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Intelligent Gesture Controlled Automation

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Abstract
The project focuses on simplifying various tasks by enabling individuals to control appliances in their surroundings wirelessly by using simple hand gestures. An alternative to pushing buttons on remotes and switches, this method offers various advantages over its counterparts such as:-

1) Allowing quick and convenient method of controlling a large number of appliances
2) Empowering those with loss of vision, partial motor skills, or mobility
3) Efficient centralization of control and monitoring

The device used to achieve this will consist of an accelerometer, a microcontroller and an RF transmitter that will be attached to the hand of the user. The respective devices that are to be controlled will be connected to a receiver and multiple decoders. Simple hand gestures will be analyzed by the microcontroller and the corresponding instruction will be invoked from a look up table and transmitted digitally. Accordingly at the receiver end, the respective appliance will be controlled as desired by the user.
A machine learning algorithm known as Learning Vector Quantization (LVQ) is implemented in this project to create clusters associated with different hand gestures which are determined by the user. As a result, different users may set different gestures for control as per their convenience. The application scope of this project may range from home automation to more important things such as facilitating handicapped individuals, military drone control, sign language translation, security systems and medicinal automation.

Keywords: Gesture, LVQ, Accelerometer, Clusters

Introduction
Everything around us, from home to office to signal system to aviation and many more, everything is getting automated. Considering the increase in demand of automation, we are designing a completely automated hand gesture based device control.
In today's world, we normally control most number of devices by the means of switches or buttons. This we call manual switch control. To improve the quality of life and its ease, these controls can be replaced by more convenient means, such as that of gesture or voice control. The need of manual control and the need to move around switching things on/off can be eradicated.
Gesture is widely used amongst people. People use gestures for expressing a diversity of internal states, for attracting the attention of other people and so on. Gestures can be made with the hands or with the body. There are unfortunate situations (i.e., certain diseases) when gestures become the only way of communication for some people. Speech recognition and voice control are also used for automating devices. The major limitation of this method of automation is that devices can become irresponsive due to noise in the surrounding area. Also, it requires the user to be in close proximity to the device.
In contrast, gesture control can be implemented to produce faster and more efficient results. Some advantages of using gesture control over other methods of controls:-

1) Effortless and convenient
2) Simple design
3) Relatively inexpensive
4) Accurate results
5) Instantaneous
6) Easy to use once familiar with the gesture vocabulary

A. Implementation
Gesture control can mainly be implemented in areas of home automated appliances, medical devices and controlled devices used in the defense to provide ease of control. In such designs, each gesture within a set of predetermined gesture is monitored to give a certain output, which is used to control various devices. This output is fed into the microcontroller and transmitted wirelessly to parallel receivers which are linked to their respective devices. Thus each device can be electronically controlled. This is a more convenient way of dealing with things.

B. Intended Use
In this paper, we have described how we have implemented our design, mainly focusing on home automation. Using sensors and microcontrollers and other devices, we have implemented an algorithm that enables the user to control a device with ease and minimal errors. The algorithm is a machine learning algorithm called Linear Vector Quantization (LVQ) which is explained in detail in further sections.

C. Assumptions

The following are assumed in this project:

1) Communication will be established on their own between the controlling unit and the user.
2) The glove should be worn to facilitate wireless gesture control
3) The gesture vocabulary should be familiar to the user for smooth control.
4) The household appliances should be electrically controllable.

D. Limitations

There are a few limitations concerning this project:

1) Only electrically controllable devices can be monitored.
2) A limited number of devices can be controlled.
3) Power source must be attached throughout.
4) The difference in gestures should be significant.

Existing Mechanisms and Drawbacks

With the simple hardware used in this design, gestures may even be classified by setting threshold voltage levels on different axis on the accelerometer. Such a method introduces several difficulties in classification of gesture. For instance the threshold voltage levels cannot be easily changed by the user. Therefore it would be difficult for a layman user to change the set gesture to the gestures he or she is more comfortable with. Moreover, the response of this model may vary as the source of the voltage either changes or drains slightly, since the programmed threshold, which is proportion of the input voltage, will remain constant still.

