Wheel-Chair Control Using Accelerometer Based Gesture Technology

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ABSTRACT

This work presents a novel approach to gesture recognition system using accelerometer MEMS sensor in addition with ultrasonic obstacle detection. Gesture recognition has been extensively investigated and has traditionally been accomplished by methods based on joystick and camera based vision where camera is always tracking the movement of different body parts like face, eye etc. In our research we present a low cost, easily learnt and accessible system which utilizes the MEMS technology to detect the gesture.MEMS based technology is extensively used in many fields like motion control, tilt sensing, mobile phones and many more. Our system uses a MEMS accelerometer and it is able to recognize several gestures which have been previously specified. This system not only controls the movement of wheelchair but also detects the obstacle coming in its path and gives alarm to the user to take necessary action. Our project Automatic wheelchair basically works on the principle of acceleration, as the user moves his hand or tilts his hand it generates analog signal proportional to tilts that are processed by microcontroller unit and thus gives commands to the motors in which direction rotates.

Keywords- Microcontroller, accelerometer, wheelchair controls, gesture recognition, MEMS.

I. INTRODUCTION

The aim of our work is to develop an automatic wheelchair that could move forward, backward, left, right with obstacle detection in its path. The overall framework of this work is to provide supports to physically challenged person who cannot navigate from their places. A wheelchair consists of accelerometer sensor as sensing element, a microcontroller unit a decision making device and motors to navigate the wheelchair. By tilting accelerometer sensor wheelchair can be moved in four directions. The wheelchair is associated with ultrasonic sensors to obstacle detection. Obstacle in the way is determined by wheelchair and wheelchair will stop automatically. The wheelchair can also integrate with Head movements and computers; the pilot can use the same controls to drive the wheelchair and operate another assistive device, so handicap person who cannot make use of his hands can drive chair by Head movements.In biomedical field, a wheel-chair is an important device to help patients to navigate without any help. The present wheel-chairs either require constant monitoring of someone or needs lots of efforts.Traditional wheel-chairs used by the physically challenged and elderly people have some drawbacks, limited functions and flexibilities. Most of the traditional electric powered wheelchairs are joystick operated. The joystick controlled wheelchair cannot be used by physically challenged person who cannot control the movement of their hand and fingers. The recent development in robotics and Sensor technology promises to develop an advanced wheel-chair that could overcome the drawback in traditional wheel-chairs.

In existing system a pc with camera will be used for the gesture recognition and controlling the movement of wheel-chair [1]. Hence along with pc this would increase the complexity of the system. The complexity of system can be reduced by using MEMS accelerometer instead of a pc that is very small IC placed on the fingertips of the patient. Gesture control robots are extensively employed in human non-verbal communication that works with our hand gesture also making the system less complex and lighter in weight. The whole system has two parts: 1. Transmitter – The gesture sensing and RF signal transmitting device. 2. Receiver – RF receiver and microcontrollerto controls movements of motors installed on wheel-chair. The MEMS accelerometer which is used for gesture recognition is a micro electromechanical sensor which is highly

ISSN: 2278 – 1323

sensitive sensor and capable of detecting the tilt. This sensor finds the tilt and makes use of the accelerometer to change the direction of the wheel-chair depending on tilt. For example if the tilt is to the right side then the wheel-chair moves in right direction and if the tilt is to the left side then the wheel moves in left direction. The wheel-chair movement can be controlled in forward, reverse, left and right direction with obstacle detection using ultrasonic sensor. This wheel-chair automatically senses the presence of obstacle in its path and deviate its direction of movement.

The whole device is portable and system operation is entirely driven by wireless technology. The system uses a microcontroller, which is programmed, with the help of embedded c instructions. This microcontroller is capable of communicating with transmitter and receiver modules. The MEMS sensor detect the tilt and provide the information to the microcontroller and the controlled judges the instruction for the movements i.e. right, left, forward and backward. The controller is interfaced with two motors to controls the direction of wheel-chair. Also, the devices are operated wirelessly through MEMS accelerometer sensor. To perform the task the controller is loaded with intelligent program written using embedded _c' language and this program is converted into .hex file using 'keiluvision' complier.

