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An Android Based Human Computer Interactive System with Motion Recognition and Voice Command Activation

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Abstract: The computer industry is getting advanced. In a short span of years the industry is growing high with advanced techniques. This paper introduces a technique for human computer interaction an effective design of an Android-based Human Computer Interactive (HCI) system with voice command activation and gesture recognition to control a computer. With a continuous data acquisition from a 3-D Accelerometer sensor embedded into the smart phone, the proposed system substantiates remote computing through processing of the orientation readings of physical movement of the phone and compilation of inputted audio texts. With Wi-Fi connectivity, the smart phone is attached to the wrist of a human body. The motion parameters are utilized to control the cursor movement of the host computer and the voice commands are used for ultimate execution of an instruction. Such a wireless system provides reliable and effective control operations of the computing domains, electronic devices and robotic structures. Physically challenged people get benefitted by such systems through easy and faster computing operations. The developed work has been tested under certain conditions and the performance analysis affirms its sustainability.

Keywords: Accelerometer, Android, Human Computer Interactive, Motion Recognition, Voice Command, Wireless.

I. INTRODUCTION

The world has reincarnated itself by dint of the prevalence of smart computing technology and mobile telephony facilities. Introduction of smart phone interfacing with computers has intensified the human-computer interaction. Electronic gadgets embedded with Accelerometer, Gyroscope, Magnetometer, Wi-Fi and Bluetooth communication technologies have enhanced the dimensionality of innovation. Today the command interface to the computers is being influenced by the advancements of smart phone based communicative preferences. The mouse and keyboard applications are tending to be replaced by voice commands and gesture identification. Such a work has been presented in where a pattern matching based motion recognizable gaming console has been introduced. Another gesture identifying prototype has been proposed in which a wireless Power-point presentation scheme is. Such practices facilitate the physically challenged people to take advantage of remote computing with ease and comfort. In robotics and automation, wireless machine control phenomena are getting modified day by day. In a manned space mission the monitoring process of the expedition can be set up through the wireless circumstantial communication with the controlled machineries. An efficient system based on smart phone imbibed computer control mechanism via voice command execution and motion recorded activity identification with Wi-Fi connectivity has been proposed here. The controller is an Android operated handset and the host is a computer running on either Windows or Linux platform. The cursor movement is interpreted by moving the phone vertically and horizontally along the axial references. The motion parameters are retrieved from a 3-axes Accelerometer which is inclusively mounted into the smart phone fabrication.

The developed system consists of two customized server applications and an executable prompt. The installed programs as well as the basic operatives like start or shut down a console of the host computer can be controlled by implementing voice commanding process. Such a system has been reported in where a Google voice recognition engine has been fabricated. An Android-based comprehensive Application Programming Interface (API) security system has been reported in. A human-machine interrelated rehabilitation robot control mechanism has been formulated in. The proposed HMI system in this paper operates upon the executable commands in both forms of vocal texts and gesture recognition. The system works on identifying separable commands encoded in voice and simultaneous gesture pattern through processing Accelerometer readings and computation of relevant software programs. A motion recognition based hierarchical classification system has been proposed in which differentiates the motion activities from the non-motion ones. In integrated computing has been proposed where the host monitor is controlled by the phone display and the keyboard is controlled by the touchpad. Gestures are the movement of any body part used to convey the meaningful information. Communication through gestures has been widely used by humans to express their thoughts and feelings.

Gestures recognition refers to the process of identifying gestures performed by human so that machine can perform the corresponding action. Gestures have been classified in

two categories static and dynamic. Static gestures refer to still body posture and dynamic refers to movement of body part. Gestures can be performed with any body part like head , face, arms, hands, etc. but most predominately we use hand to perform gesture like we wave hand to say 'good bye'. Hand gestures have been widely used for many applications[like human – computer interaction (HCI), robotics, sign language, human machine interaction, TV interaction etc. With the advancement of technology, human robot interaction (HRI) has become an emerging field in recent years. Hand gestures can be effectively used to give commands to the robot which in turn can be employed in large number of applications. Now-a-days, human robot interaction using hand gestures has widely been used in medical sciences. But still challenges regarding robustness and efficiency are to be considered. The basic step of hand gesture recognition is to localize and segment the hand from the image. Various techniques are available for hand segmentation. The most popular and simplest technique is skin color model which is used to get the skin pixels in the image but it has some limitations that skin color of different person can vary and background image can also contain the skin pixels. Other techniques are thresholding which divides the image into two regions foreground and background based on color, depth, etc. Some researcher uses background subtraction for segmenting the hand. In our approach keeping in view the limitation and simplicity of skin color model we will combine it with thresholding for hand segmentation. Skin color segmentation can be applied on any color space-RGB, HSV, YCbCr, YUV, etc. Every color sp ace has its own benefits.

