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Research Article

Implementation of Head Orientation Intelligent Controller for Wheelchair using MEMS Sensor

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Abstract

The people who have lost the ability to control upper and lower limbs due to quadriplegia, amputated arms, paralysis or ageing side effects. The user requires special control systems to use an electrical wheelchair instead of using traditional control by joystick. This paper presents a novel implementation of head orientation intelligent controller for wheelchair with integrated sensors and the sensors measures the bio-signals of a person and sends the status to the doctor if abnormalities occur. The system uses accelerometer MEMS sensor, obstacle detection IR sensor, heart beat sensor, temperature sensor, GSM and eye blink sensor. The wheelchair movement direction and speed depend on the position of the user's head related to X, Y and Z axis. The MEMS sensor detects the position of head movement and control signal pass to the microcontroller. The system uses powerful PIC16F877A microcontroller to perform the control application and use embedded C for programming. This wheelchair uses an interactive system which overcomes the difficulties of existing system.

Keywords: Electrical wheelchair; MEMS sensor; Obstacle detection; Microcontroller.

Introduction

Many researchers work in the field of rehabilitation engineering to help quadriplegia, hand amputees, elderly and paralyzed patients. The patient cannot use traditional electrical wheelchairs with joystick control. One of the important goals of intelligent systems is to allow the user to do his daily movement and activities without the need of others help. Voice control is an important solution to control the wheelchair which is performed by using the Voice Recognition (VR) technology. The VR technology converts the sound wave to an electrical signal [1,2]. The electrical signal is further digitized and used as a control signal, which can be understood by computers and microcontrollers. The voice recognition technology cannot give excellent performance in high noise and in outdoor application [3-5].

The head movement can be used as a controller for the wheelchair using different procedures. Infrared and ultrasound sensors were used to detect the head movement and used as controller [6-8]. Other researchers used cameras to detect the head gesture as a wheelchair controller [9-11]. There are many drawbacks and limitations in the previous methods. In this paper, head orientation intelligent controller, bio-signal measurement, obstacle detection IR sensor and GSM are implemented in the wheelchair proposed [10]. The system uses the head movement and orientation as a controller for intelligent application. The user's head tilts around the X and Y axis is interpreted to a wheelchair movement in the forward, backward, left and right directions [12]. The intelligent wheelchair is loaded with several units such as microcontroller, relay and driver circuit which synchronously work with the help of a PIC16F877A microcontroller [13-15]. It includes some more features like obstacle detection for safety purpose and to measure the Bio-signals such as temperature and heart beat by the sensors and eye blink sensor for drowsiness.

System construction

The proposed system is a part of a multi-input control system that uses different available body signals to control any intelligent rehabilitation application. The system design takes into consideration that it can be used easily and comfortably by quadriplegia and elderly patients. It also includes a MEMS sensor, which gives the user the option to abort the head tilts controller when necessary. Fig. 1 shows the block diagram of the system. It includes the core microcontroller

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and the main units and sensors. The block and structure of the system will be explained in detail in the next section.

