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Head Movement Controlled Wheel Chair Using MEMS Sensors

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Abstract - *The limitations with traditional wheel chairs mainly include exibility, weight and limited functions. Many developments have been made in the field of wheel chair technology, but these could not aid the quadriplegics to navigate independently. Automatic wheel chair using MEMS technology enabled the head and neck mobility of quadriplegics in a cost effective manner. The position of user's head is converted into speed and direction by the control system. MEMS sensor and PIC controller are the main parts of the system. The change in direction of head is sensed by the MEMS sensor and corresponding signal is given to microcontroller. The microcontroller controls the wheel chair directions with the help of DC motors.*

Key Words: DC Motor, MEMS Sensor, Quadriplegics.

1. INTRODUCTION

The number of people moving around the world with the help of artificial means due to illness or accident is increasing at an alarming rate. Their quality of life has to be enhanced by using sophisticated and cost effective locomotive devices. Today's technology has shifted to automation minimizing the need of human intervention. These automated systems have less manual operations with high reliability and accuracy. Intelligent wheel chairs are very much helpful for severely impaired people who have difficulties in driving standard powered wheel chairs. Persons with high degree of impairment such as quadriplegics are not able to drive electric wheel chairs. Medical devices designed to help such persons are very much complicated and expensive. So, a microcontroller based system that enables wheel chair movement by head motion is introduced. The system describes a wheel chair for physically disabled people which use head motion and MEMS sensor interfaced with DC motor. MEMS sensor is a micro electronic mechanical sensor which effectively translated head movements into computer interpreted signals. The accelerometer data is calibrated for motion recognition.

1.1 Basic Block Diagram of Proposed System

The proposed system has major components like PIC microcontroller 16F877A, MEMS sensors, two DC motors, relay motor driver circuit, crystal oscillator, LCD display and power supply as shown in Fig-1. The MEMS sensors sense the tilt angles produced by the patients and in accordance to that the programmed microcontroller produces PWM signals. The PWM signals drive the two DC motors and moves the wheel chair with the help of relay circuit. Embedded C is used for programming the microcontroller. The controller is interfaced with DC motors through relay circuits. It is capable of communicating with both input and output modules.

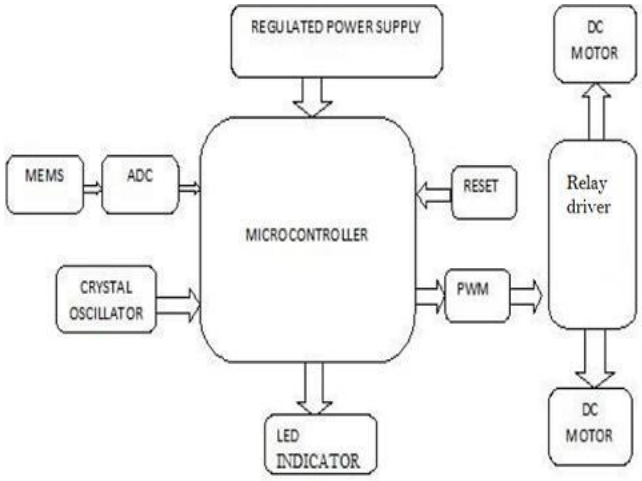

Fig 1: Block Diagram

2. EXSISTING SYSTEMS

The existing systems include hand gesture based, accelerometer and voice controlled systems etc. The hand gesture based system used the transfer of hand gesture information commands to move the wheel chair. The accelerometer and voice controlled system used voice recognition kit and MEMS motion sensor to drive the wheel chair. The issues with the existing system are:

1) Unable to adapt to external conditions.
2) Less identification accuracy.
3) Classification techniques employed are complex.
4) Time consuming and costly.

3. PROPOSED SYSTEM

This system operated with taking head movement as input signal to control the motion of wheel chair in any direction. A MEMS sensor or accelerometer is used to track the movements. A cap is placed on the head and the sensor is connected to it. The variations produced by the sensor according to head movement are trapped and fed as input to the microcontroller. The microcontroller takes decision based on the inputs provided and controls the wheel chair. The decisions made by microcontroller are:

1) If the head tilts in forward direction, the wheel chair moves in forward direction.
2) If the head tilts in backward direction, the wheel chair moves in backward direction.
3) If the head tilts left, the wheel chair moves left.
4) If the head tilts right, the wheel chair moves right.