In contrast, Learning Vector Quantization allows users to themselves set the gesture and automatically updates the positions of the centers of clusters corresponding to different gestures. Once set, the centers of respective gestures regularly update their positions as and when these gestures are performed by the user, thus addressing both the problems presented by the first method that is excluding the use of machine learning.

Currently, even voice control is being used for automation, such as to operate cars and phone.

However, there are several disadvantages in using voice control. For one, noise in the surrounding area might interfere with the input voice to the device, causing the device to react erroneously. In addition, you'll have to be in close proximity with the device for it to hear your voice. Besides that, after voicing your commands, you will have to wait until your voice has been sent to the processing server, and received back after being processing correctly. Thus, not only do you need flawless diction, but also Internet connectivity combined with high processing power in order to be able to operate through your voice commands.

On the other hand, gesture control is very precise and easy to control. One can control from a convenient optimum distance and still get accurate outputs, and thus save both time and effort.

Overview of the Design

The hand gestures made by the user cause the voltage levels on the three axes of the accelerometer to vary. These variations are translated into different gestures by the microcontroller. The microcontroller then executes different operations depending on the detected gesture.

Fig.1. Design Process

The accelerometer is capable of responding to acceleration in 3 axes, labeled here as x, y and z axes.

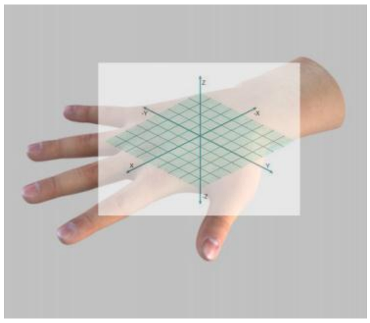

Fig.2. Representation of accelerometer axes with respect to hand

The output voltage levels along each axes varies with respect to the angle at which the hand is tilted in a manner similar to the diagram shown below:

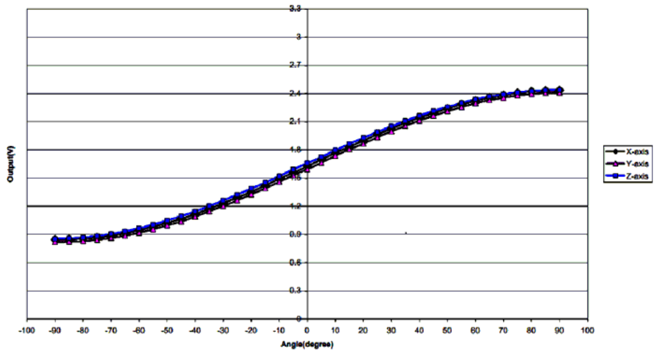

Fig.3. Tilt angle versus Output Voltage

In order to test the successful classification of gestures, 5 different gestures were made by tilting the hand in five different directions; namely 'no tilt', left, right, forward and reverse tilts.

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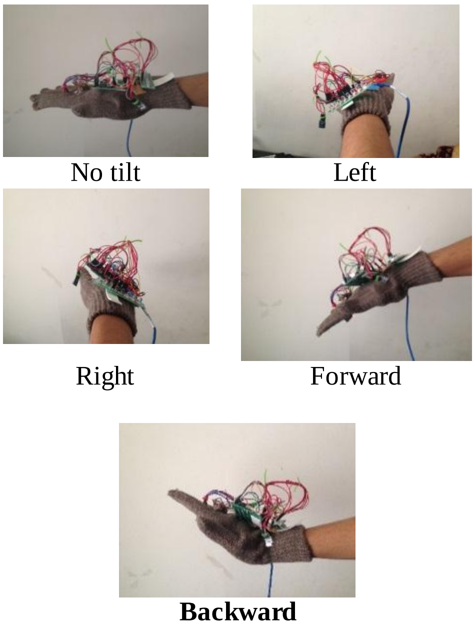

Fig.4. Gestures performed with the accelerometer

The accelerometer readings corresponding to these gestures were stored and plotted on OCTAVE to produce the following 3D scatterplot:

