input, which of two likely classes forms the output, resulting into a non-probabilistic binary linear classifier.

A support vector machine constructs hyper plane or set of hyper planes in a high or infinite space, which can be used for taxonomy, degeneration, or other tasks. Instinctively, a fine partition is achieved by the hyper plane that has the biggest distance to the adjoining training data point of any class, since in general the bigger the margin the least the simplification error of the classifier.

Linear SVM: Given some training data D, a set of *n* points of the form:

$$D= \{(m_i, n_i)\} \mid m_i\, E\, R,\ n_i\, E\, \{-1, 1\}\}_{i=1\to n}$$

(E refers to summation)

Where, n_i is either 1 or −1, representing the class to which the point $\boldsymbol{m_i}$ belongs. Each m_i is a *x*-dimensional real vector. We need to find the max-margin hyper plane which divides the points having n_i=1 from those having n_i=-1. Any hyper plane can be written as the set of points M satisfying

$$W.m-b=0,$$

where, w-normal vector and b/||W|| results the counteract of the hyper plane from the origin along the normal vector. If the training data are linearly distinguishable, we can select two hyper planes, the region bounded by them is called "boundary".

As we also have to prevent data points from falling into the boundary, we add the following constraint: for each 'i' either.

$$w.m_i-b>= 1 \text{ or}$$

$$w.m_i-b<=-1$$

3) Body Gesture Recognition:

Yang introduced a new system which is capable to detect body. He does so by using a **Hidden Markov Model**.

→Body Feature Detection.

* Pose Restoration Method: To detect human subjects out of video frames and creates a 3D representation of it. To do so 2D frames of a human being are taken and viewed by different angles.

* Least square Minimization approach: 2D shapes of the human are generally matched with a 3D Model of human body. It allows to allocate each elbow, fingers, ankle, palm etc. to their position in 3D space.

→Body Feature withdrawal and Gesture recognition: The previously presented 3D model gains for each frame of a video the structural feature points of the body. The centre of this 3D space is located in the region of the shaft of the 3D human model. Each of these points are first proposed in all the three planes. Then the angle between this ridge points and the axis are calculated.

→Hidden Markov Model: It is most commonly used to take out moving a knee and wrist, rising a left hand, walking, waving a hand, running, sitting on the floor, lying down on the floor, jumping and getting down on the floor gestures.

It is comprised of two parts:

*Ergonic model: This model has the task to pull out the garbage movement. In this category all movements which are not to be detected are put in it.

*Left-right model: This detects the desired gestures. By training the model with the help of feature vectors, Gesture can be evaluated.

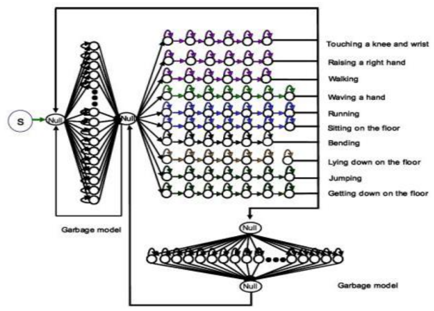


Fig. Key Gesture Spotting Model

III. CONCLUSIONS

3.1 Conclusion:

Hence, we can finally conclude the following things:

(1) Gestures are significant, evocative body motions involving physical movements of the face, hands, legs and other parts of the body.
(2) Despite the rapid advancement of technology, the advent of this technology will be a gradual process.
(3) Gesture recognition is an extensively developed technology available which is designed to identify human gestures and perform the desired output. Gestures can be used more to make easy communication with digital applications because of their consequential nature.
(4) Hand Recognition has turned out to be more beneficial and meaningful as far as the rest of the body gestures have been taken into consideration.

3.2 Future Scope of this technology:
(1) The area of this technology is very vast and never ending. Hand recognition system can be useful in many fields like Artificial Intelligence, Embedded Systems and Neural networks as well as Fuzzy logics.
(2) Gestures are intended to play an increasingly important role in human-computer interaction in the future.
(3) Facial Gesture Recognition Method can also be used as an alternate while driving, especially when the driver is intended to sleep.
(4) As this technology is very user and environment friendly, it will surely create a good impact as well as curiosity between the researchers.

3.3 Applications:
(1) Robotics
(2) Artificial Intelligence
(3) Games
(4) Desktop and PC Applications.
(5) Neural Networks.

REFERENCEES

[1] Cadoz, C., "Le Geste Canal de Communication HommeMachine, la Communication 'Instrumentale'", Technique et Science Informatiques, 13, 1, 1994, pp 31-61.
[2] Sung, K. and Poggio, T., "Example-Based Learning for View-Based Human Face Detection", Massachusetts Institute of Technology AL Lab Technical Report 1521, 1994.
[3] Hannaford, B., and Venema, S., "Kinaesthetic Displays for Remote and Virtual Environments", in Barfield, W.,and Fumess, T.A., (Eds.), "Virtual Environments and Advanced Interface Design", New York, Oxford University Press, 1995.
[4] Bryson, S., and Levit, C., "The Virtual Wind Tunnel", IEEE Computer Graphics and Applications, 12, 4, 1992, pp 25-34.
[5] Sushmita Mitra and Tinku Acharya, "Gesture Recognition: A Survey", IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART C: APPLICATIONS AND REVIEWS, VOL. 37, NO. 3, MAY 2007, Page No. 311-320.
[6] Cédric Graf, "Arm and Body gesture recognition".
[7] Vladimir I. Pavlovic, Rajeev Sharma and Thomas S. Huang, "Visual Interpretation of Hand Gestures for Human-Computer Interaction: A Review", IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 19, NO. 7, JULY 1997, Page No. 675-687.
[8] Ms. Sweta A. Raut and Prof. Nitin J. Janwe, "A Review of Gesture Recognition Using Image Object Comparison and Neural Network", International Journal of Computer Technology and Electronics Engineering (IJCTEE) National Conference on Emerging Trends in Computer Science and Information Technology (NCETSIT-2011), Page No.55-60.
[9] Hatice Gunes and Massimo Piccardi, "Automatic Temporal Segment Detection and Affect Recognition From Face and Body Display", IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART B: CYBERNETICS, VOL. 39, NO. 1, FEBRUARY 2009, Page No. 70-74.
[10] Mokhtar M. Hasan and Pramod K. Mishra, "Hand Gesture Modeling and Recognition using Geometric Features: A Review", Canadian Journal on Image Processing and Computer Vision Vol. 3 No. 1, March 2012, Page No. 12-17.
[11] Shoaib Ahmed.V, "MAGIC GLOVES (Hand Gesture Recognition and Voice Conversion System for Differentially Able Dumb People)".

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