International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015
ISSN 2091-2730

Gesture Controlled Computer Applications Using Embedded Accelerometer in Android Device

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Abstract— The most widely used mode of human computer interaction, keyboard and mouse, restrict the pace and naturalness with which the interaction takes place. The use of intuitive hand gestures is a widely sought after alternative for desired ease of use. Controlling our personal computers via hand movements from a distance can elicit great freedom in terms of position and convenience. The proposed system aims to achieve that by putting to use the built in 3-axis accelerometer in mobile phones. The accelerometer determines the phone's motion and orientation in terms of X, Y and Z axis. Thus, it can sense the tilt, movement and speed being applied to the phone. The various gesture patterns made in the air while holding the phone can be used to manipulate the controls on our personal computers. Our system uses the Dynamic Time Warping technique for measuring the similarity between two temporal sequences which vary in time and speed. This system is going to be implemented with some already known and some new techniques. Due to the intuitive nature of the system it promises to be user friendly and can find its use in many other applications.

Keywords— Human Computer Interaction, Accelerometer, Dynamic Time Warping, Euclidean distance, Gesture Recognition, Android, Serialization.

INTRODUCTION

The idea of manipulating the digital world by the wave of a hand until a few years ago seemed like a scene out of a science fiction movie. But with the wider research in the field of gesture recognition, this has transformed into reality. Taking it a step forward, the system utilizes man's most trusted device; the cell phone to maneuver the controls of different applications in a personal computer.

Desktop PCs and laptops are not always within the reach of hands, when watching a movie or listening to music. The volume, track etc need to be monitored or operated either through the keyboard or the mouse, which requires the user to reach out to the PC. Considering a scenario when the user is in another room or is lying down and doesn't want to get up to change the track or turn down the volume, a simple gesture of the hand with the phone in hand can produce the desired result. What sets it apart? It won't require gloves or any sensor to be attached to our hand. Same can be said about presenting power point slides on a big screen, imagine how convenient it would be if you could change the slide with a predefined slight movement of the hand with the phone in hand.

Mobile devices, such as mobile phones, mobile gaming devices or wearable computers, provide new possibilities for communication and computing on the go, but they also introduce new problems due to small screens and input facilities. These situations can be avoided when a bigger screen is used for gaming and the game controls are directed remotely. This gives the user the elation of playing games on a bigger screen but with portable and handy controls.

The user needs to install the application on the phone which is going to be used as the sensor and a desktop application on the PC that is supposed to be controlled. Once the installation is completed, the user can customize gestures and train data sets. And start using gesture control right-away. The only requirement in the mobile phone is to have an accelerometer. Accelerometers are widely embedded into various devices, such as consumer electronic devices, smart phones, other mobile devices, and game devices, due to immense increase in microelectronics technology. Also recently, 3-axis accelerometer-based gesture recognition has been discussed in many researches. This accelerometer monitors the motion and orientation. The analysis of the signals obtained is done using Dynamic Time Warping algorithm.

