Low Cost Gesture Detector Using Artificial Neural Network

Nikita Sharma, Aishwarya Nambiar, Shivam Chakoo, Tanmay Dinde,Sreedevi Nair

Abstract— In today's day to day life, there are many situations where one might want to control devices with the help of gestures. For example, let's say you're listening to music and your mom calls. You need to turn the sound down quickly while answering the phone. All you have to do is to make a simple wave and you can adjust the volume immediately. With natural hand gestures, you can also change the song, stop and pause the same. Similarly, while presenting a topic to the colleagues one can flip through the slides in the same way, too. This is where the concept of Gesture recognition plays a vital role and help you work with ease & independence. There are some products available in the market that do this job. But those are costly and not affordable by the common man. Thus we are planning to develop a device that will be compact and cost-effective. So our objective is to design and develop a low cost gesture detector using neural network.

Index Terms— Artificial Neural Network, Accelerometer, Back Propagation Algorithm, Gesture Recognition, Low cost, Static gestures, Wireless.

1 INTRODUCTION

In today's world, people cannot live without computers and laptops. The communication with a computer is done with the help of keyboard, mouse or trackball. But this is not always comfortable. For example, while giving a PowerPoint presentation, one might hover over the computer screen and mouse rather than making use of the space and moving around the room while sharing information. So our primary goal is to develop a system that can acquire gesture, identify them and take actions accordingly.Human gesture consists of motion expressed by body, hand, face or eye. Among these, hand gestures are more expressive and easy to understand. These gestures can be static or dynamic. A gesture for e.g thumbs up is static, whereas waving goodbye is dynamic.

There have been many research work done before for gesture recognition. The Myo armband developed by Thalamic Lab is a wearable gesture and motion control device that can control your phone, computers, laptops and much more. They have used Medical Grade Stainless Steel EMG sensors and highly sensitive nine-axis IMU containing three-axis gyroscope, three-axis accelerometer, three-axis magnetometer [1]. The cost of this armband is around 13000 INR. Such a high cost is not affordable by the common man. So we are planning to use only one sensor, i.e. 3-axis accelerometer ADXL335 [2]. For our device to be wireless we rely on Bluetooth technology as it is the cheapest and available in most of the laptops and phones. The device to function, we require a microcontroller and we are using MSP430 as it requires low power.The block diagram is shown in fig. 1.

Our research consist of following methodology

1) Study various gesture recognition technique
2) Study of Artificial Neural Network
3) Formulate the design requirement and specification for the gesture detector
4) Fabrication of the device
5) Estimate the cost
6) Testing for the various applications

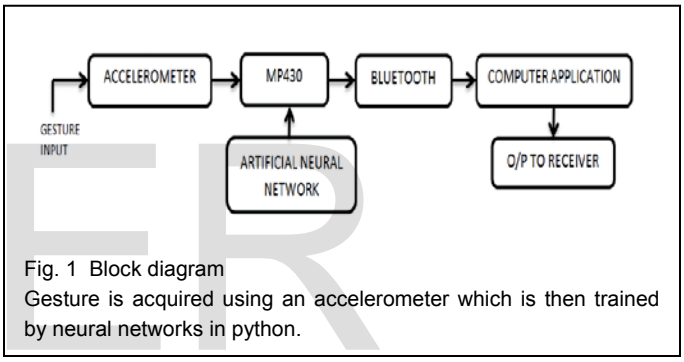

Fig. 1 Block diagram

Gesture is acquired using an accelerometer which is then trained by neural networks in python.

2 GESTURE RECOGNITION TECHNIQUE

The first step for human-computer interaction is to collect raw data. This data is then processed through various algorithms to extract the context of the data for performing various tasks. There are two main methods to acquire gesture:

1) Glove-based
2) Vision-based

2.1 Glove-based

Data glove based interface are employed for replacing static and fixed keyboard and mouse to have more natural way of communication by making gestures while communication. But have this, the gesture must be recognized first and thus data glove is used. These can provide input to the computer about the position and rotation of the hands using magnetic or inertial tracking devices [3]. Special glove-based devices have been developed to analyze finger and hand motion and use them to manipulate and explore virtual worlds.