II. PROPOSED DESIGN AND IMPLEMENTED SYSTEM LAYOUT

The basic manifestation of the developed system includes two major operational segments-

Host Server Application:

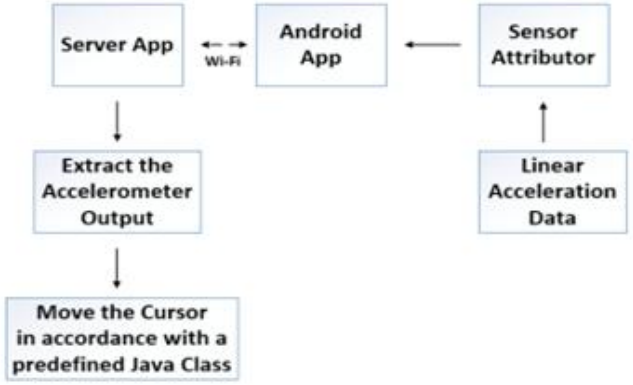

Fig.1. Functional diagram of the consistent process of cursor movement.

Android-based smart phone application: The salient features of the demonstrated system are documented in the following excerpt. In Fig.1 the implementation of mouse cursor movement is shown. In Fig.2 the voice commanding mechanism is presented. The command transformation from the controller Android application to the controlled host computer invoke distinctive operational segments which are briefly discussed here.

A. Motion Recognition

Motion identification is completely dependent on consistent data logging from the embedded 3-D Accelerometer sensor. In this case, linearly accelerated orientation values have been processed and then attributed for further manipulation to enhance a precise control over mouse cursor movement. Through a Wi-Fi connectivity medium the orientation data are continually transferred to the server application. A Java class has been specified to compile the motion parameters and in accordance with the fragmented software topology the cursor is moved along the host console.

B. Voice Command Activation

A customized Android application has been developed to take textual commands as inputs. These commands are the converted interpretations of randomly inputted vocal speeches and words. The vocal sounds are processed through Google speech to text converter and then transmitted to the server application wirelessly. There is a customized database which contains almost 25 instructional pneumatics. The relevant text is scrutinized to match with any of the pre-allocated texts of the database. The eventual command execution state would commence with the matched directive. Java Runtime object is responsible for solemnizing the command activation phenomenon.

C. Implemented Software Kits and Functional Libraries

The host computing program has been developed using JDK 1.8 (Java Development Kit). The respective Android application has been fragmented by Android SDK 4.4.2 (API 19). The programming platform has been provided by Eclipse LUNA. In case of server application, the program structure has been built using libraries like java.net and java.awt packages.. app, android. Hardware, android. Content, android. OS, android. Speech, android.view, android.Widget and java. Util. .

III. EMBEDDED TRI-AXIS ACCELEROMETER

An Accelerometer is an electromechanical device that measures the acceleration forces. MEMS (Micro Electro Mechanical Systems) Accelerometers are of the simplest types which are generally utilized for low power density and low bandwidth with high sensitivity applications. Accelerometers, referred to as orientation sensors, in smart phones are utilized to detect the physical orientation of the device and evaluate the linear acceleration of movement. There are different ways to fabricate orientation sensors. Some sensors are built using piezo-electric effect. They contain microscopic crystal structures that get stressed by accelerative forces, which causes a voltage to be generated. Capacitive sensors are made of spring loaded, micro machine structure, mounted on a Silicon base. Force on the structure changes the seismic mass attached to the spring and this deflection is measured using fixed plate capacitor sensors. Capacitive sensing relies on the variation of capacitance pertaining to its geometry and its sensitivity is intrinsically insensitive to temperature changes. The change in acceleration can be static (gravity) and dynamic (forced

strain). Neglecting the fringing effects, the parallel-plate capacitance is

$$C = \frac{\epsilon A}{d} \quad (1)$$

A = area of the electrodes, d = separation between the electrodes and = permittivity of the material. A change in any of these parameters make changes in capacitance and this variation is used in MEMS sensing. For linear acceleration mechanism the dynamic changes in orientation along 3 axes can be defined as

$$\vec{a_x} = \frac{d\vec{v_x}}{dt}$$
$$\vec{a_y} = \frac{d\vec{v_y}}{dt}$$
$$\vec{a_z} = \frac{d\vec{v_z}}{dt} \quad (2)$$

It acceleration would be

$$\vec{a} = \vec{a_x} + \vec{a_y} + \vec{a_z}$$
$$|\vec{a}| = \sqrt{|\vec{a_x}|^2 + |\vec{a_y}|^2 + |\vec{a_z}|^2} \quad (3)$$

Here dv/dt = change in velocity (along a reference axis) with respect to time. The X-axis (lateral), Y-axis (longitudinal) and Z-axis (vertical) orientations of the smart phone are measured by the calculative speculation of tri-axis accelerated values of the positioning sensor.