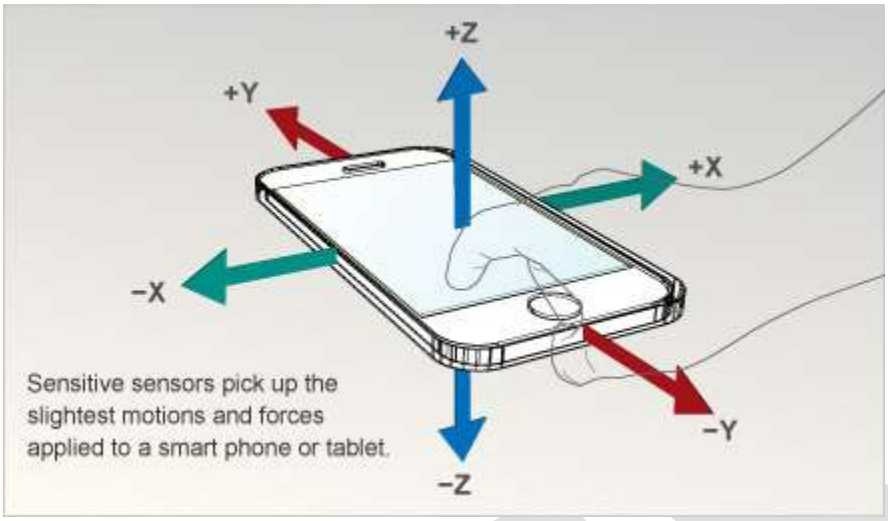

Fig. 1. 3-axis of an accelerometer

Sensor-based gesture control has some advantages compared with more traditional modalities. Gestures require no eye focus on the interface, and they are silent. For certain tasks, a hand gesture may feel more natural than pressing a button on a keyboard.

BACKGROUND:

Gesture Recognition is process by which gestures made by users is identified by the receiver using mathematical algorithms It can be seen as a way of humans directly communicating with machines with intuitive actions. The human body communicates with the computer where gesture is the input. This input is interpreted using statistical analysis and mathematical algorithms. The input is then adjusted which is known as trailing or learning. Input data is then matched with trained data. In case of a match, signal is sent to the computer using Wi-Fi.

Dynamic Time Warping algorithm was originally developed for speech recognition. It is used to find an optimal match between two sequences of vectors by warping the time axis. The pre-stored pattern data by the user in time series of acceleration and the acceleration data obtained from accelerometer are compared using the DTW algorithm.

EXISTING TECHNIQUES:

Gesture Recognition is one of the most researched areas in Human Computer Interaction. Different methods have been used to implement gesture recognition. Image processing is one such widely used technology. [13] uses image processing and various other techniques like Image Acquisition, Color Segmentation, Edge Detection and Removing Noise, Finger Tips Detection. But, there are certain limitations and ambit of performance associated with image processing. Some of them are:

- The user has to be in the line of sight of the web cam
- Light intensity should be adequate
- Wearables are required

One of the systems uses facial expressions to detect if a driver is drunk, the system though useful but produces many unnecessary alarm calls hampering the real time experience. Accelerometer based gesture recognition has also been implemented in [2] [3], but with limited accuracy.

OVERALL DESCRIPTION OF THE PROPOSED SYSTEM

A gesture identification system, that identifies the orientation and motion of the mobile phone held in hand to manipulate the controls of a computer at a finite distance. The system needs to identify and recognize different kinds of gestures defined for a specific task in

an application and then instruct the respective application to perform that particular action. The gesture needs to be context based to provide a more intuitive experience to the user.

A. Components of the System

The system to be developed will comprise of two main components:

i) Mobile Application: A mobile application based on the android platform is needed to monitor the movements or gestures made by the user. The application can be used to set the context specific gesture for each control. Once the gestures are customized, the user can select which application is to be controlled via the phone. The application uses the inbuilt tri-axis accelerometer to create x, y and z axis graphs of the movements performed by the user. This input graph is matched with the predefined gesture graph. If it matches, the associated activity signal is sent to the corresponding computer. This application is the basis of gesture recognition.

ii) Desktop Application: A desktop application is required for the target PC that is to be controlled. This application will be developed in java. The java application will send and receive signals from the phone. These signals will then be used to control the current running application for the respective operation. The java application will run a servlet class that will interact with the server for communication over the network.

