



# **Hand Gesture and Common Interaction Recognition Using MEMS**

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**ABSTRACT:** The main aim of this project is to provide hand gesture recognition with low cost, high dynamic rate and to replace vision based hand gesture recognition. In this project, a wearable prototype model for Hand gesture recognition and common interaction system using MEMS accelerometer has been made. It also provides a compacted portable device. The accelerations of a hand motion in three perpendicular directions are detected by MEMS accelerometer and the acceleration values were transmitted to microcontroller. An automatic gesture recognition algorithm is developed to identify individual gestures in a sequence. Finally the gesture is recognized by comparing the acceleration values with the stored templates that has been stored in EEPROM. If the motion of the MEMS is equal to stored templates, then the respective number is displayed on the LCD and the audio sample is played through speaker via voice Module.

**KEYWORDS:** Micro Electro Mechanical Systems, Microcontroller, LCD, Speaker.

## **I. INTRODUCTION**

Gesture recognition enables humans to communicate with the machine and interact naturally without any mechanical devices. Gesture recognition has been a research area which received much attention from research communities such as human computer interaction and image processing. The increase in Human-Machine Interactions (HMI) has made user interface technology progressively more important. Gesture recognition can be conducted by computer vision and image processing.

In this project, a wearable prototype model for Hand gesture recognition and common interaction system using MEMS accelerometer digital sensor has been designed. The accelerations of a hand motion in three perpendicular directions are detected by accelerometer and its acceleration values are transmitted to microcontroller. An automatic gesture recognition algorithm is developed to identify individual gestures in a sequence. Finally the gesture is recognized by comparing the acceleration values with the templates that has been stored in EEPROM and the respective commands are displayed on the LCD and common interaction samples are played through the speaker using a voice module. The main aim of the project is to replace vision based hand gesture recognition with MEMS accelerometer. The main objective of this project is to provide hand gesture recognition with high dynamic rate at low cost. It is a compact portable device and also it is designed to aid specially challenged people.

The existing gesture recognition system is based on image/video, magnetic or inertial tracking techniques touch screen. Wired gloves are used to provide input to the computer about the position and rotation of the hands using magnetic or inertial tracking devices. The first commercially available hand tracking glove type device is the Data Glove, a glove type device which can detect hand position, movements and finger bending. This uses fibre optic cables which is running down the back of the hand.

Depth aware specialized cameras such as structured light or time-of-flight cameras, one can generate a depth map of what is being seen through the camera at a short range, and use this data to approximate a 3D representation of what is being seen. Stereo cameras uses two cameras whose relations to one another are known, a 3D representation can be approximated by the output of the cameras. Single standard 2D camera can be used for gesture recognition where the environment would not be convenient for other forms of image based recognition.



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In touch screen, the gesture should be written on the screen and it will be compared with the templates and desired output is shown in screen. It is mostly applicable in 2D gaming.

In wired gloves hand gestures techniques, light pulses are created. When the fingering motion is bend, light leaks through small cracks and the bending loss is registered, hence it is not high accurate and also cost is high. In image/video based hand gestures techniques, there are many challenges associated with the accuracy and usefulness of gesture recognition software. For image based gesture recognition there are limitations on the equipment used, slower dynamic response and image noise. Images or video may not be under consistent lighting or in the same location. Items in the background or distinct features of the users may make recognition more difficult. Furthermore, the distance from the camera and the camera's resolution and quality, also cause variations in recognition accuracy and also it requires high cost to implement. The cost of the touch screen is high and also it cannot be used to identify 3D gestures.

To overcome the limitations such as unexpected ambient optical noise, slower dynamic response, and relatively large data collections/processing of vision based method and to strike a balance between accuracy of collected data and cost of devices, an Inertial Measurement Unit is utilized in this project to detect the accelerations of hand motions in three dimensions.

