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A NOVEL LOW COST GESTURE BASED UNIVERSAL POWER CONTROLLED WHEELCHAIR

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Abstract: This paper describes the design and evaluates an accelerometer based gesture recognition system for driving a power wheelchair. A hand gesture based interface, is designed for hand gesture recognition of the wheelchair user. The gesture recognition circuit mainly consists of accelerometer which will generate direction identifying commands to the microcontroller unit which controls the motion of the wheelchair with the help of motors and chain drive mechanism according to the user's wish. It is intended to be used as a human-friendly interface for disabled people. It is the first prototype developed that can be used for any physically handicapped individual suffering from any disability, accident or disease condition (except vision) without any additional modification in its design. Thereby making it a "Universal Power Wheelchair" used for any disability condition. Another key criteria taken into account is its cost & affordability, which rounds up to just 180 USD which is almost even one seventh as compared to the starting range price of the basic base model Power Wheelchair. Over and above its embedded control system along with its motors, can be fitted easily on any conventional Manual Wheelchair. Hence increasing its flexibility tremendously and further reducing its cost. This is an extremely useful & novel system for users with any disability condition, making it a universal power wheelchair & most importantly affordable to all.

Keywords: Wheelchair; Microcontroller; Physically disabled; Control; Accelerometer, Gesture recognition

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INTRODUCTION

It is believed that man's earliest inventions were chair on the wheel way back in 4000 B.C. The first record of wheeled furniture was an inscription found on a stone state in china and a Childs bed depicted in frieze on a Greek vase, both dating back to the 6th century B.C.E. Chinese used their invented wheelbarrow to move people as well as heavy objects. In an around 1553, evidences are found that Greek and Roman physicians a transportation for the sick or disabled. To get people out in fresh air, and help work with whatever they could do in this field. In Latin-America the physically disabled are estimated in 55 million people, which represent the 9% of its total population [1]. Today due to advancement in medical services and demand of independence of disabled people light weight, versatile and manual as well as power wheelchair are being designed.

- **Research Goal**

There are in excess of 380 different causes that may require a wheelchair to become necessary. Stroke, transient ischemic attack , head injury ,subarachnoid hemorrhage, hysteria, arterial blockage, spinal cord injury are some of the causes. Children without safe and independent strolling cannot learn and develop new skills which makes them introvert and may develop negative thoughts. Adults who are dependent on other people for mobility are less self -sufficient which may lead to depression. The solution for this can be a power wheelchair, while standard wheelchairs are mainly used by those who have the necessary upper-body strength to propel and maneuver it, electric power wheelchairs (EPWs) are destined for those who cannot [2]. But some people suffering with specific disabilities like Parkinson, spasticity , tremors or cognitive deficits cannot use simple power wheelchair with joystick control.

Hence, these accidents or diseases force scientists & researchers to develop Smart Power Wheelchairs that are more "Universal" in nature i.e. they can be used for any disability, accident or disease condition without any additional modification in its design. The goal of the project is to make a "Universal Power Wheelchair" used for any disability condition by using MEMS accelerometer sensor. We are using ADXL335 MEMS accelerometer which is highly sensitive sensor with extremely low noise and power consumption is low. It's capable of detecting the tilt and depending on tilt the wheelchair will moves. The main objective or goal of the project is to:

- *To design a Universal Power Wheelchair*

This is achieved by using a microcontroller based system, using ADXL335 MEMS accelerometer sensing just tilt. Thereby, any physically disabled person can use this system by moving either his hand, leg, head, or any body part without any type of physical contact with the control system. Thereby requiring no additional force & accuracy in the switching operations by the user, while using the wheelchair.

- *To modify manual wheelchair into electric wheelchair*

This is done by fixing dc motors to the simple wheelchair with the help of chain drive mechanism along with the embedded system control. Thereby making the system flexible and hence can be mounted on any manual wheelchair.

- *To be portable, comfortable and less expensive for wheelchair users.*

Thereby making the system cost effective & economically viable to the poorer sections of society, which forms the major intention behind the development of this project. Provided along with the portability & comforts of a manual wheelchair.

- **Block Diagram and Flowchart**

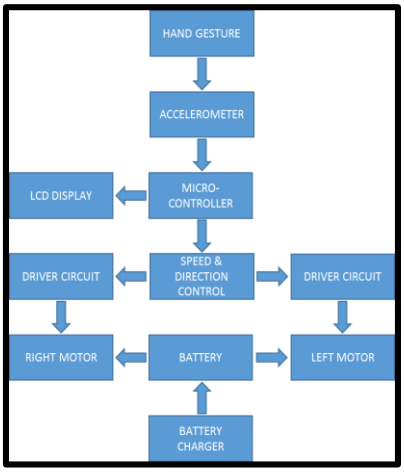

Figure 1. Block Diagram

Figure 1, shows the block diagram of the project. This diagram gives the idea of the project flow. Input in the form of hand gestures is given to the accelerometer in the form of tilt angles. Accelerometer produces output in the form of voltage which is analog in nature. Accelerometer's output is given to the microcontroller unit. Microcontroller's inbuilt ADC

converts the analog output in to digital form. According to this digital output motors are driven in particular direction. That direction is simultaneously displayed on the LCD display. There are 12V batteries to power the motors. Also there is a battery charger to charge the batteries.