2.2 Vision-based

In vision based hand gesture recognition system, the movement of the hand is recorded by video camera(s). This input video is decomposed into a set of features taking individual frames into account. The hands are isolated from other body parts as well as other background objects.

Theisolated hands are recognized for different postures [3]. Since, gestures are nothing but a sequence of hand postures connected by continuous motions, a recognizer can be trained against a possible grammar. With this, hand gestures can be specified as building up out of a group of hand postures in various ways of composition, just as phrases are built up by words. The recognized gestures can be used to drive a variety of applications.

3 Artificial Neural Network

Classification of gesture can be done using two approaches

1. Rule based approach : In this approach, input is compared with the manually encoded rule. If any of the input matches with the rule, then the corresponding gesture is given as output. The one of the major drawback of this approach is that they rely on the ability of human to encode rules.
2. Machine based approach : A popular machine learning approach is to treat a gesture as the output of stochastic process. Hidden Markov Model (HMM)[3], Artificial Neural Network (ANN) [4], Fuzzy Clustering Algorithm[5], Histogram Based Feature[3]are some of the machine based approach.

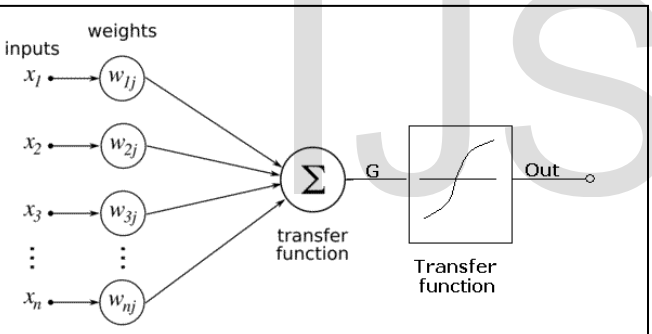

Fig. 2 Single neuron processing element

The Artificial neural network is based on neurons of the human brain that consist of massive large interconnection of a large number of neurons that achieve different tasks in small amount of time. The neurons are connected by links and each link is associated with a weighing factor. The nodes can take input, combines them and perform some nonlinear operation to obtain the desired output, which is then sent to other neurons as shown in fig. 2. ANNs are capable of learning by altering weighing factors and then generalize. Generalization means network after learning is capable of producing output for an input not used in the training set. We have used Feed forward neural networkwith back propagation algorithm. Feed forward neural network is very simple to implement and it used along with back propagation yields high accuracy[3].

3.1 Back Propagation Algorithm

This algorithm uses supervised learning [3] which means it learns by example. As the name suggests, the error is propagated backward. So basically in feed forward neural network with back propagation algorithm, there are two phases. In forward path, input vector is fed and it propagates through the network to produce an actual output. In backward path, weighting factors are adjusted in order to reduce the error. The difference between actual and desired (target) response gives error signal. This error is propagated backwards through the network. The ANN learns the training data till this error is reduced.

Neural network packages are available for various programming languages such as MATLAB, python, octave, java,C etc. We are implementing neural networks using python [6] as it is open source software and consist of extensive standard library. There are various packages available such as Pybrain, scikit-learn,neurolab etc. These are available free of cost.

4 Hardware

Based on the various factors such as cost, power consumption, complexity etc following components were chosen.

4.1 Microcontroller

Fig. 3 MSP430G2553 Launchpad

The microcontroller used here is MSP-EXP430G2 Launchpad because it is efficient, simple, inexpensive and ultra-low-power device. The MSP-EXP430G2 Launchpadcomes with an MSP430G2553 series IC. It has a 16 bit RISC architecture with built-in 16 bit timers, 10-bit analog-to-digital converter, a versatile analog comparator, up to 24 I/O capacitive-touch enabled pins and built-in communication capability using the universal serial communication interface [7]. They have one active mode and five software selectable low-power modes of operation.

