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Development of Hand Gesture Recognition Framework Using Surface EMG and Accelerometer Sensor for Mobile Devices

Vasant B. Chavan [1], Dr. N. N. Mhala [2]

1 M.Tech., Electronics Department, Bapurao Deshmukh College of Engineering, Sewagram, Maharashtra, India
[2] Professor, Electronics Department, Bapurao Deshmukh College of Engineering, Sewagram, Maharashtra, India

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Abstract - ***For any gesture recognition framework to work dictionary of gesture is to be made. The dictionary can be divided scale viz., small scale gesture and large scale gesture. We need to make use of sensor to recognize the gesture on the basis of assembled dictionary. The analog data from the sensor is provided to the microcontroller to be processed. The processed data is then transferred to the mobile device through the Bluetooth module. The gesture recognising sensor is connected to the microcontroller through one Bluetooth module and the microcontroller and mobile device is connected to the other Bluetooth module. Making use of the gesture recognition framework mobile device can make a call, receive a call, take a picture and receive a text. The recognition of the gesture is done in three axial (x, y, z) manner. For sensing, two potential technology are used which are surface Electromyography (SEMG) and Accelerometer sensor. We proposed a three axis accelerometer are being increasingly embedded into many personal electronic devices like the Apple i-phone, Apple i-pod touch, Apple i-pad and Lenovo laptop. In this paper a survey of recent hand gesture recognition framework is presented.***

Key Words: *Hand gesture, Human Computer Interaction (HCI), Segmentation, Feature extraction, Accelerometer sensor, Surface Electromyography sensor.*

1. INTRODUCTION

Gesture is nothing but a movement or position of the hand, arm, body, head, or face that is expressive of an idea, opinion and emotion that is called gesture. Gesture recognition means identification and recognition of gestures originates from any type of body motion but commonly originates from face, hand and head. In gesture recognition technology, the sensors read the movements of the human hand and communicate the data to a mobile device that uses the gesture as input to control device or application For example, a person doing some gesture is sensed by the, gesture recognition sensor and mobile device operated. Gesture recognition does not require the user to wear any special equipment or attached any devices to the body. For hand gesture recognition the user simply wear a hand gloze to operate a mobile device [1]. Gesture recognition is the process by which gestures made by the user are used to convey the information or for device control. In everyday life physical gestures are a powerful means of communication. A set of physical gestures may constitute an entire language, as in sign languages. They can economically convey a rich set of facts and feelings. In this paper makes the modest suggestion that gesture based input is such a beneficial technique to convey the information or for device control with the help of identification of specific human gestures [2], [3]. The essential aim of building hand gesture recognition framework is to create a natural interaction between human and compute or mobile device where the recognized gesture can be used for conveying meaningful information [4].

Human computer interaction (HCI) also named man machine interaction (MMI) refers to the relation between the human and the computer or more precisely the machine, and since the machine is insignificant without suitable utilize by the human [5]. Gestures are two types which are static and dynamic. Static gesture required less computational complexity where as dynamic gesture required more complex but suitable for real time environment [6]. The application of gesture recognition framework for Human Computer Interaction have explain in some recent year which are Robot control, games, and surveillance using different tools and algorithms [7], [8]. Another major application of gesture recognition is find out in the aviation industry for placing the aircraft in the defined bay after landing, using this technique we can make a passenger aware about the safety features by the airhostess. For the physically challenged people gesture is only method to communicate visible people at some audible distance [9], [10].

Human- Robot or human- Computer interaction is one of area where hand gesture recognition has been successfully used. Using of key board and mouse is limited to 2D but the controlling of a robot should be in 3D space. Hand gesture is most suitable for such purposes. Other application includes Virtual Reality for communication media systems such like controlling television device to turn the TV ON or OFF or for changing the channel and volume of the TV [11].

2. GESTURE RECOGNITION

For the hand gesture recognition gesture based interaction prototype enables operating a mobile device without touching it. It consists of a wearable gesture capturing device and an interaction application program running on a mobile device.