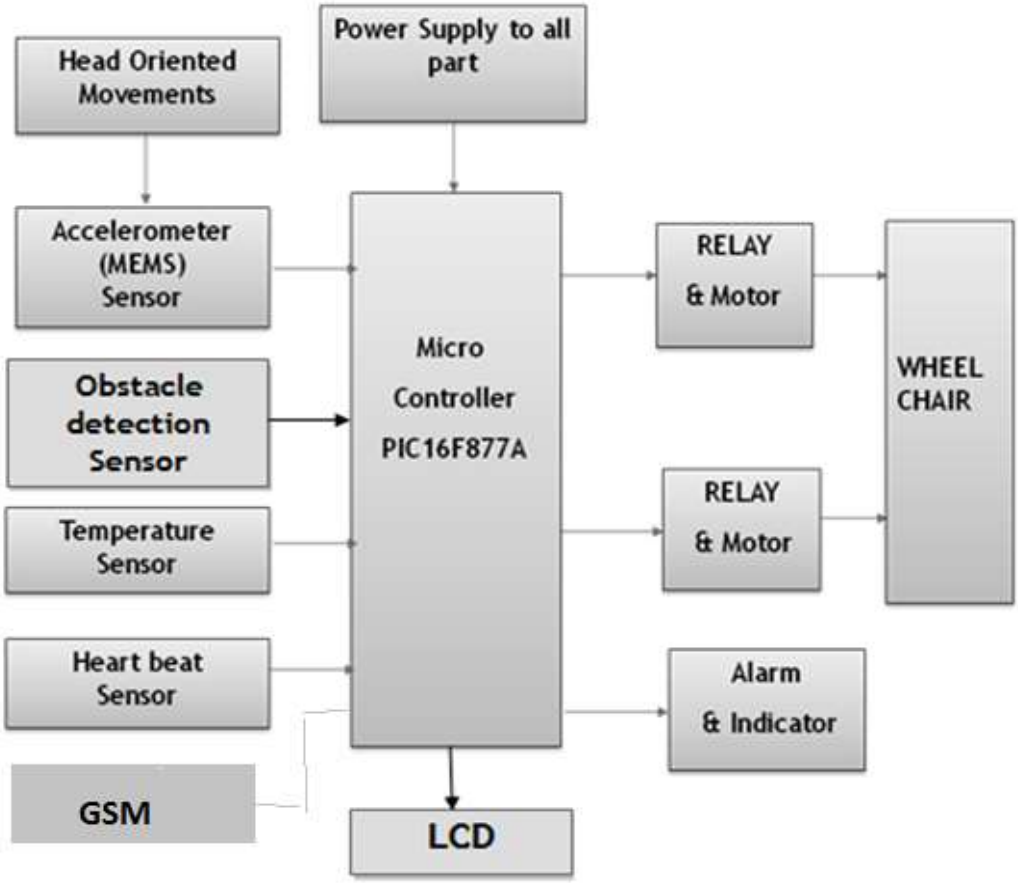

Fig. 1 Block diagram of proposed system

Microcontroller Unit

PIC microcontroller is the RISC based microcontroller fabricated in CMOS that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The proposed system uses the PIC 16F877A. The microcontroller programmed to control the intelligent wheelchair. It receives the signal from the various sensors and acts depend on signal received .

Acceleration (MEMS) Sensor

Accelerometer sensor can measure static or dynamic acceleration in all three axes. This sensor has its application on various fields. This sensor measures level of acceleration where it is mounted and enable us to measure acceleration of object like car or robot, or tilt of a platform with respected to earth axis, or vibration produced by machines. Sensor provides 0G output which detect linear free fall. This sensor is mounted on the head. Depends upon the head movements the wheelchair can move any one of the direction right, left, forward and backward.

Obstacle Detection Sensor

Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other. The transmitted signal is given to IR transmitter whenever the signal is high, the IR transmitter LED is conducting it passes the IR rays to the receiver. The IR receiver is connected with comparator. The comparator is constructed with LM 741 operational amplifier. In the comparator circuit the reference voltage is given to inverting input terminal. The non-inverting input terminal is connected IR receiver. When the IR rays interrupted between the IR transmitter and receiver, the IR receiver is not conducting. This ensures the present of any obstacle in front of the wheelchair. If it is present

the IR receiver do not receive the signal the microcontroller stops the wheelchair.

Heart Beat Sensor

Heart Beat sensor is designed to give digital output of heart beat when a finger is placed on it. It is connected directly to the microcontroller. The Beats per Minute (BPM) is measured and displayed on the PIC16F877A microcontroller. If any abnormalities occur the microcontroller sends the signal to the alarm as well as the SMS alert to the doctor.

Temperature Sensor

The LM35 is an integrated temperature sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). This sensor placed on seats of the wheelchair to measure the temperature continuously. If the temperature exceeds the preset value the alarm circuit is operated and sends SMS alert to the doctor.

Relay and its Driver Circuit

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. It drives the Motor of the intelligent wheelchair.

Motor

DC Motor is high quality low cost DC geared motor. It has steel gears and pinions to ensure longer life and better wear and tear properties. The gears are fixed on hardened steel spindles polished to a mirror finish. The output shaft rotates in a plastic bushing. The whole assembly is covered with a plastic ring. Gearbox is sealed and lubricated with lithium grease and require no maintenance.

Global System for Mobile communications

Global System for Mobile communications (GSM) is the technology that underpins most of the world's mobile phone networks. The GSM platform is a hugely successful wireless technology and an unprecedented story of global achievement and cooperation. GSM module which has SIM card slot to place the SIM and send SMS to the doctor if the temperature and heart beat exceed the preset values.

Eye Blink Sensor

This Eye Blink sensor is IR based. The Variation Across the eye will vary as per eye blink. If the eye is closed means the output is high otherwise output is low. This is to know the eyes closing or opening position. This output is given to logic circuit and sends signal to the alarm. This can be used to control accident due to unconscious through Eye blink.

System Operation

The amputated arms, or paralyses patients requires special control systems to use an electrical wheelchair instead of using traditional control by joystick or human help. The patient wears the accelerometer sensor in the head, depends on the head movement the intelligent wheelchair moves. Suppose the patient is drowsy or sleeping the eye blink sensor sends the signal to the microcontroller and it stops the movement of wheelchair. If the temperature or heart beat exceed the preset values then the GSM module will send the SMS to the doctor. All the operations are monitored and controlled by PIC microcontroller.

Conclusions

The proposed system based on PIC microcontroller is found to be more compact, user friendly and less complex, which can readily be used in order to perform several tedious and repetitive tasks. “Head orientation intelligent controller for wheelchair” is fully software controlled with less hardware circuit. Paralyzed persons depend on others for their day to day activities. In order to overcome their difficulties and improve the quality of their life we developed head orientation intelligent controller for wheelchair using MEMS sensor with reduced complexity.

Conflict of interest

Authors declare there are no conflicts of interest.

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