The proposed recognition system is implemented based on MEMS acceleration digital sensor. Since heavy computation burden will be brought if gyroscopes are used for inertial measurement and hence the project is based on MEMS accelerometers only and gyroscopes are not implemented for motion sensing.

## II. SYSTEM MODEL AND ASSUMPTION

The PIC16F877A is one of the latest products from Microchip. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as: the control of different processes in industry, machine control devices, measurement of different values etc.

Some of its main features are

- PIC16F877A series normally has five input/output ports. They are used for the input/output interfacing with other devices/circuits.
- Most of these port pins are multiplexed for handling alternate function for peripheral features on the devices.
- All ports in a PIC chip are bi-directional.
- It has an operating frequency of (0-20) MHz.
- Software selectable frequency range of 8MHz to 31 KHz.
- It requires 2.0-5.5 voltage of power supply.

The LIS302DL is an ultra compact low-power three axes linear MEMS accelerometer sensor. It includes a sensing element and an IC interface able to provide the measured acceleration to the external world through I<sup>2</sup>C/SPI serial interface. The sensing element, capable of detecting the acceleration, is manufactured using a dedicated process developed by ST to produce inertial sensors and actuators in silicon. The IC interface is manufactured using a CMOS process that allows to design a dedicated circuit which is trimmed to better match the sensing element characteristics. The LIS302DL has dynamically user selectable full scales of  $\pm 2g/\pm 8g$  and it is capable of measuring accelerations with an output data rate of 100Hz or 400Hz. A self-test capability allows the user to check the functioning of the sensor in the final application. The device may be configured to generate inertial wake-up or free-fall interrupt signals when a programmable acceleration threshold is crossed at least in one of the three axes. Thresholds and timing of interrupt generators are programmable by the end user on the fly. The LIS302DL is available in plastic Thin Land Grid Array package (TLGA) and it is guaranteed to operate over an extended temperature range from -40°C to +85°C.

WTV-SR recording IC is one of the members of recording serial products created by Guangzhou waytronic. This module can be record as well as fixed voice playback, recording content uploaded and a variety of control modes can be chose. With the master chip and plug-in SPI-FLASH, it has a great advantage in the duration of recording and cost performance. Flexible supply (can either supply module, or supply solution), is an effective recording solution.



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Some of the main features of WTV-SR Voice Module are:

- 7 kinds of operating modes: MP3 mode, one to one key mode, parallel mode, one record one play key mode, Audio-book mode, two-wire serial mode and three-wire serial mode.
- Support MIC and LINE-IN recording;
- Support plug-in 64M bit SPI-FLASH, recording time up to 1600 seconds
- Support upload and download voice via USB.
- Support playback the high-quality voice which downloaded from computer.

A Liquid Crystal Display (LCD) is a flat panel display, electronic visual display or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits and seven segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. They are common in consumer devices such as clocks, watches, calculators, telephones and have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays and since they do not use phosphors, they do not suffer image distortion. LCDs are however, susceptible to image persistence.

COM-0915 is a small audio speaker that is ideal for radio and amplifier projects. It has a power rating of 0.5W with an impedance of 8 ohm. It has a dimension of 50mm diameter, 16mm height and 28mm base diameter. Dynamic loudspeaker uses a lightweight diaphragm or cone, connected to a rigid basket or frame via a flexible suspension, commonly called a spider, that constrains a voice coil to move axially through a cylindrical magnetic gap. When an electrical signal is applied to the voice coil, a magnetic field is created by the electric current in the voice coil, making it a variable electromagnet. The coil and the driver's magnetic system interact, generating a mechanical force that causes the coil (and thus, the attached cone) to move back and forth, thereby reproducing sound under the control of the applied electrical signal coming from the amplifier.

Enclosed Vibration motor (325-100) is designed without any external moving parts and also includes screw holes on the most case plate. This vibration motor is a uni vibration motor with diameter 24.4mm. It has operating voltage as 3V. This vibration motor is a 3 pole machine and has precious metal brushes and is wound to 3V nominal.