3.1 MEMS Sensors

Tiny integrated devices or systems that combine mechanical and electrical components are created using MEMS technology. They have ability to sense, control and actuate on micro scale and generate the effects in macro scale. It is one of the most promising technologies of 21st century. It consists of mechanical micro structures, micro sensors, micro actuators integrated on to the same silicon chip. Changes in the system's environment are detected by the micro sensor and corresponding electrical signal is produced. Micro actuators react to this signal. In the proposed system, MEMS sensors measure the tilt angles produced by the patients. It is a three direction accelerometer having X, Y and Z directions. The voltage is in the range of 1.3V to 1.9V.

Fig 2: MEMS Sensor

Due to its small size, MEMS devices are applicable in area where large measurements are needed. With the help of micro electronics, different devices can be integrated into a single chip. Thus, data reception, storing, interfacing, etc can be carried out with a single chip.

3.2 Control Unit

PIC16F877A is the control unit of the system. The input to the control unit is provided by the sensor section. PIC has separate program and data memories. The latest model PIC has 32-bit wide data memory.

Fig 3: PIC 16F877A

PIC 16F877A devices are available in 40 pin packages. They have five input output ports and fifteen interrupts. The 20MHz operating frequency device has eight A/D input channels. Parallel slave port implementation is one of the salient features of the device. The device has 10-bit analog to digital module and 35 instruction sets.

3.3 DC Motor

It is a device that converts direct current into mechanical energy. It contains a current carrying armature which is connected to the supply. Fleming's left hand rule is used to determine direction of force acting on the armature. The rule states that if index finger, middle finger and thumb of left hand are extended in such a way that if current carrying conductor is placed in magnetic field (index finger) perpendicular to the direction of current (middle finger), then the conductor experiences a force in mutually perpendicular direction (thumb). DC motors have electro mechanical mechanism to change the direction of current flow. The speed can be controlled either by using variable supply voltage or changing the strength of current in field windings.

Fig 4: DC Motor

3.4 Working of the System

The system consists of MEMS sensor, microcontroller, DC motors and relay. The paralyzed person will be placed on the wheel chair and sensor is placed on cap on the head. The tilt angles produced by the patients are sensed by the sensor and produces corresponding voltage. This output voltage of the sensor is fed into the microcontroller. The source code for the microcontroller is written in embedded C using Proteus. Based on the source code the microcontroller drives the DC motors. Relay section helps to drive the DC motors simultaneously. According to the tilt angles the motor rotates in forward, backward, left and right directions. The direction of movement of wheel chair is displayed by the LCD interfaced with the microcontroller. This system increases mobility and physical support. It reduces human activity and physical strain.

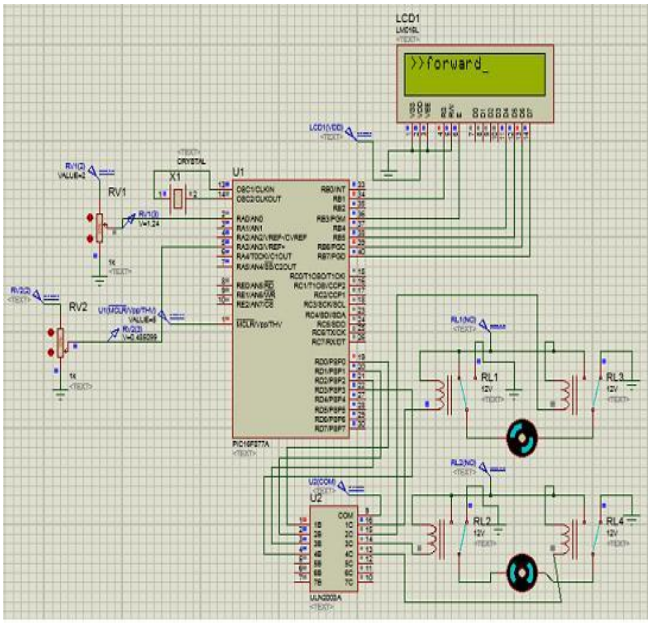

Fig 5: Layout of the System

4. SIMULATION

Embedded systems combine hardware and software to perform special and predefined tasks. The source code for the microcontroller is written in embedded C and simulated using Proteus 8. HEX codes will be generated after compiling microcontroller program. These codes are then burned into the memory of the microcontroller to perform the logic.