IV. PROPOSED MECHANISM OF CURSOR MOVEMENT AND COMMAND EXECUTION

This section elaborates the technical aspects and implemented software topologies of the reported work. The presented work is the innovative one as it uses speech recognition system to provide the direction to the wheelchair. Definition of speech recognition can be stated as speech recognition is the method of converting the speech signal i.e. spoken word to a sequence of word by use of an algorithm which is implemented as a program. In this work the main modules are as follow:

- **Android Phone:** Which is used to receive voice command from patient and is connected wirelessly to Bluetooth module.
- **Bluetooth Module:** This is used for wireless serial connection between Raspberry pi and Android Smartphone.
- **Speech Recognition System:** This is the main component which performs the speech recognition process and controls all the operations.
- **Motor Driver:** This component is used to drive the DC motors which are connected to the Raspberry Pi via the motor driver IC. 5) DC Motors: DC Motors are used to move the wheelchair in different directions as per the received voice command.

A. Cursor Movement Algorithm

The topology of precise cursor movement deals with the spontaneous data acquisition from the embedded orientation sensor. The cursor position is depicted as a 2-D coordinate value like (X,Y) and respective changes in the coordinate values result in corresponding changes in the cursor position. The momentary variations in (X,Y) values are stored and according to a set of customized code snippets, these oriented position data are utilized to control the mouse navigation. The systematic procedure of continuous cursor movement is presented

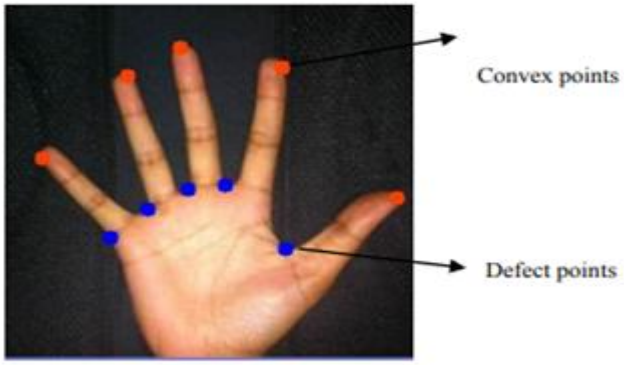

Fig.2. convexity defects in the image.

B. Voice Activation Algorithm

The algorithmic approach towards the capitulation of voice command and control mechanism commences with the creation of a Speech Recognizer object in the firmware. Taking input from the smart phone microphone, the driving program sends the available word or text to the server through wireless networking module and this task is undergone in a repeated manner. The application console provides probable textual suggestions for every other input to search for the correct samples to materialize relevant instructions. The implemented topology for voice commanding.

C. Server Application Topology

The server application mechanism initiates with the definition of Client application variables and their differential changes. The cursor navigation is regulated by assigning two specific conditions upon the Changes in Client variable positive increment and negative increment. If any of these two avails, cursor along the host computer is shifted to a new position according to the differential change. If the conditional assignment does not happen, it implies that the incoming command is not matching with any text stored in a customized data base containing approximately 25 instructional directives. When it matches with any of the sample command, simulation gets activated using Java Runtime Static class and the governing code is supposed to be executed. Then the data recording process is reiterated and takes place continually unless the termination instruction is provided.

Algorithm:

Algorithm for Server Application
\Client application variables → X, Y
Elementary changes → dX, dY
Program termination variable → T T ← 0 ;
program executed T ← 1 ;
program completed Cursor position → (X0, Y0)

Initialize:
X ← 0
Y ← 0
dX ← 0
dY ← 0
T ← 0

Start:
Take inputted (X,Y)
X=X+1 and Y=Y+1; positive increments
X=X-1 and Y=Y-1; negative increments
if (X+ = dX) &&(Y + = dY) && (T == 0)
then (X0, Y0)=(X, Y)
end if
if(X− = dX) &&(Y − = dY) && (T == 0)
then (X0, Y0)=(X, Y)
end if
else (X0, Y0)=(X0, Y0)
Go to START

Application of Motion Recognition in Robot Control: The implemented motion detection based remote control over a host computer urges the applicability of accelerated readings in case of wireless control of a robotic structure from a moderate distant place. As the embedded Accelerometer sensing mechanism has been proven efficient, especially in the state of signal interference, the processed motion data can be utilized to manually control the movement and other activities of a robotic body from a remote place. The data transformation can take place through Wi-Fi, GSM (Global System for Mobile Communication) or Bluetooth technology. The developed HMI system has been tested for controlling operation of a customized robotic framework which can navigate along a 2-D XY surface. The robot has been programmed to take inputs from the Android Client application which sends.