Power to the microcontroller is provided by two 12v, 32Ah batteries. Accelerometer interfaced with microcontroller draws 5v power from it for user's navigation. 3 axis accelerometer sensor is used for movement of wheelchair in the desired direction intended by the user.

- **Hardware**

The accelerometer based hand gesture recognition circuit consists of accelerometer sensor, speed and control, software for user interface. Accelerometer can measure acceleration in two dimensional or 3 dimensional spaces known as 2D and 3D accelerometer respectively. Usually accelerometer has certain range measured in gravity of earth and is equal to 9.80665m/s .Generally accelerometer has range of 1.5g to 6g.

Accelerometer always measures acceleration relative to earth's gravity that is if it is not at all terms of 'g'. Where g is the acceleration due to accelerating, like being placed on the table or held in hand, it will show acceleration along the direction of earth's gravitational field, and when it is free falls (that means actually accelerating due to g) it will show zero acceleration. This concept is used to sense tilt of device.

- *Operation of 3 axis accelerometer*

Inside the accelerometer sensor minute structures are present that produces electrical charges if the sensor experiences any movement. The output of any axis of accelerometer is an analog voltage proportional to the acceleration in that axis. As the acceleration can be positive, negative or zero.so the output has zero bias point which means the output is held at this point for zero acceleration. Negative acceleration will result in voltage less than the zero g point . Normally this zero bias point is half of supply voltage.

- *Case 1:*

The acceleration due to gravity is in the direction of X axis so the output is positive hence voltage greater than 1.65V.

- *Case 2:*

The device is inverted, now the acceleration due to gravity is opposite to the X axis hence a negative acceleration or a Value which is less than 1.65v.

- *Case 3:*

If the device is made to lie flat so that X axis is perpendicular to earth's gravitational field then the output will be close to 1.65v.

Similarly, done for Y & Z axis of accelerometer as well. The ADXl335 is a triple axis accelerometer with extremely low noise and power consumption-only 320µA.The sensor has a full sensing range of ±3g.There is no on-board regulation, provided power should be between 1.8 and 3.6V DC. This accelerometer is used to sense human gestures for mobility of wheelchair. It has 3 axis X, Y and Z for three dimensional (3D) Motion control, out of which only the X & Y axis are required for the motion control of the wheelchair in any particular direction. The Z-axis can be used for any future extension or modification to the existing system.

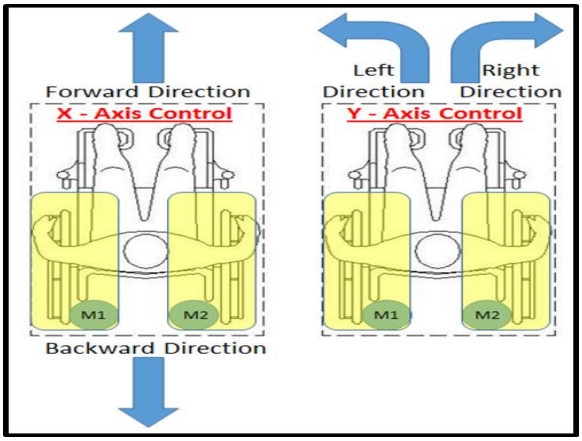

Figure 2. X-Axis and Y-Axis Control of accelerometer

As shown in Figure 2, the wheelchair has two wheels on its left & right, wherein two independent motors M1 and M2 are used for driving the wheels respectively. Now, the X-axis basically controls the wheelchair movement by rotating both the motors M1 & M2 in the clockwise or anticlockwise direction, to get the wheelchair move in forward direction or backward direction respectively. Y-axis on the other hand controls the wheelchair movement by rotating only one motor & stopping the other motor & vice-versa, to give a left & right control. In other words, if the user wants to move the wheelchair to the left, then only motor M2 gets activated and the wheelchair shifts left. Whereas if the user wants to move the wheelchair to the right, then only motor M1 gets activated and the wheelchair shifts right.

The sensor detects the gestures given by the user through either hand, head, leg or any body part (without any physical contact with the control system). Hence the input device is not

limited only to the hand but can be mounted on any body part of the user making it a universal system for any disability issue.

