AN INERTIALSENSOR BASED IN-AIR HANDWRITING AND GESTURE RECOGNITION SYSTEM FOR HUMAN COMPUTER INTERACTION

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Abstract— In this paper an accelerometer based portable device for digit and gesture recognition is being presented. The recognized data will be displayed on the monitor. A speech module is also embedded. The system finds its application in assisting patients. Apart from its HCI and gaming applications, it can be incorporated to assist the communication of deaf and dump with the visually challenged people. The digital pen consists of a tri-axial accelerometer, a microcontroller and a display unit. The device operates with microcontroller as its heart. The system is capable of identifying the digits written on air display it on PC and also give a voice corresponding to the digit written. Users can use the pen to write digits or make hand gestures, and the accelerations of hand motions measured by the accelerometer are transmitted to a computer for online trajectory recognition. The device can use to control the PC in substitute of mouse operation.

Index Terms—Human computer interaction, MEMS, PC, Remote control.

I.INTRODUCTION

Volatile growth of efficient technologies in electronic circuits and components has greatly decreased the dimension and weight of consumer electronic products, such as smart phones and handheld computers, and thus made them more handy and convenient. Due to the rapid development of computer technology, human–computer interaction (HCI) techniques have become an indispensable component in our daily life. Recently, an attractive alternative, a portable device embedded with inertial sensors, has been proposed to sense the activities of human and to capture his/her motion trajectory information from accelerations for recognizing gestures or handwriting[1].

The inertial sensor device can facilitate the inter communication between humans and machine more freely and without the use of traditional keyboards or mouse or remote controls. Gesture or trajectory recognition based on inertial devices is an original direct human-computer interacting way, because the motion of limbs is driven by the force from muscles and the inertial devices could detect the outcome of the force, say acceleration and angular velocity directly, so people could even use them without any distraction all the time[2].

A significant advantage of inertial sensors for general motion sensing is that they can be operated without any external reference and limitation in working conditions.The ease with which an HCI device or technique can be understood and operated by users has become one of the major considerations when selecting such a device. Therefore, it is necessary for researchers to develop advanced and user-friendly HCI technologies which are able to effortlessly translate users' intentions into corresponding commands without requiring users to learn or accommodate to the device[3]. Technologies are being developed which are able to intuitively express users' intentions, such as handwriting, gestures, and human body language, to naturally control HCI devices. These technologies have many applications in the fields of remote control, virtual reality, sign language, signature authentication, sport science, health-care applications, and medical rehabilitation.However, a low-cost, flexible, and robust system to continuously monitor and control based on consumer requirements is at the early stages of development. In this study, we have designed and implemented a ZigBee-based inertial sensor device. We used the LabVIEW (Laboratory Virtual

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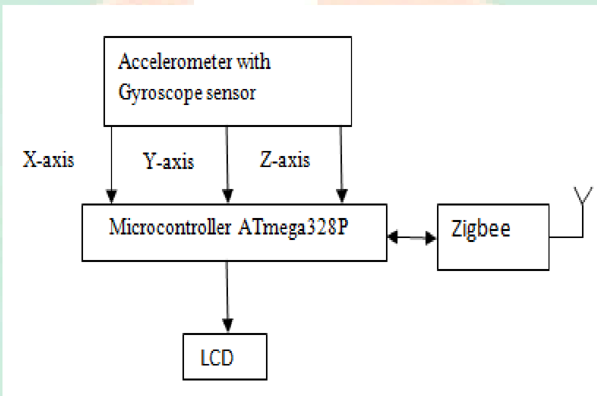
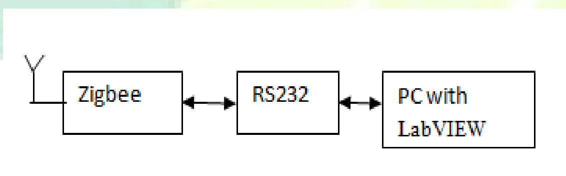
Instrument Engineering Workbench) for handwriting and gesture recognition which is visual programming language and user friendly.The major challenge of inertial-sensing- based handwriting and gesture recognition using acceleration or angular velocity signals is misrecognition, since different users have different preferred speeds and styles[4].