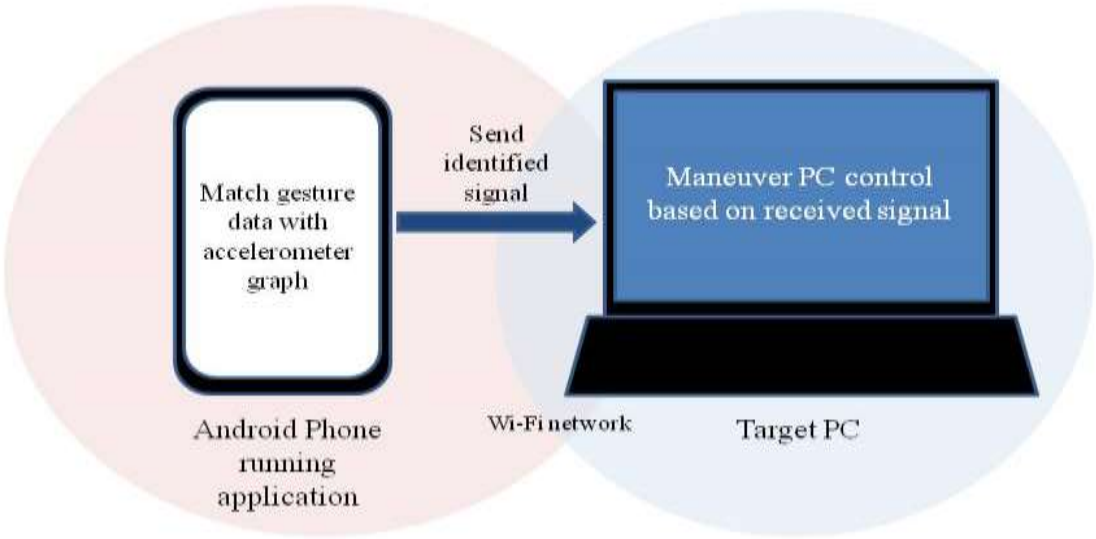

Fig. 2. System Overview

B. Technology Used

The proposed system aims to integrate different technologies into a single unit. With different kinds of communication devices interacting with each other, it is difficult to choose the platform to work on. The three main technologies that will be used in the proposed system are:

i) *Android:* With 85% Smartphone market share in the second quarter of 2014, it was an obvious choice to consider Android as the platform to run the gesture recognition application. Apart from that, from a developer's point of view; to develop efficiently, the Android Developer Tools offer a full Java IDE with advanced features for developing, debugging, and packaging Android apps. Using the IDE, one can develop on any available Android device or create virtual devices that emulate any hardware configuration. Thus the powerful development framework provided by Android makes it the final choice.

ii) *Java:* Java makes it unbelievably easy to work with resources across a network and to create network-based applications using client/server or multitier architectures. Hence we wish to develop the desktop application running the servlet in Java. Due to its platform independent nature we need not worry about the compatibility on different machines.

iii) Wi-Fi: The two applications, one running on the phone and the other running on the desktop need to communicate with each other. This communication is provided over the Wi-Fi network. All smart phones and laptops provide Wi-Fi connectivity. It is very easy to use and adding users to the network is brisk.

C. Features

The proposed system aims to implement gesture recognition via the accelerometer located in mobile phones. The system provides features that can be divided into three modules.

i) *Game controls*: The cellular device can be used to play games on PC, without touching the keyboard and mouse. The mere tilting of phone can be used to play games sitting at a suitable location.

ii) *PowerPoint controls*: While we give seminars and present our slides, it becomes highly inconvenient to regulate the slides and present at the same time. The whole flow of our ideas can get disturbed due to such nuisance. This wouldn't be the case if we were changing slides instinctively. The system can change slides by slight gesture of the hand in left or right to move to the next or previous slide respectively.

iii) *Media controls*: It is often observed that while watching a movie or listening to music we tend to be in a laid back frame of mind. Getting up to change tracks or alter volume levels seems like the greatest of troubles. This can be avoided by drawing start, stop, next and previous symbols in air with the phone in our hand.

Apart from this, the whole idea can be extended to other applications. In this specific project we will be concentrating on the above stated features.

SYSTEM DESIGN

The system contains two major components, the Smartphone and the target machine. While implementing the system the android application running on the Smartphone captures the X,Y and Z axis values using a three axis accelerometer embedded in the device. 50 sets of accelerometer values are captured for each gesture and serialized to be stored in an object.