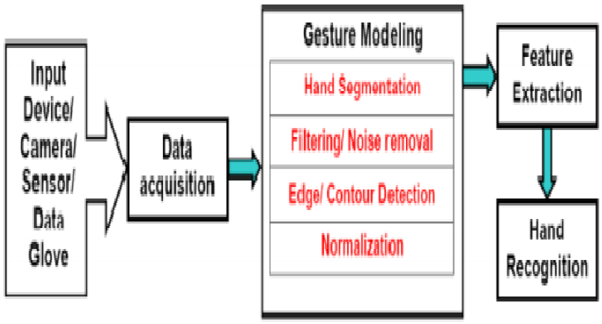

Fig-1: Block diagram of gesture recognition [11]

The gesture capturing device records sensor signals, and send them to the mobile through a wireless connection. The interaction application program processes these signals, translates each gesture into instructions, and then provides feedback [12]. For gesture sensing the use of camera is an early development technology, but there were some drawbacks of camera gesture sensing in mobile cases such as changing light and background. Now a days for gesture sensing two potential technologies are used which are surface electromyography sensor and accelerometer sensor. Accelerometer sensor can measure acceleration from vibration and gravity where as surface electromyography sensor which indicate relative activities of muscle during gesture execution. Both the sensor is good at capturing noticeable, large-scale gesture. Surface electromyography sensors have some advantages in capturing fine motion such as wrist and figure movements and can be utilized to realize human computer interfaces [12]. The block diagram of hand gesture recognition is as shown in fig. 1, which consists of Data Acquisition, Gesture Modeling, Feature extraction and Recognition Stage.

2.1 Data Acquisition

In the data acquisition process collection of input data like hand, face or body gestures classifies the input tested gestures using classifier. There are a number of input device for data acquisition. Some of them are data gloves, marker, hand images and drawings [11]. Data gloves are the devices for perfect data input with high accuracy and high speed. Data gloves can provide accurate data of rotation, location, and joint angle in the various virtual reality environments. Now a day's wireless data gloves are available commercially so as to remove the hindrance due to the cable. Another input device coloured markers are attached to the human skin hand localization is done by the colour localization [13], [14].

2.2 Gesture Modeling

In this steps the pre-processing to ensure the successful unification. The success of the gesture recognition mostly depends on gesture modeling stage [1].In this step different data received from data acquisition are to be modeled properly depending on type of applications. For gesture modeling four steps are involved viz. Hand segmentation, Filter/Noise removal, Edge/contour detection and Normalization. The segmentation of the input data is carried out easily in this process. In the segmentation process starting and end points of each motion from the signal steam is find out. The Pre-Processed of input data before segmentation to minimize the noise. The pre-processing consists of smoothing and calibration [11], [15].

2.3 Feature Extraction

After successful modeling of input data or gesture, the feature extraction should be smooth since the fitting is considered the most difficult obstacles that may face; these features can be hand/palm/fingertips location, joint angles, or any emotional expression or body movement [1]. The extracted feature might be stored in the system at training stage as templates or may be fused with some recognition devices such as neural network, HMM, or decision tree which have some limited memory should not be over taken to remember the training data. Feature extraction is the important elements for hand gesture recognition [11]. Large number of feature, such as, contour, motion, textures, distance, shape, orientation, and centre of gravity etc., Can be used for gesture recognition. Feature extractions are geometric and non-geometric. The geometric features are like hand contour, fingertips, finger detections. The non-geometric features are colour texture and silhouette available for gesture recognition [15].

2.4 Recognition Stage

This stage is consider to be a final stage gesture system and the meaning of the gesture should be declared and carried out, this stage usually has a classifier that can attach each input testing gesture matching class[1]. Scale wise classification of gesture is done on recognition process, small scale, medium scale and large scale gesture classification with the help of some laws. For example a Byes linear classifier for small scale gesture classification and Hidden Markov models for large scale gesture classification. These are the algorithms of gesture classifier [11].