4.2 Accelerometer

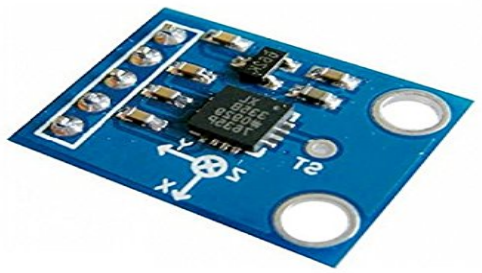

Fig.4 ADXL335 3-axis accelerometer

For acquiring gesture, sensors like gyroscope, flex sensor or even an accelerometer can be used. ADXL335,a three-axis accelerometer has been opted to acquire gesture information as the other methods involve computational complexity. It is a small, thin, low power, product that measures acceleration with a minimum full-scale range of ±3 g [8]. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. It is a compatible device powered by a 3.3v source and also generates 3.3v peak outputs [8]. It has three outputs for each axis i.e. X, Y & Z. These are analog outputs and thus require an ADC in a micro-controller.MSP430 solves this problem. It utilizes capacitive sensing known for its high accuracy and stability. Changing the gap between the plates changes the electrical capacity of the system, which is measured as a voltage output. This method of sensing is Capacitive accelerometers are also less prone to noise and variation with temperature, typically dissipate less power, and can have larger bandwidths due to internal feedback circuitry.

4.3 Bluetooth

Fig. 5 HC-05 Bluetooth module

For our project to be portable and user friendly, the wireless technology employed is the BLUETOOTH technology. This has enabled us to explore our application area as Bluetooth is available in almost all devices today such as laptops, smart phones, tablets etc. Also it is cost effective as compared to it's counterparts namely Zig-bee & Wi-Fi technology.HC-05 module enables us to configure it in both master and slave mode-an advantage over other modules available that can work only in one mode. The module allows for serial communication with response time less than 300ms.

5 Estimation Of Cost

Our main aim is to design a product that would be cost-effective. It should be economical and feasible for the user. So, accordingly we have chosen our hardware. The Table 1 shows the estimated cost. It can be observed that the cost is below Rs 2000. Also MSP-430 launch pad is used only for programming the IC. So if we consider only the cost of IC, the price goes down to Rs 900 (cost of IC- Rs 200).

6 Conclusion

TABLE 1
COST OF THE PRODUCT

HARDWARE	COST
MSP-430	1200
Accelerometer	220
Bluetooth	260
Battery	20
PCB board, ICs, resistors	200
TOTAL	1900

Through this project we tend to develop a compatible hand wearable band that will enable its users to control various computer based applications such as a PowerPoint presentation, a music player etc. The proposed system will provide flexibility of motion to the user as there is no wired connection. This is also because the glove based approach for gesture acquisition is employed instead of the more complex vision based approach which restricts the motion of the hand within the coverage region of the capturing device. The application provides a flexibility of defining user interest gestures for specific command which make the application more useful for physically challenged people, as they can define the gesture according to their feasibility. The application range of the proposed device can be extended to developing a sign language or controlling a robot etc. Thus the future scope of the project lies in the imagination of the user.

Acknowledgment

We would like to thank the Department of Electronics and Telecommunication of Fr C Rodrigues Institute of Technology for making resources available for the project work.

References

[1]HTTPS://WWW.MYO.COM/
[2] Ruize Xu, Shengli Zhou, and Wen J. Li, *Fellow, IEEE* , "MEMS

Accelerometer Based Nonspecific-User Hand Gesture Recognition" *IEEE SENSORS JOURNAL*, VOL. 12, NO. 5, MAY 2012

[3]J. J. LaViola, "A survey of hand posture and gesture recognition techniques and technology," Brown Univ., Providence, RI, Tech. Rep.CS-99-11, Jun. 1999.

[4] Dr. Hanan A.R. Akkar, Firas R. Mahdi, "Evolutionary Algorithms For Neural Networks Binary And Real Data Classification" *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH* VOLUME 5, ISSUE 07, JULY 2016

[5] Preeti.S.Ratnaparkhi and Devesh D. Nawgaje, "Comparative Study of AI Based Gesture Recognition" *International Journal of Emerging Trends in Electrical and Electronics (IJETEE)* Vol. 1, Issue. 3, March-2013.

[6]https://www.python.org/

[7] http://www.ti.com/lit/ds/symlink/msp430g2253.pdf

[8]https://www.sparkfun.com/datasheets/Components/SMD/adxl335.pdf