V. RESULT AND ANALYSIS

The overall implemented system incorporates customized Android and Java based software programs to place effective remote computing method via a controller smart phone. The manifestation depends on processing of voice commands and motion identification of an Accelerometer embedded smart device. In Fig. 3, the console of the developed Client application is presented. The system has been tested under different circumstances and the performance analysis accounted for has been quite satisfactory. Chronicles of several casework.

TABLE I: Evaluated Deviations in Cursor Movement

θ (Deg.)	error
5	0.08
10	0.10
15	0.12
20	0.17
25	0.21
30	0.24

Case-1: Effect of Angular Orientation on Precise Cursor Movement: The cursor navigation depends on the axial orientation of the smart phone and these motion parameters are derived from the processing of Accelerometer sensing values. The demonstrated system has been tested for accurate mouse movement application in regard to the substantial alignment of the smart phone across a 2-D XY surface, when the azimuthally (Z-axis) component of motion has been considered constant. To observe the effects of angular motion parameters on the simultaneous cursor position, the console of the host computer has been regarded as a virtual 2-D surface of 100 square grids, each of them contains an area of 1cm2 . The testing process is referred to a threshold of θ = 5Degree for an elementary change of 1 unit in the cursor position denoted as (X,Y) coordinates. In case of different angular positioning, the respective deviational errors of the cursor movement have been evaluated from a graphical interface fabricated into the host machine. The observed deviations in cursor position are stored in Table I.

$$|\text{error}| = |r - r_0|$$

where r_0 = reference position
and r = actual position.

Case-2: Effect of Voice Intensity on Command Activation: The voice commanding mechanism has been established by dint of corrugated analysis of different vocal samples which are both of male and female users. The inputted speech files are first converted into respective text formats and then the textual instructions are carried out in order to control the operation of the host machine. The developed system has been experimentally tested for 100 voice samples with different intensity measured in Decibel units. The vocal intensity varies with respect to the pitch of a sample and according to these variations; the accuracy of detecting executable commands has also changed to a considerable extent. The observed accuracies for different vocal intensities are stored in Table II. I = Voice intensity in dB and α = accuracy of command execution in %.

Case-3: Effect of Wireless Connectivity on System Efficiency: The presented system has been tested in a noisy environment where signaling interference and other communicative variances prevailed. The practical simulation has circulated that the remote control over a targeted computer has been established from a fair distance of 15-20m via a reasonably strong Wi-Fi network while with a slow and relatively weak as well as multiple accessed networking provision, the smart phone application can access the host from a distance of 10m. The caseworks stated in Case-1 and Case-2 have been analyzed with a prevalence of a strong and compatible Wi-Fi networking utility. Distant control operation yields to the availability of an efficient wireless concert which is free from noisy artifacts and interferences. Table III contains system efficiencies for different operating distances within noise-free single mode and noise-corrupted multi mode Wi-Fi connectivity zones respectively. d = tested operating range (m) of the system within a Wi-Fi connectivity zone, here range means the distance between the Client smart phone and the targeted computer; ηs = efficiency

in % for a noise-free connectivity and ηn = efficiency in % for a noisy connectivity.

Case-4: Application of Motion Recognition in Robot Control: The implemented motion detection based remote control over a host computer urges the applicability of accelerated readings in case of wireless

TABLE II: Evaluated Accuracies in Voice Activation

T (dB)	α (%)
90	96
85	93
80	91
75	87
70	84
65	79

TABLE III: System Efficiencies for Clean and Noisy Connectivity

d (m)	η_c (%)	η_n (%)
5	91	83
10	88	79
15	83	76
20	81	71
25	77	65

control of a robotic structure from a moderate distant place. As the embedded Accelerometer sensing mechanism has been proven efficient, especially in the state of signal interference, the processed motion data can be utilized to manually control the movement and other activities of a robotic body from a remote place. The data transformation can take place through Wi-Fi, GSM (Global System for Mobile Communication) or Bluetooth technology. The developed HMI system has been tested for controlling operation of a customized robotic framework which can navigate along a 2-D XY surface. The robot has been programmed to take inputs from the Android Client application which sends the orientation parameters of the smart phone.

Fig.3. Robot control mechanism of the HMI system: (a) shows the contribution of the Accelerometer (b) shows the robotic structure.

VI. CONCLUSION

In this paper, the prospects of an Android-based wireless human-machine, basically computer, interrelated software dependent system has been elaborately presented. The system consists of certain dedicated software applications and data acquisition mechanism from embedded motion sensor. The motion recognition and voice command execution avail stable remote control phenomenon over the operation of a host machine. The demonstrated system has been proven sustainable on the basis of its performance evaluation. The wireless communicative system is happened to be useful in applications of remote controlling of robots and electronic devices. The physically impaired people are beneficiaries of such an interactive medium. Such reliable systems augment the horizon of advancement in smart computing and invoke further development in this field.

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