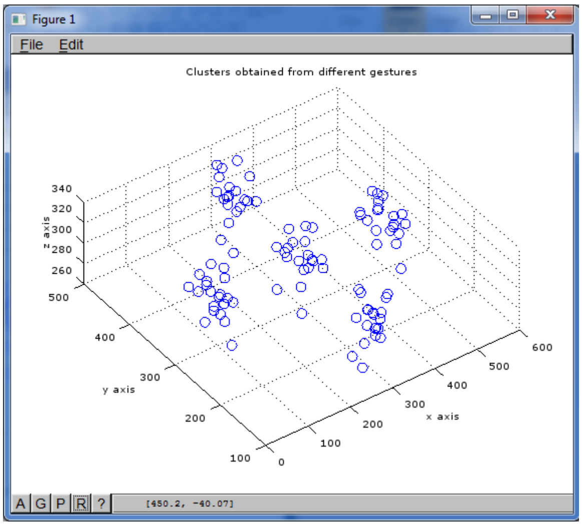

Fig.5. Plotting gestures into clusters using OCTAVE

We then introduced 5 class vectors (coordinates of centers) initialized at 0. By implementing Learning Vector Quantization, we allowed these vectors to converge at the centers of the 5 different clusters that are vaguely distinguishable in the scatterplot above. The result obtained after classification is shown in the image below, where different colors correspond to elements that are closest to their respective class centers.

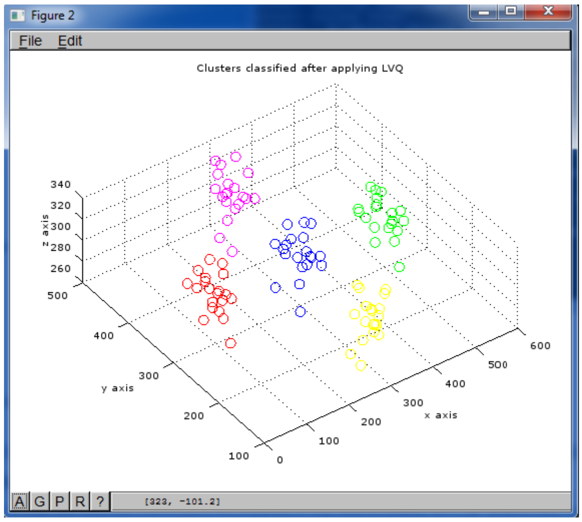

Fig.6. Cluster Plot obtained after implementations of Linear Vector Quantization

Having successfully classified different gestures, we implemented the following algorithm to build a system that allows users to conveniently calibrate the gesture recognition and control appliances wirelessly using simple hand gestures. Here the variable 'n' is used to denote the number of different types of gestures that may be implemented. In our prototype 'n' is equal to 5.