II. BACKGROUND

Several attempts have been made in Wheelchair technology that find its application where a physically challenged person has to navigates from one place to another.

In recent times there have been various control systems developing specialized for people with various disorders and disabilities. The systems that are developed are highly competitive in replacing the old traditional systems. The current electric powered wheelchairs are joystick operated which cannot fulfill the requirements of a fully automatic wheelchair.

There are some system which are voice operated too which needs suitable commands to be loaded earlier and only recognize the voice of user only [8]. Different types of assistive technologies are

1. Head Mounted Assistive Technology
2. Eye Tracking Assistive Technology
3. Neural Interface Based Assistive Technology
4. Voice Controlled Assistive Technology

The above mentioned assistive technologies have limitations like unexpected ambient noise, slow dynamic response, large data processing/collection in case vision and eye tracking technologies.

The aim of our paper is to develop a wheelchair system that's movement is controlled in four direction i.e. forward, backward, left, right using hand gestures which are sensed by MEMS sensor.

III. TECHNOLOGY

In our work we have used MEMS accelerometer based gesture technology. An accelerometer is an electromechanical device that will measure acceleration forces in three directions with respect to earth. These forces may be static or, may be dynamic depends upon acceleration or vibration of the accelerometer. The Accelerometer is a semiconductor IC that measures motion and its intensity in all 3 axes and generates analog signals proportional to acceleration. There are different types of accelerometer available in market for measuring acceleration. Some accelerometers use the piezoelectric effect - having microscopic crystal structures that get stressed by accelerative forces, which cause a voltage to be generated. Another way to do it is by sensing changes in capacitance. The accelerometer we used is ADXL335 which a low cost and low powered sensor which senses the tilt in 3-d. The ADXL335 has a measurement range of ±3 *g* mini-mum. Block diagram of ADXL335 is shown in figure 1.

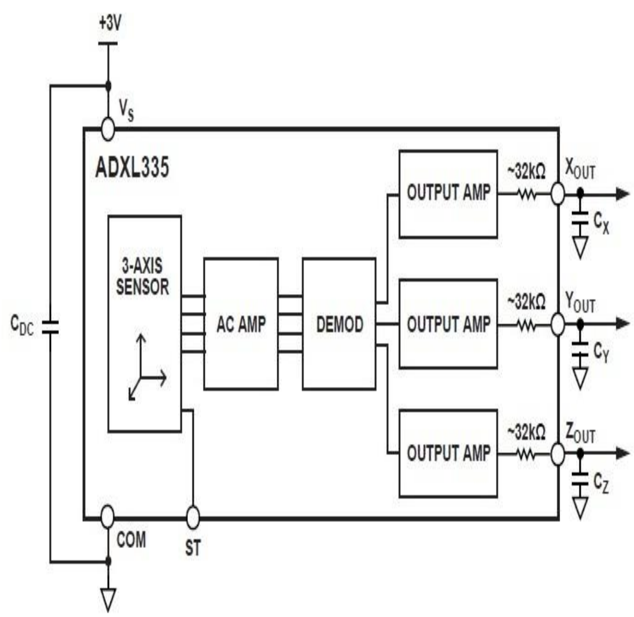

Figure1.1:- Block diagram of ADXL 335

It contains a poly silicon surface-micro machined sensor and signal conditioning circuitry to implement open loop acceleration measurement architecture.

ISSN: 2278 – 1323

The output signals are analog voltages that are proportional to acceleration.

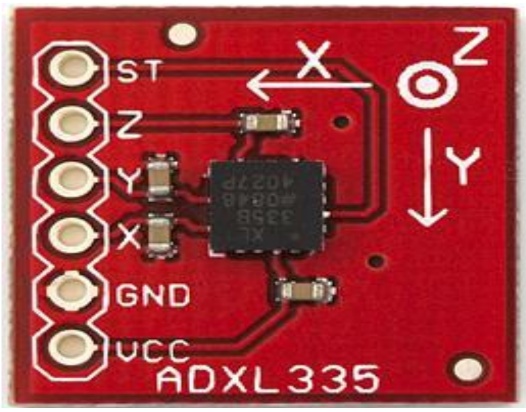

Figure1.2. ADXL 335 Accelerometer

The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

IV. PROPOSED SYSTEM

The proposed recognition system is implemented based on MEMS acceleration sensors. The block diagram of system is shown in the figure-2.