### III . DATA PROCESSING

Sensing device produces the analog values corresponding to the acceleration of three axes. Later the analog signal is converted to digital signal by an on-chip ADC in MEMS. These Acceleration values for the seven gestures were placed in the lookup table in controller. Each incoming gestures values for all three axes be compared with every axis value in the table. The tolerance level for each axes is  $\pm 5$ . The data will be looked upon the table by sign sequence and template matching.

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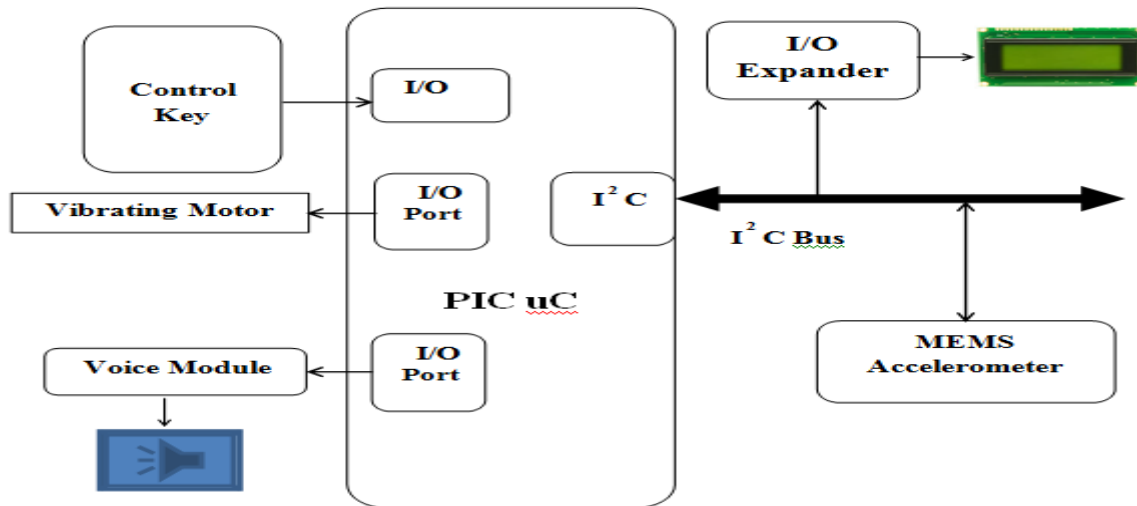


Fig 1 Block diagram of hardware connection

Sometimes a “ghost” gesture may be detected, i.e., due to environmental vibrations or unintended hand motions, it would not happen in our system as we providing a control key ,so it will active only when we are using the device for hand gesture. The following flow chart will explain overall data processing system. Based on the movement, the gesture sequence from MEMS will be send to PIC-microcontroller through I<sup>2</sup>C bus. At the gesture segmentation, the data will be checked whether it is a single dimension or two dimensions .Then the gesture is normalized and later it will be aligned based on centre of mass. It will be compared with the stored standard pattern. If the recognition is true then the PIC-microcontroller will enable the output unit .If it is not true then it will go back to area sequence recognition and analysed again.

All the templates are stored and the programs are programmed in EEPROM memory. Using embedded C programming language, programs are coded into the PIC-microcontroller. At the stage of alignment by centre of mass, the MEMS motion is compared to the stored templates which have been stored in the memory. After the recognition of motion, the PIC-microcontroller will enable the output unit.

## IV.OUTPUT UNIT

The output unit consists of three main devices LCD, speaker, vibrating motor. All the functions are controlled by microcontroller. After recognition of the motion, the respective output will be displayed in LCD, the respective sound sample will be played in speaker via voice module and the acknowledgement will be given after each number gesture through a vibrating motor.