3. SYSTEM ARCHITECHTURE

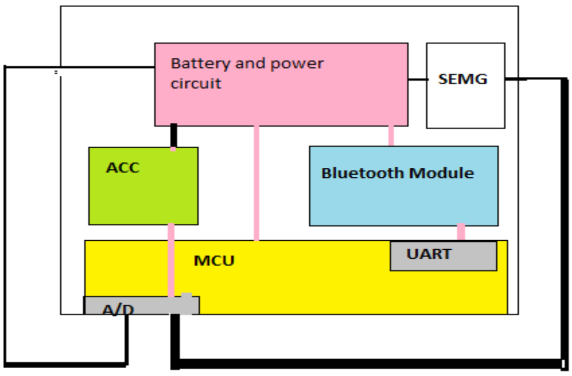

Fig-2: architecture of the gesture capturing device

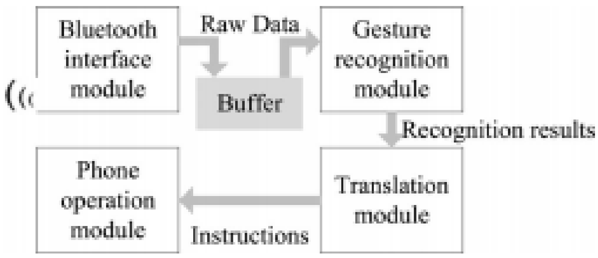

Fig-3: Architecture of the interaction application program

The gesture-based interaction prototype enables operating a mobile device without touching it. It consists of a custom gesture capturing device and an interaction application program running on a Smartphone. The gesture capturing device records surface EMG and ACC signal, and send them to the Smartphone through a wireless connection. The interaction application program process these signal, translates each gesture into instructions, and then provides feedback [18].

3.1 Gesture Capturing Device

A gesture capturing device is developed to record SEMG and ACC signals synchronously. It weighs about 60 g, and consists of surface EMG probe and a main board embedded with an Accelerometer. This surface EMG probe is connected to the main board by wire to share the battery and the controller. A 1000mA lithium battery a power circuit is embedded on the main board. Surface EMG probe amplifies EMG signals, by 500 times, and filters them within 20-300 Hz band pass. The Accelerometer (ADXL 335) is embedded with the main board. It measure acceleration along two axes (x, y) and outputs two channels ACC signals. Both the measured ACC and surface EMG signals are digitized simultaneously by a 10 bit A/D converter that is embedded with the microcontroller (AVR 8 bit controller) at a sampling rate of 600 Hz, and then sent out via Bluetooth serial port module that is produced by Ommitek Electronics Co [18].

3.2 Interaction Application Program

A Nokia 5800XM (with a 434-MHz ARM11 CPU, 128M RAM, Bluetooth 2.0 support, and running Symbian S60 v5.0) is used to demonstrate the feasibility of the gesture-based interaction. An interaction application program that is implemented in Symbian C++ includes Bluetooth interface, gesture recognition, translation, and phone operation modules. The Bluetooth interface module receives data using Bluetooth API (Application Program Interface) and stores them into a buffer. The gesture recognition module reads data from the buffer and provides recognition results. The translation module maps gestures to instructions. The number of supported gestures is less than the number of interaction tasks and users are allowed to modify the mapping relationships by doing specific gestures. System events such as receiving a phone call can change the mapping relationships too. The phone operation module executes instructions coming from the translation module by calling system APIs or sending keyboard messages, which are used by the operating system to notify programs of key press events. Although 5800XM is a touch-enabled phone with only three keys, it supports all of the keyboard messages. Consequently, the phone operation module is able to manipulate most of the phone functions by mapping gestures to keyboard messages [18].

3.3 8 Bit AVR Microcontroller

8K bytes of In-System Programmable Flash with Read-While Write capabilities, 512 bytes of EEPROM, 1K byte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM; Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register Contents but freezes the Oscillator, disabling all other chip functions until the next Interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption [19].

The device is manufactured using Atmel's high density non-volatile memory technology. The Flash Program memory can be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash Section will continue to run while the Application Flash Section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega8A is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications. The Atmel AVR ATmega8A is supported with a full suite of program and system development tools, including C compilers, macro assemblers, program simulators and evaluation kits [19].

4. SELECTION OF SENSORS

Selection of sensors for gesture recognition is very essential; the interaction with hand gesture the use of camera is an early development technology [12]. The operation of the video camera for hand gesture is formed between the front of the video camera and a uniform background in a laboratory with florescent lights in the ceiling. One by one are instructed to form gestures in front of the camera with no restrictions on the distance between the hand and the camera nor any strict restrictions in the orientation of the hand in the plane parallel to the camera. One person at a time , however, are instructed to keep the hands approximately parallel to the camera lens in order to maintain the gesture shape and motion of the figure and wrist in front of the camera [16]. The drawbacks of camera gesture recognition system in the use of most mobile cases such as changing light and background. Camera gesture for mobile device can't work because of shadow image occurs at the background. The camera sense the background shadow gesture due to which the recognition system senses the gesture wrongly, this reduces the system efficiency. Due to these drawbacks of the camera based recognition system the sensor was changed from camera to more advance gesture recognition sensor. For e.g., surface electromyography (SEMG) sensor and three axis accelerometer (ACC) sensor [12].