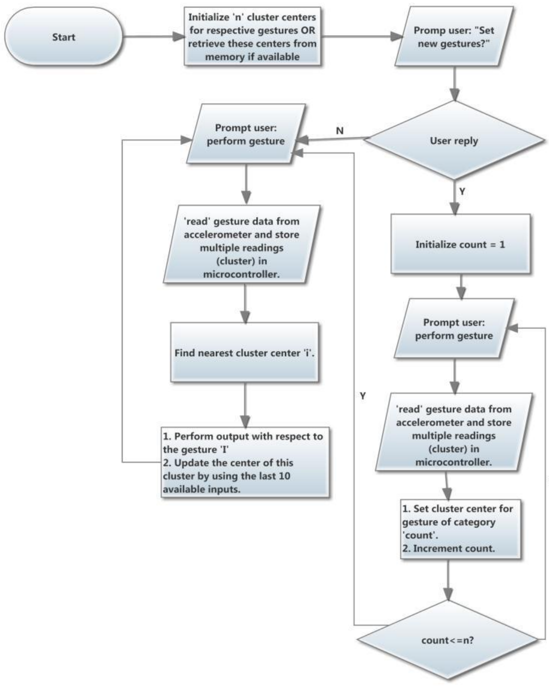

Fig.7. Algorithm of the design process and working of the entire system

Devices Used at a Glance

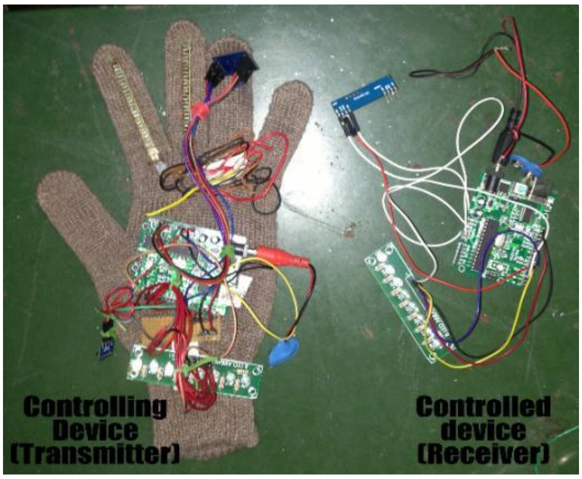

Fig.8. Complete setup fitted on a glove

A.Accelerometer

An accelerometer is an electromechanical device that will measure acceleration forces. If you have two microstructures next to each other, they have a certain capacitance between them. If an accelerative force moves one of the structures, then the capacitance will change. Add some circuitry to convert from capacitance to voltage, and you will get an accelerometer. The three axis accelerometer are basically used to identify the movements across the three axis i.e. x-axis, y-axis, z-axis.

Fig.9. Accelerometer MMA7361 used in our setup

B. Microcontroller

The Atmega 328 is a general purpose 8-bit microprocessor, which offers high performance and very low power consumption (3.3-5 V). The AVR architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler core.

C. Wireless RF Transmitter and Receiver

The 434 MHz RF pair is used to establish wireless communication between the controlling and the controlled device. It supports multiple baud rates, covers a range of 40m and is very efficient in data communication.

Application of this algorithm and its feasibility

This device can be used to control wide range of electronic devices using gesture. The uniqueness of the device lies in its machine learning algorithm. In the absence of this algorithm, the user would have had to run the device on constant and steady power, which is difficult to achieve.

LVQ helps in closely monitoring the gestures and storing the center values of all clusters. Next time the device is initiated, the value observed is compared with the center values of all and accordingly their respective functions are executed. This helps in easy, simple and free orientation of the glove (device) rather than orienting it at specific directions and angles only.

A.Home Automation

This project mainly focuses on home automation. Day to day devices such as Lights, Fans, Geysers, TV, refrigerator and Motor Pumps can be easily manipulated using gestures and controlled wirelessly, well within the house radius. Also, the intensity of light or the speed of Fan or motor pumps can be altered using your gestures.

B.Medical Automation

Touch screens, keyboards, voice control or remote controls have been used as different modes of interaction that must be approached in order to be used. We introduce the concept of gesture for the control of computer graphics, corresponding to hand position, orientation and size. Instead of manual control by means of switches, this is a less time consuming method and might be successful in saving the life of the patient at critical times.

C. Defense system

In defense, various quad rotors, helicopters and other warships can be controlled using gesture. We are avoiding the risk of human life on the battlefield and controlling the device from a very large distance.

Results and Performance Evaluation

We used 5 gestures, up, down, right, left and flat respectively. Prior to controlling using these gestures, the equipment was first 'trained' by the user. This training period was made to last for a maximum for 5 seconds. The user is given 1 second to make a different gesture each time, and the gesture is then 'stored' in the form of a vector which marks the overall center of the gesture.

After the training period, the gestures were performed at various accelerometer values. The gesture was recognized with minimum effort. A total number of 15 trials were conducted, and the output is depicted in the table.

TABLE.1. Simulation Parameters and Results

Gesture	*No of trials*	*Successful outcomes*	*Accuracy*
Left	***15***	***15***	***100%***
Right	***15***	***14***	***93.3%***
Up	***15***	***15***	***100%***
Down	***15***	***15***	***100%***
Flat	***15***	***14***	***93.3%***

Conclusion

The project "Gesture control Automation" has been successfully designed and tested. The glove contains hardware components that have been integrated to analyze gestures. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. An algorithm on machine learning has been implemented and tested on the glove to enable feasible control.

The proposed gesture recognition enables the user to set different gestures as per convenience. One can have a chart or a datasheet of different gestures, in order to keep track of them. On setting the gesture, the algorithm automatically updates the center of the clusters, allowing smooth control. Thus, the gesture control for a certain position automatically becomes more efficient with usage.

Unlike usual gesture control algorithms which require the user to maintain the source voltage measure, either by providing a regulated supply or regularly changing batteries, the proposed algorithm counteracts the drawbacks by using Linear Vector Quantization.

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