Liquid Crystal Display is used to display the output. As LCD’s doesn’t have an I<sup>2</sup>C bus interface, we are providing an I/O expander .Thus it easily adds I/O via I<sup>2</sup>C or SPI-bus for input/output, key scan or to control LCDs and also provides Combats "Feature Creep" by expanding I/O ports instead of requirement for new  $\mu$ C. So we can easily use for future work .It is connected at the I/O port of pic-micro controller. We are using 20x4 LCD to provide 20 characters per line, so it is capable of providing 80 characters.

Speaker is used to play the audio sample. As speaker doesn’t have storage capacity we are providing a voice module in between the controller and speaker. The voice module offers true single chip voice recording, non-volatile storage and playback capability for 16 minutes, it is connected at port D of the PIC-micro controller and the audio sample can be loaded to the voice module. Thus the audio sample can be played in speaker.

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Vibrating motor has been used to provide acknowledgement after the completion of each gesture. It is connected at the one of the I/O port of PIC-micro controller. Enclosed Vibration Motor (325-100) has been enabled by PIC-microcontroller after each gesture. This component is added for specially challenged peoples and it can be modified based on the requirement.

## V. SIMULATION AND RESULT

MPLAB IDE v8 is a 32-bit application on Microsoft Windows and includes several free software components for application development, hardware emulation and debugging. Hi-tech C compiler V9.5 is used for programming 16F877A PIC microcontroller. The HI-TECH C Compiler for PIC10/12/16 MCUs is a free-standing, optimizing ANSI C compiler. It supports all PIC10, PIC12 and PIC16 series devices.

The hardware consists of MEMS, speaker, LCD, vibrating motor, Voice board, PIC-microcontroller. Using step down transformer, input 220V is stepped down to 12V and the rectifier is used to convert input AC signal to DC signal. Constant voltage is provided to microcontroller by using regulator. Voice Board consist of voice module. Control Key is pressed and hold to initiate the operation. Now the MEMS is moved in certain numerical action and the respective axes values are given to PIC-Microcontroller. Then the microcontroller will compare the motion with the stored patterns and it will enable the LCD to display the corresponding number and the audio sample is played through speaker. After recognizing each gesture, acknowledgement is provided by the vibrating motor. The hardware output has been shown in Fig