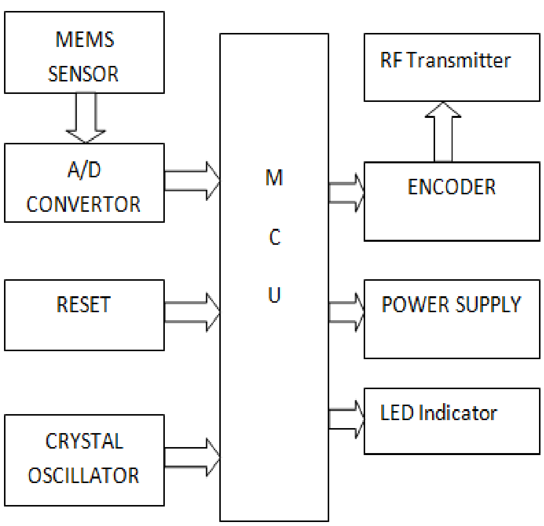

Figure:- 2.1:- Transmitter Block

Since heavy computation burden will be brought if gyroscopes are used for inertial measurement [7], also vision based technologies are suffered with limitation like it constantly requires neck or shoulder movement which is tiring and uncomfortable for the user. Our current system is based on MEMS accelerometers only and gyroscopes and cameras are not used for gesture recognition.The proposed work is implemented in three steps. They are gesture recognition by tilting action of accelerometer, transmitting and receiving of signal by RF module and finally controlling the direction of wheel-chair based on received gesture commands by motors installed on system. The forward, backward movement of motors are controlled by microcontroller.

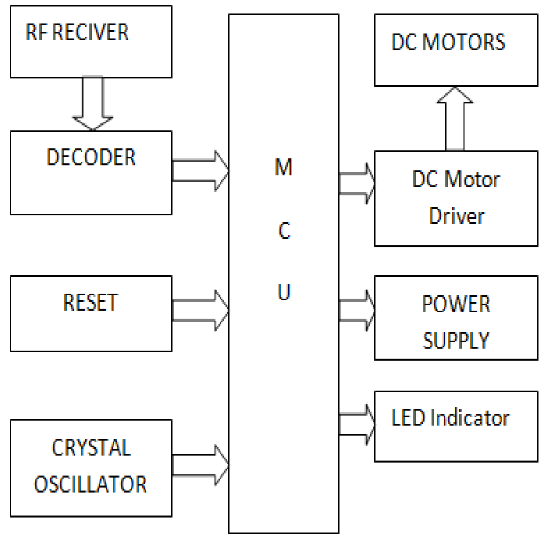

Figure: - 2.2:- Receiver Block

Hand Gesture Module

Hand gesture module is prepared by a sensing device known as MEMS accelerometer that capable of measuring the tilt in 3-D i.e. x, y and z. A relatively low cost accelerometer (ADXL 335) can be used for this[11]. The accelerometer sensor senses the accelerating force (acceleration due to gravity) and thus gives proportional analog voltage for 3-D thus the data is processed by the MCU unit and provides controls to the wheelchair. The basic block diagram of accelerometer is given in figure 3.

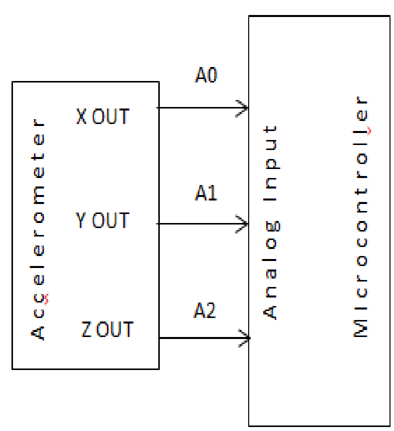

Figure 3:- Accelerometer outputs to microcontroller

ISSN: 2278 – 1323

GESTURE RECOGNITION

A. Data Acquisition and Pre-Processing

To collect reliable hand gesture data for the sensing system, the gesture should be performed as indicated and there should exist time interval between two gestures so that the segmentation program can separate the gesture sequence correctly. Raw data received from the sensors are pre-processed during the data acquisitions stages as follow

1. Slide average filter to filter the frequency noises which introduced by the environment.
2. Hamming Band Pass filter with the band between 10Hz to 40Hz to filter the gravity interference and only reserve the main gesture motion.
3. The sensor data are normalized to unify the different amplitude of gestures.