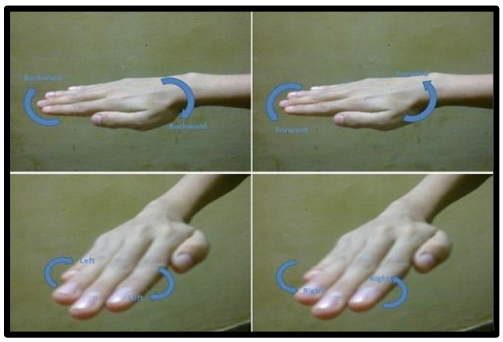

Figure 3. Accelerometer mounted on hand

Hence for explanation purpose the input device is mounted on hand and hand is moved in a particular direction as shown in Figure 6. ATmega16 controller is used to process these gestures i.e. it reads the analog output values(X, and Y axis values of the accelerometer) of the ADXL 335 accelerometer sensor and converts the analog value to digital values with its analog to digital converter. The digital values obtained by the above method are processed by the ATmega16 microcontroller and according to the tilt of the accelerometer sensor mounted on hand, the wheelchair is driven in the forward, reverse, left, right direction and stops it. The above same input device can be mounted on any movable body part of the user.

- *Chain drive*

A chain drive transmits rotary motion over a distance using a chain and two gear wheels. A chain is made up of series of links with the links held together with steel pins. This arrangement makes the chain a strong and long lasting way of transmitting rotary motion from one gear wheel to another.

- *DC motor*

Motors are the most essential part of the power wheelchair as they provide motion to the system. The operation of motor is based on simple electromagnetism. The current carrying conductor generates magnetic field; when this is placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field.

The DC motor of 17W 26RPM, gear assembly and two free wheels. These components are used to convert manual wheelchair into electric wheelchair.

- *Speed and Direction Control of Motor*

Gears used are two free wheels which initially do not rotate in any direction. A chain in adjusted on these two gear wheels which helps the chair to move forward as well as in reverse direction.

Figure 4. Motor & Gear Arrangement

Figure 9, shows mechanical module of the wheelchair. A chain drive adjusted on two free wheels along with motors and a 12v 36Ah lead acid battery.

- **RESULTS & DISCUSSION**

The future of Gesture Based Universal Power Controlled Wheelchair looks really bright indeed due to its Flexibility & diversity in being used for any disability condition. The Following tasks were carried out during the study, analysis & evaluation of Gesture Based Universal Power Controlled Wheelchair:

A. The Gesture Based Universal Power Controlled Wheelchair Prototype was designed & constructed as shown in Figure 10. This prototype project was carried out successfully, gives a smooth, steady, precise & effective while moving.

B. This system provides a universal solution to all the disability issues, thereby not changing or interfering with the design concept of the wheelchair for different disability issues. Thereby making it a Universal Power Wheelchair for any disability issue (except vision).

C. Another added advantage to this system is that its embedded control system along with its motors, can be fitted easily on any conventional Manual Wheelchair. Hence increasing its flexibility tremendously and further reducing its overall cost.

D. Low Cost is an added asset

In any project design the key criteria taken into account is its cost & affordability, which plays a major role. Here the Gesture Based Universal Power Controlled Wheelchair Prototype developed costs just 180 USD. As compared to the minimum price range of the base model Power Wheelchair with only joystick control, priced in the market at 1181 USD. Thereby making our proposed system 84.75% cheaper & economically more viable.

Another, added advantage is that its embedded system can be connected to any conventional wheelchair, making the system flexible as we discussed earlier, but in the process reducing its cost even further. As the embedded system including the motor & gear system costs only 79 USD & the conventional manual wheelchair used costs only 101 USD, amounting to 180USD. Thereby, making the end user pay just 79 USD to make his old manual wheelchair, a gesture based Universal Power wheelchair.

The intent & motivation behind this research is to reach out to the poorer sections of society that cannot afford highly sophisticated wheelchairs suited for their particular disability, although their condition demands it. Hence the alternative need of development to suite cost & justify all types of disabilities with a single universal wheelchair holds the key to development of Power Wheelchairs.

- **CONCLUSION AND FUTURE WORK**

This paper describes the actual prototype designed and implemented by us, on the accelerometer based hand gesture control wheelchair. According to the tilt angle provided by the user, the wheelchair moves in particular direction. Speed is controlled by chain drives and gears. Motors rotates the wheels in the direction specified by the accelerometer.

Our future research will be focused on more modifications like interfacing voice recognition circuit with microcontroller will yield a voice controlled wheelchair along with hand gestures. Also, sensors like ultrasonic sensor and infrared sensor can be used to give the wheelchair more characteristics and modified look as per the user's requirement.

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