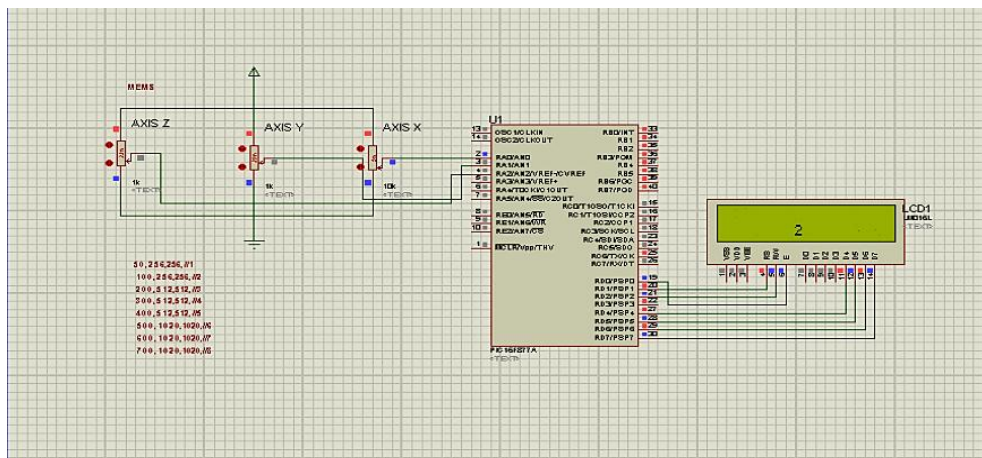


Fig 2 Simulated Output in Display

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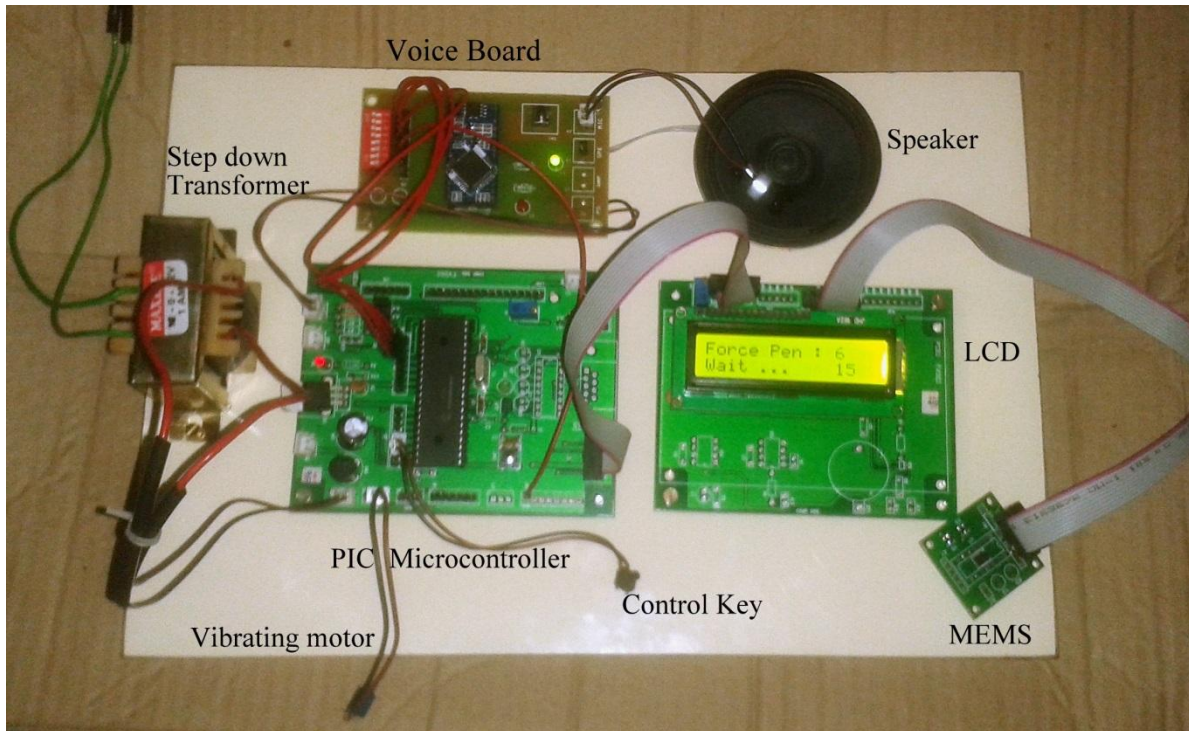


Fig 3 Hardware Output

## VI. CONCLUSION

This project represents the hand gesture recognition and common interaction through the use of MEMS accelerometers. It provides accuracy to this system. The system consists of LIS302DL MEMS Sensor for sensing the hand gesture, a microcontroller and display unit with speaker. The incoming acceleration value for each gesture will be compared with values in the stored templates. Since the standard gesture patterns are generated by motion analysis and are simple features represented by only acceleration values, big data base and complex recognition systems were not required and no needs to collect as many gestures made by different people as possible to improve the recognition accuracy. Advantage of this approach is low cost, does not require any physical device like touch screen, wired-gloves, Very high recognition rates, High dynamic rate and Potential of mobility. In this project, a simple MEMS accelerometer is used which is very easy to wear and it don't need any special training which makes it as user friendly and can be used by all. The main aim and objective of the project is to replace vision based hand gesture recognition and to provide hand gesture recognition with low cost with high dynamic rate .It also provide a compact and portable device to aid specially challenged people.

In future, the gesture recognition system can be used to identify alphabets with more advanced algorithm than proposed and existing one have to be developed and use the same to detect gestures made by the people for automation. It can be applicable in military and traffic light signaling. All the high tech mobiles have an on chip three axes accelerometer and hence the project can be implemented in mobiles also.

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