II .SYSTEM DESCRIPTION

This paper presents a digital pen based system to find out the trajectory of the written digits and gestures. As a HMI application to this device, various gestures are used to turn on and off other devices.Microcontroller is the heart of this system. Arduino ATmega328P is the microcontroller used in this paper. Microcontroller is being programmed in embedded C language and is being simulated in AVR Studio 5. The input device to this microcontroller is a three axis accelerometer. The accelerometer is used to measure the acceleration signals with respect to x, y and z axis. The acceleration values are displayed on the LCDDisplay.



a).TransmittingSection



b).Receivingsection

Fig 1. Functional block diagram of the system

The working of the system is asfollows. The entire working can be said to have two parts -Digit recognition part and the device control part. The digital pen can identify the digits from zero to seven and display it on a PC. Also a voice module and loud speaker is being attached to the system to give a voice output of the digits written and displayed. The single APR module can only store and output eight signals. So the recognition of only eight digits – zero to nine are carried out in this paper. The trajectories of the digits are shown in Table 1. This system facilitates the communication between deaf, dumb and the blind[5]. The device control part aims at giving a further application to this pen. So it aimed of a human machine interaction one. The digital pen can be used to control other machines like fan, light etc. Four gestures where used – up, down, right and left. Table 2 shows the various gestures used.[6]

These gestures can open, select and close various system menu and files effectively. In future further more devices can also be incorporated which can be controlled remotely. This can thus find application in assisting disabled or physically challenged people to communicate easily with the surroundings. This device thus provides a tool for an intelligent environment.

Table 1 Trajectory of Digits

0	1	2	3	4	5	6	7	8	9

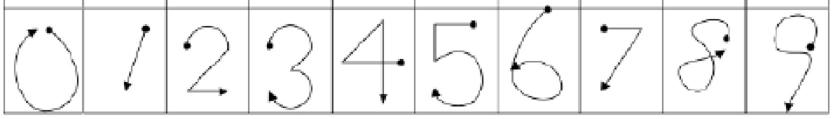


Table 2 Trajectory of Gestures

Up	Down	Right	Left
↑	↓	→	←

III WORKING METHODOLOGY

A. Signal extraction and motiondetection

1).MEMS accelerometer and its working: An accelerometer detects change in position. MEMS accelerometer differs from integrated circuits in that a proof mass□ is machined into the silicon. Any displacement of the component causes this mass to move slightly according to Newton’s second law, and that change is detected by sensors. Usually the proof mass disturbs the capacitance of a nearby node; thatchange is measured and filtered. Although it may seem counterintuitive, an accelerometer can sense the inclination (tilt) of a device even when stationary. Since gravity is an acceleration of 1 g, tilt is proportional to the sine of the angle the accelerometer makes with the Earth’s gravitational field. Much better results can be had using two or more sensors oriented orthogonally to each other The most important specification is the number of axis. The MEMS proof mass can measure one parameter in each available axis, so a one axis device can sense acceleration in a single direction. Three axis units return sensor information in the X, Y, and Z directions[7][10].

2).MEMS Gyroscope sensor : The motion detection procedure involves the following steps movement signal acquisition and normalization. Once the non- motion and motion intervals are separated during the segmentation step, we can calculate the orientation angles within those two intervals. The purpose of the orientation estimation for the non-motion interval is to obtain the initial orientation angles for the motion interval. The signals measured from the accelerometer is utilized to estimate the orientation angles during the non-motion interval since the initial orientation angles cannot be directly obtained from the signals of the gyroscope.

*3).ATmega 328P:*ATmega328P is the microcontroller used in this paper. Microcontroller is being programmed in embedded C language. It is a 32bit microcontroller on Arduino UNO board. The analog input from the inertial sensors i.e., X , Y and Z axis values are extracted by the microcontroller. These analog input values are then converted to digital values between 0v and 255v and is mapped into bits. The Arduino UNO has an inbuilt analog to digital converter.The output signal is then fed to zigbee module for transmission to the PC. The sampling rate of the abovementioned measurement signals is set at 75 Hz. The size of the pen-type board is 130 mm ×15 mm ×8 mm . Note that all signal processing procedures are performed on a PC. The overall power consumption of the hardware device is 30 mA at 3.7v The battery of the inertial pen is replaceable and rechargeable.