B. Segmentation

When the pre-processed data stream arrives to the CPU, it passes through a segmentation module which identifies the beginning and the end of the gestures.

C. Vector Quantization

The vector quantization is used to convert the three dimensional sensor data into one dimensional prototype vectors. The collection of the prototype vectors is called a codebook. In our experiments the size of the codebook is selected empirically to be eight. Vector quantization is done by mean of k-means algorithm.

D. HMM Training

In our system the HMM is initialized for every gesture and then optimized by Baum-Welch Algorithm. We utilized an erotic topology for the HMM training [6]. In case of gesture recognition from accelerated signals, both erotic and left to right models have been reported as giving similar results.

V. SYSTEM WORKING

The system working is easily understood by the following steps:-

1. Accelerometer sends gesture data to transmitter controller as analog inputs.
2. Analog inputs are converted and processed based on digital data is out to ht12e for encoding.
3. Then it is being transmitted wirelessly using RF module.
4. RF module sends RF data to wheel main control.
5. Main control gets data and based on that microcontroller at main control process then sends logic to L293D motor driver.
6. So on direction and motion is controlled at receiver end.

VI. RESULT and EXPERIMENTATION

The prototype of gesture control wheel-chair has been shown in the figure. This wheelchair has been tested by tilting MEMStransmitter attached on hand.

Figure 3.1:- Prototype Model

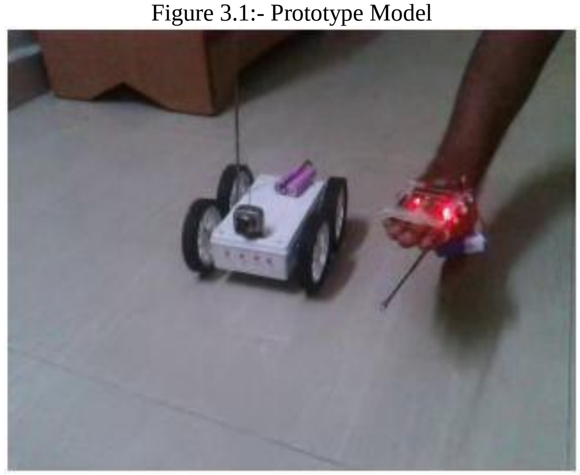

Figure 3.2:- Movement of Wheelchair

The receiver module controls the movement of wheelchair in four direction i.e. forward, backward, left direction and right direction. And if any obstacle present in the path of wheel-chair then the wheel-chair automatically stops.

We obtained following four results from acceleration sensor which we used to drive a motor in four Directions.

ISSN: 2278 – 1323

DIRECTION	No. of Trials	Success	Success Rate
FORWARD	15	14	93.33%
BACKWARD	15	13	86.67%
LEFT	15	13	86.67%
RIGHT	15	14	93.33%
	OVERALL RESULT		**90.00%**

VII. CONCLUSION

In this study, an improved gesture technology based system based on portable and low cost components in a wearable form is proposed and implemented. The results tabulated indicate that the proposed system constitutes a promising user interface to navigate the wheelchair in outside and inside the home without external help.

VIII. ACKNOWLEDGMENT

We are using this opportunity to express our gratitude to anonymous reviewer who provides constructive comments and suggestions that have contributed to the improvement in the quality and presentation of this paper. We express our warm thanks to Ms. Suman Rani H.O.D. Department of Electronics and Communication Engineering, PPIMT Hisar (Haryana) for their generous contribution and continuous support and guidance.

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BIOGRAPHY

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ISSN: 2278 – 1323