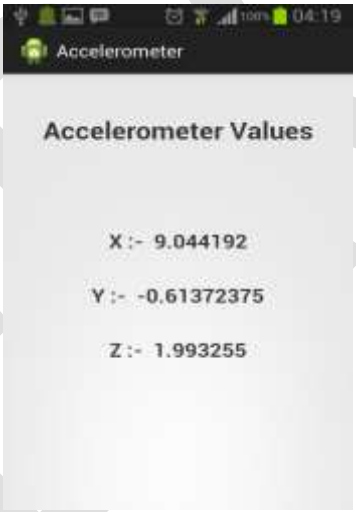

Fig. 3. Application showing accelerometer values

This object is sent over the network to the server running on the target machine. This server continuously runs in the background in order to capture any gesture. As the server receives an object with the accelerometer values it de-serializes it and converts it into a vector table. This vector table data is compared with the stored gesture values and an error rate for each stored gesture is calculated. This constitutes the feature extraction part of the system.

Once all the error values are calculated, the gesture with minimum error value is selected as the gesture to be performed. The selected gesture might immensely vary from the actual defined gesture. In order to avoid such leniency in the system, the error value of the selected gesture is compared to a predefined threshold value. If the given gesture is well within the threshold, the gesture is to be performed. The post processing of the gesture detection is done by simulating the activity to be performed. A Robot API is used to simulate the specific control signals.

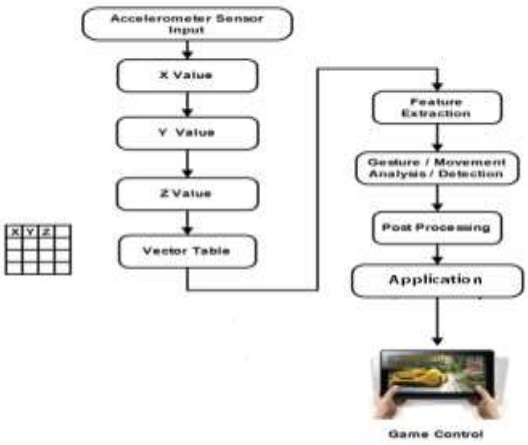

Fig. 4. Flow of the System

RESULTS

We conducted two different performance tests measuring the response time and the recognition rate of the system. Table 1 depicts the response time for different gestures and three different sets of users namely I, II, III. These response values were taken for three different no. of accelerometer values.

Gesture Name	No. of Accelerometer values 50			No. of Accelerometer values 75			No. of Accelerometer values 100		
	I	II	III	I	II	III	I	II	III
Left	1.50	1.33	1.43	3.15	3.11	3.12	4.16	3.77	3.82
Right	1.55	1.61	1.55	3.05	2.93	3.27	4.00	3.67	3.85
Start	2.49	2.27	2.54	3.21	3.66	3.60	3.83	4.30	4.01
Stop	1.99	1.44	1.49	2.88	2.89	2.60	3.60	3.77	3.62

Table 1. Response time in seconds for four different gestures performed by three different users.

From the above table it can be clearly observed that the response time is least for all the gestures when the no. of accelerometer values taken is 50.

Table 2 has been used to calculate the recognition rate for different threshold values. Four different gestures left, right, start, stop have been calibrated against the three threshold values, 150, 200 and 250. Each gesture for every threshold value was performed 15 times and the no. of recognitions was noted.

Threshold value	Gesture name				Total(60)	Recognition rate(%)
	Left(15)	Right(15)	Start(15)	Stop(15)		
150	9	7	7	4	27	45
200	12	7	12	6	37	65
250	14	13	10	8	45	75

Table 2. Recognition rate for different gestures against three different threshold values.

From the above table it can be concluded that the system has the best accuracy when the threshold value is 250.

CONCLUSION

Accelerometer based gesture recognition has revolutionized the way we interact with our mobile phones. The same feature can be implemented to find an alternative way to communicate with our personal computers. This gives rise to the idea of air gesture recognition to operate the controls of our computer.

In this system we concentrated on three basic applications of gesture recognition using android phone. Dynamic Time Warping algorithm will be implemented to capture gesture data and process it. The whole system comprises of a mobile application and a desktop application connected via WLAN.

The fundamental notion driving this system is to find a more intuitive and convenient approach of interacting with our computers.

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