B. Wireless ZigbeeModule

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards There are wide range of wireless modules present in the market but Zigbee is used because it support unique needs like low-cost, low-powerwireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band. In my paper this module is helpful to transmit data from pen unit to PC. We preferred to use Zigbee networks because they are secured by 128 bit symmetric encryption keys. In home automation applications, transmission distances range from 10 to 100 meters line-of-sight, depending on power output and environmental characteristics

C. Arduino UNOController

The Arduino Uno is a microcontroller board based on the ATmega328 it is Open source and extensible hardware. The output signals from the sensors are integrated to the control unit Arduino UNO controller. Arduino is a single-boardmicrocontroller to make using electronics in multidisciplinary projects more accessible. The hardware consists of an open-source hardware board designed around an 8-bit AtmelAVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on themicrocontroller.

It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules costless.

An Arduino board consists of an Atmel 8-bit AVR microcontroller which has a complementary components to facilitate the programming and incorporation into other circuits. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²Cserial bus, allowing many shields to be stacked and used inparallel.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides adevelopment environment for their microcontrollers, AVR Studio and the newer Atmel Studio The Arduino IDE supports the C and C++ programming languages using special rules of code organization. The Arduino IDE supplies a software library called "Wiring" from the Wiring project, which provides many common input and output procedures. A typicalArduino C/C++ sketch consist of two functions that are compiled and linked with a program stub main() into an executable cyclicexecutiveprogram.

D. Data Processing AndRecognizing

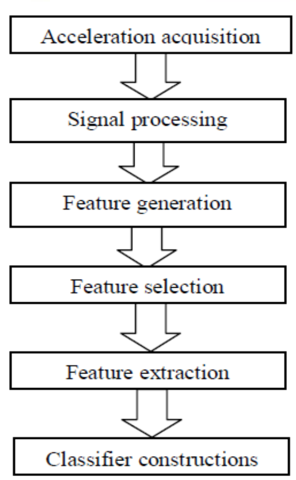


Fig 2. Steps For Recognition

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1) signal pre-processing: The signal pre-processing procedure consists of calibration, a moving average filter, a high-pass filter, and normalization. First, the accelerations are calibrated to remove drift errors and offsets from the raw signals. These two filters are applied to remove high frequency noise and gravitational acceleration from the raw data, respectively[8][9][12].

Feature Generation: The features of the pre- processed acceleration signals of each axis (three axis) include mean, correlation among axes, interquartile range (IQR), mean absolute deviation (MAD), root mean square (rms), VAR, standard deviation (STD), and energy. The characteristics of different hand movement signals can be obtained by extracting features from the pre-processed *x*, *y*, and*z*-axis signals, and we extract eight features from the tri-axial acceleration signals[12].

2) Feature selection: The objective of the feature selection and feature extraction methods is not only to ease the burden of computational load but also to increase the accuracy of classification. The reduced features are used as the inputs of classifiers[12][13].

3) Feature extraction: For pattern recognition problems, LDAis an effective feature extraction (or dimensionality reduction method) which uses a linear transformation to transform the original feature sets into a lower dimensional featurespace.

IV RESULTS

The programming language used in this project is Embedded C. The code was written and simulated in AVR Studio 5. The code was loaded to the microcontroller. The device can successfully recognized digits zero to nine. The digits were displayed on the PC. So as to calculate the effectiveness of proposed algorithm. The trajectory recognition algorithm consist of the following procedures: acceleration acquisition, signal pre- processing, feature generation, feature selection, and feature extractions explain in early section.

V CONCLUSION

There are several methods available for the gesture recognition. This paper describes a nonspecific person gesture recognition system by using MEMS accelerometers. The recognition system consists of sensor data collection, segmentation and recognition. After receiving acceleration data from the sensing device, a segmentation algorithm is applied to determine the starting and end points of every input gesture automatically. The sign sequence of a gesture is extracted as the classifying feature, i.e., a gesture code. Finally, the gesture code is compared with the stored standard patterns to determine the most likely gesture. The recognition system does not require a big data base and needs not to collect as many gestures made by different people as possible to improve the recognition accuracy.This result encourages to further investigate the possibility of using our digital pen as an effective tool for Human Computer Interaction applications. In future an interface system can be constructed which can allows an advanced user to interact with the computer.

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