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Automatic Wheelchair using Gesture Recognition Along with Room Automation

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Abstract— Patients who have inabilities in movements will get a much better life by using electronic supports for their daily needs. The aim of this work is to implement wheel chair direction control with hand gesture reorganization. This paper proposes an integrated approach to real time detection, tracking and direction recognition of hands, which is intended to be used as a human-robot interaction interface for the intelligent wheelchair. This paper demonstrates that accelerometers can be used to effectively translate finger and hand gestures into computer interpreted signals. For gesture recognition the accelerometer data is calibrated and filtered. The accelerometers can measure the magnitude and direction of gravity in addition to movement induced acceleration. In order to calibrate the accelerometers, we rotate the device's sensitive axis with respect to gravity and use the resultant signal as an absolute measurement. In this project automatic controls are incorporated in a wheelchair. All the electronic gadgets in patient's room can be controlled by certain gestures from the patient. The signals for room automation are communicated through Zigbee modules. Also there is an emergency call alert system in the wheelchair. For that GSM modules are used. For the wheelchair control we use a 3 axis accelerometer, which effectively translate finger and hand gestures into computer interpreted signals. Integrating a single chip wireless solution with a MEMS accelerometer would yield an autonomous device small enough to apply to the fingernails because of their small size and weight.

Index Terms- Gesture recognition, MEMS accelerometer, Microcontroller, Human-robot

I. INTRODUCTION

As computation is getting to play an important role in enhancing the quality of life, more and more research has been directed towards natural human-computer interaction. In a smart environment, people usually hope to use the most natural and convenient ways to express their intentions and interact with the environment. Button pressing, often used in the remote control panel, provides the most traditional means of giving commands to household appliances. Such kind of operation, however, is not natural and sometimes even inconvenient, especially for elders or visually disabled people who are not able to distinguish the buttons on the device. In this regard, gesture-based interaction offers an alternative way in a smart environment. There are many assistive systems using visual aids like Smart Wheelchair systems, using Joystick and much more. There are even systems based on voice recognition too. The basic assisting using voice control is to detect basic commands using joystick or tactile screen. These applications are quite popular among people with limited upper body motility. There are certain drawbacks in these systems. They cannot be used by people of higher disability because they require fine and accurate control which is most of the time not possible.

Micro-electromechanical systems (MEMS) are free scale's enabling technology for acceleration and pressure sensors. MEMS based sensor products provide an interface that can sense, process or control the surrounding environment. MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. MEMS-based sensors are a crucial component in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs. MEMS technology provides the following advantages: cost-efficiency, low power, miniaturization, high performance, and integration. Functionality can be integrated on the same silicon or in the same package, which reduces the component count. Accelerometers can be used to effectively translate finger and hand gestures into computer interpreted signals. Integrating a single chip wireless solution with a MEMS accelerometer would yield an autonomous device small enough to apply to the fingernails because of their small size and weight. Accelerometer, which is a MEMS device is attached to the fingertips or back of the hands. The sensitive direction of the accelerometer is in the plane of the hand. The overall framework of this project is to restore autonomy to severely disabled people by helping them use independently a power wheelchair.

II. BACKGROUND

Early smart wheelchairs were actually mobile robots to which seats were added. Majority of the smart wheelchairs that have been developed to date have been based on heavily modified, commercially available power wheelchairs ; a smaller number of smart wheelchairs have been designed as "add-on" units that can be attached to and removed from the underlying power wheelchair[1]. Even though increased in popularity as power wheelchairs, there are still many disabled, elderly or injured people who cannot buy a power wheelchair. The number one reason why a person cannot buy a power wheelchair is due to financial reasons.

In biomedical sector, a wheelchair is an important device because of the recent shift in the industrial populations. The demand of the physically handicapped and the aged are ever rising. The present wheelchairs do not have integration of technologies for their working. It either requires constant monitoring by the helper or hence lot of effort. In existing systems pc will be used for gesture recognition and processing of voice commands [3]. Hence along with wheelchair a pc has to be equipped which increases complexity of the system. This complexity can be reduced by using voice recognition IC and MEMS accelerometer which is a very small IC placed on the finger tips of the patient. Within the analogue control systems, joystick is the most common drive control [6] and it can be mounted for either right or left hand use. Accordingly, a lot of research has been focused on vision-based interfaces, where control is derived from recognizing the user's gestures by processing images or videos obtained via a camera. With such interfaces, face or head movements are most widely used to convey the user's intentions. When a user wishes to move in a certain direction, it is a natural action to look in that direction, thus movement is initiated based on nodding the head, while turning is generated by the head direction. However, such systems have a major drawback, as they are unable to discriminate between intentional behavior and unintentional behavior. For example, it is natural for a user to look at an obstacle as it gets close, however, the system will turn and go towards that obstacle [5].

III. PROPOSED SYSTEM

Implementation of this proposed problem mainly involves three steps. They are gesture recognition, room automation and controlling direction of wheelchair using microcontroller based on the recieved gesture commands. The motors used for controlling the wheelchair will be driven by controller. The system comprises of two main parts: Transmitter part and receiver part. In transmitter part the hand gesture is recognised by the sensor, digital output is transmitted to the controller. Corresponding signal for room automation is transmitted through Zigbee modules. The same data is received at receiver side by the Zigbee receiver. DC Motors which are interfaced to the controller by the motor driver controls the direction of the wheelchair.