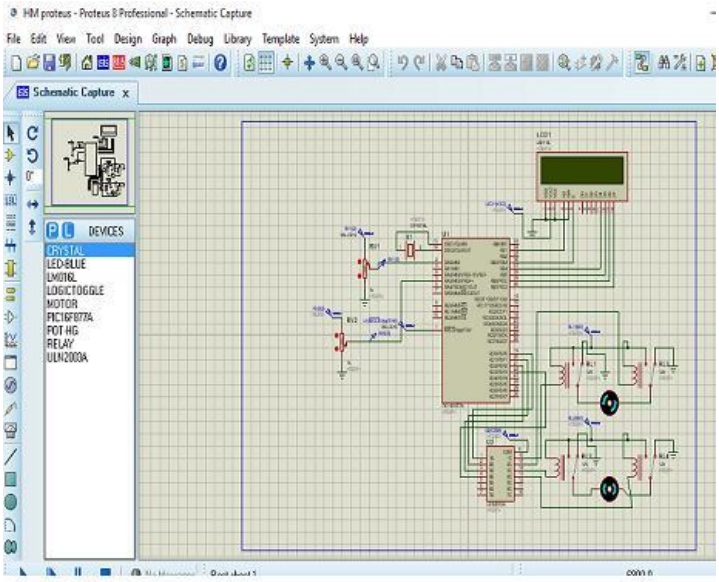

Fig 6: Simulation in Proteus

5. RESULT

The proposed system is intended to create a cost effective wheel chair to help quadriplegic people who find it difficult to move independently. The system uses head movement to control the wheel chair. The tilt angles produced are sensed and corresponding voltages are generated by the MEMS sensor. These voltages are fed into microcontroller which in turn controls the direction of wheel chair.

Table – 1: Output of the System

Direction	Axis	Voltages
Forward	X	Less than 1.5V
Backward	X	Greater than 1.7V
Left	Y	Less than 1.5V
Right	Y	Greater than 1.7V

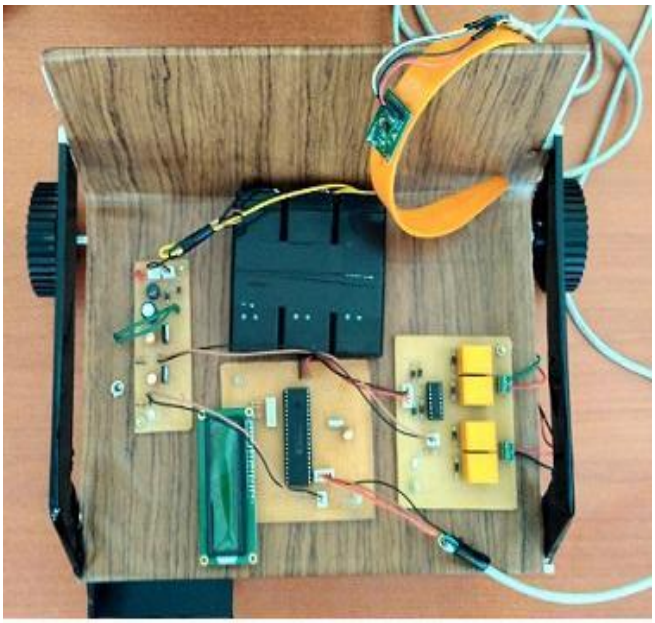

Fig 7: Wheel Chair Prototype

6. CONCLUSIONS

The head motion controlled wheel chair system is implemented as an example of companionship of human and machine. Independent movement is achieved with the help of the system. Errors appearing when the user makes free head motions can be reduced to a certain extent using an enable switch. It is designed to be characterized by low price and higher reliability.

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