Two potential technologies for gesture sensing are Accelerometer sensor and surface Electromyography sensor. Accelerometers can measure acceleration from vibration and gravity, where as surface Electromyography sensor sense relative activities of muscle during gesture recognition. The Accelerometer does not provide information on muscle forces like EMG sensor, but the results show that it provides useful supplementary information [12].

4.1 EMG feature Extraction

Two sets of characteristic features extracted from EMG sensor recordings were used to represent the EMG sensor data for classification of the intended movements. The time domain feature set, composed of four time domain statistics of the EMG sensor; mean absolute value (MAV), zero crossing (ZC), slope sign change (SSC), and waveform length (WL). For Autoregressive EMG signal can be modelled as below

$$x(n) = -\sum_{k=1}^{p} a_k x(n-k) + v(n) \qquad \textbf{(1)}$$

Where x (n) denotes the recorded signal at discrete time n $\{a_k$, k=1,2, ...p$\}$ are AR model coefficients, p is the AR model order, and u(n) is the residual white noise. AR model assumes that the present value of the time series x (n) is in some (linear) way dependent on past values of the time series x (n-1), x (n-2), and so on. The AR model coefficients were computed from each EMG analysis windows and used to present the EMG pattern for classification of different motion classes [17].

The three axis accelerometer sensor is a thin, small, light-weight, and power efficient with signal conditioned voltage output. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration [11].The sensor uses a single structure for sensing the X, Y, and Z axes. As a result, three axes sense directions are highly orthogonal and have little cross- axis sensitivity. Mechanical misalignment of the sensor die to the package is the chief source of cross-axis sensitivity [12]. Mechanical misalignment can, of course be calibrated out at the system level. The performances of the accelerometer sensor rather than using additional temperature compensation circuitry, innovative design technique ensure that high performance is built in the accelerometer sensor. The result of the accelerometer sensor shows that there is no quantization error or non-monotonic behaviour, and temperature hysteresis is very low.

5. APPLICATION OF GESTURE RECOGNITION

The useful application of the hand gestures recognition is given below;

i. Sign Language
ii. Desktop and Tablet PC Applications
iii. Robotics
iv. Games
v. Directional indication through pointing
vi. Monitoring automobile driver's alertness/drowsiness levels
vii. Coffee for Yawns
viii. Switching channels, without a TV remote
ix. Automated homes
x. Driving to safety.

6. RESULTS

The result for hand gesture recognition framework using surface EMG and ACC sensor are tabulated in table below in the tabulated form.

Table-1: Output of Gesture Recognition Framework

Input gesture	Output on LCD display	Description
Initaly without any gesture input to the system and power supply applied to the system.		When we connect a power supply to the gesture device, it will firstly clear the LCD display and then after we have seen the display character later connected on the LCD display.
		While doing a gesture using ACC sensor toward –Y axis, it will send a text mail.
		While doing a gesture using ACC sensor toward +Y axis, it will read a text mail on the screen of LCD display.
	Using this gesture we are only send text message to the other mobile device.	While doing a gesture using ACC sensor toward –X axis, it will send a text message to the other mobile device.
		Surface EMG sensor which indicate relative activities of muscle on screen board of LCD

		display. Using that muscle activity of surface EMG sensor we will make a call.

7. CONCLUSIONS

With the increase in applications, the gesture recognition system demands lots of research and development in different directions. A large number of research works carried out during last twenty three years have been reviewed. The different sub-components, methodologies and design algorithms used for recognition of mainly hand gestures in those works have been described. A brief comparison of backgrounds, segmentation techniques, features used and the recognition methods have been done and presented.

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BIOGRAPHIES

Vasant B. Chavan received the B.E. Degree from Dr. BAMU, Aurangabad, Maharashtra, India in 2012, and the M.tech Degree From the university of RTMNU, Nagpur, Maharashtra, India, pursuing in Electronic Engineering. His Master's degree work focus on Development of Hand Gesture Recognition Framework using surface EMG and Accelerometer sensor for Mobile Device under the supervision of Dr. N. N. Mhala.)