A. Transmitter Module

From the Fig. 1 accelerometer send the information about the tilt of the accelerometer sensor. This information is in the form of analog and the information of the tilt is in the form of x, y, z. The x, y, z axis information indicates the position of the pointer. The data from the accelerometer is given to the ADC controller. The ADC controller can convert the analog information to the digital information for the micro controller to understand [1]. The micro controller can take the information from the ADC controller and spit the data in three forms. The micro controller can sends the position of the pointer with the basic information from the accelerometer. In this proposed model the accelerometer data can either be used to control the direction of wheelchair or for room automation. Zigbee modules are used for the latter. GSM module is provided for mobile communication during emergency situation.

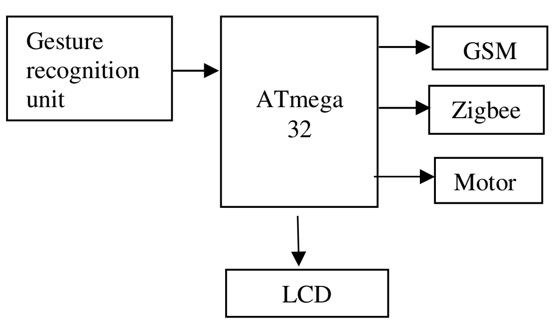

Figure1: Block diagram for transmitter section

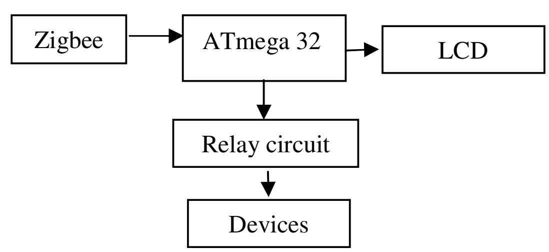

Figure 2: Block diagram for receiver section

B. Receiver Module

The receiver is having the RF receiver to receive the signal from the transmitter. The signal from Zigbee receiver is given to the microcontroller. According to the signal received each device in the room is controlled using relay circuit.LCD module is used to display the status of each device.

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IV. GESTURE RECOGNITION

Based on the movement of hand, direction of motor is to be controlled. For recognising hand movement, MEMS accelerometer is used.Accelerometer is interfaced to the controller through analog to digital conversion pins as shown in figure 3[1].

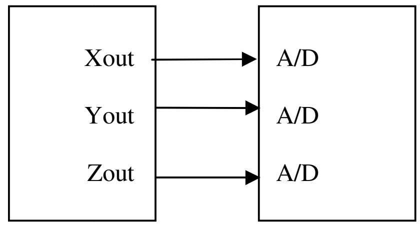

Figure 3: Accelerometer interfacing to controller

A. *Accelerators*

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

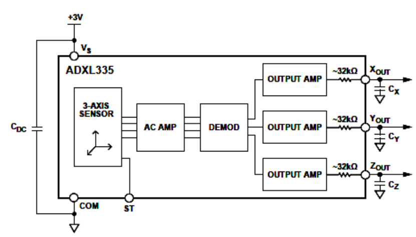

Figure 4: Functional block diagram of ADXL 335

B. *Tilt Sensing*

The acceleration sensor can be modelled as a movable beam that moves The sensor is a polysilicon surface-micro machined structure built on top of a silicon wafer (Fig.4). Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration. The demodulator output is amplified and brought off-chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing.

Two capacitance are formed; one between the movable beam and the first stationary beam and the second between the movable beam and the second stationary beam. Accelerometer uses switched capacitor techniques to measure the g-cell capacitance and extract the acceleration data from the difference between the two capacitors. As the beams attached to the central mass move, the distance from them to the fixed beams on one side will increase by the same amount that the distance to the fixed beams on the other side decreases. The change in distance is a measure of acceleration. The g-cell beams form two back-to-back capacitors (Fig. 5). As the centre beam moves with acceleration, the distance between the beams changes and each capacitance value will change, ($C = A\varepsilon/D$). Where A is the area of the beam, ε is the dielectric constant, and D is the distance between the beams. This concludes that displacement is directly proportional to capacitive distance. Capacitance difference is in the form of analog voltages. When the sensing system is switched on, the accelerations in three perpendicular directions are detected by the MEMS sensors and transmitted to the controller. The gesture motion data then go through a segmentation program which automatically identifies the start and end of each gesture so that only the data between these terminal points will be processed to extract feature.

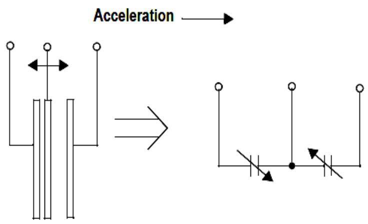

Figure 5: Simplified transducer physical model

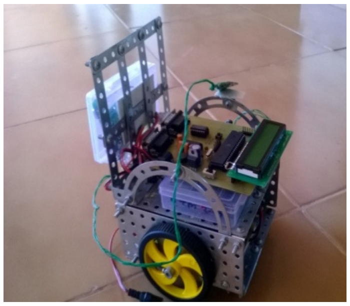

Figure 6: Hardware setup

V. RESULTS

We obtained four combinations from acceleration sensor which we used to drive the motor in four directions.

TABLE-1: MOTOR CONTROL

DIRECTION	MOTOR 1	MOTOR2
FORWARD	FORWARD	FORWARD
BACKWARD	BACKWARD	BACKWARD
LEFT	BACKWARD	FORWARD
RIGHT	FORWARD	BACKWARD

VI. CONCLUSION

In the race of man versus machine, hand gesture controlled system comes as an example of companionship of man and machine. Recent development promises a wide scope in developing smart wheelchair. Taking the technology to the next level from speech recognition and wired connections is the technology of wireless hand gesture controlled system. This system gives the user independence and a psychological advantage of being independent. Future work involves implementing the proposed gesture recognition system on a smart phone or any other personal device with a built-in accelerometer. This wheelchair can be extended using GPS technology so that position of wheelchair can be tracked.

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