

# SENSOR BASED AUTONOMOUS WHEELCHAIR

**S.SHAHEEN<sup>#1</sup>**

Dept of EEE  
V.S.B.Engineering College  
Karur, Tamil Nadu, India  
[shaheenece@gmail.com](mailto:shaheenece@gmail.com)

**R.YOKEESWARAN<sup>#2</sup>**

Dept of EEE  
V.S.B.Engineering College  
Karur, Tamil Nadu, India  
[gyokee@gmail.com](mailto:gyokee@gmail.com)

**J.KAMALINE ISABELLA<sup>#3</sup>**

Dept of EEE  
V.S.B.Engineering College  
Karur, Tamil Nadu, India  
[ranu\\_es@yahoo.co.in](mailto:ranu_es@yahoo.co.in)

**Abstract:** In the fast emerging world, people leading their life in faster way. But it is highly difficult for the People With Disabilities (PWD), stroke affected people, paralysis affected people. They suffer a lot to move from one place to another and hence the wheelchair was introduced. In hospital environment the wheelchair based disable people need a helper. The embedded device acts as a boon for wheelchair users in hospitals. The places are assigned in button and based on the people with disabilities requirement the wheelchair moves to the assigned place with the help of Brushless DC Motor (BLDC). The PIC Microcontroller operates the overall design. The Li - battery package is implemented in wheelchair to give power. Based on IR sensor the path is identified by the wheelchair. Also a pulse detection sensor is placed in the disable body and if they suffer from any health problem an automatic call to the doctor and nurse takes place. With the help of GSM modem the operation happens and hence the doctor can give immediate treatment to the patient. Also an Electro larynx is placed in the patient's throat, where the vibration is converted into clear speech. By connecting the electro larynx with controller, Radio Frequency (RF) transceiver and speaker the helper at home satisfies the patient needs.

**Keywords:** Wheelchair, People with Disabilities, PIC Microcontroller, IR Sensor, BLDC, GSM Modem, Pulse Detection Sensor, Electro larynx, RF transceiver.

## 1. INTRODUCTION

The wheelchair has long been viewed as essential for People with Disabilities (PWD). While many changes in recent years, image of wheelchair user is dependent on other people is still quite dominant, especially within the care services. To overcome these problems a novel sensor based embedded wheelchair is proposed. Several researches are done for the wheelchair users and many papers deal about it. The previous work focussed over wheelchair movement by flex sensor [1] and intelligent

wheelchair which directs an automatic call to the doctor when patient press the assigned button in their emergency [2]. The previous work drawbacks are overcome in the proposed work.

Njah M *et al.* proposed an electric wheelchair with ultrasonic sensor and fuzzy controller. For obstacle avoidance the ultrasonic sensor is used and the fuzzy controller acts a velocity generation for the movement of wheelchairs [3]. Gonzales R.A *et al.* designed a wheelchair based on the autonomous movement robot [4]. The sensors and GPS system used to move the wheelchair to its destination place. Widiotriatmo A *et al.* implemented a dynamic controlled wheelchair. The required velocity commands (both right and left wheels) are controlled by the automatic wheelchair.

From both wheels the velocity feedback is encoded with the help of PID (proportional-integral-derivative) control algorithm [5]. Rabhi *et al.* designed a neural joystick controlled wheelchair which is inverse of standard joystick. The system is used to control the devices and DC motor of wheelchair [6]. Songmin Jia *et al.* proposed a wheelchair based on omni-directional wheels with seat pressure sensor. The wheelchair can control by both automatic and manual modes of operation [7]. The conventional joystick device is used in manual control mode of operation and based on weight shift measurement values with fuzzy controller the automatic control mode of operation takes place. Nguyen Kim-Tien *et al.* developed many possible ways to control the electrically powered wheelchair [8]. The Electromyogram (EMG) and Electrooculogram (EOG) signal was implemented with bio signal recognition to control the wheelchair. The severe disabilities can direct the wheelchair without using the hands.

The bio signal recognition contains the computed eyes movement, muscle contractions and identified control commands which compares the parameter ranges. To follow the sensor value an obstacle avoidance algorithm is introduced.

Pinheiro E.C *et al.* introduced an unobtrusive sensor based wheelchair which monitors the cardiac action of the user. To process the operation, the digital signal processor is used. A WI-Fi server controls the tasks from remote clients and it sends the information if the patient in an emergency [9]. Abdolalipour A *et al.* developed sensors based wheelchair for assessment activity for Cardio-respiratory which can obtain the biomedical signals with FMCW-D Radar (Frequency Modulated Continuous Wave Doppler Radars). The data acquisition architecture was introduced to increase the accuracy [10]. Rui Dai *et al.* proposed a wheelchair which monitors the user's pressure relief measures. The piezo resistive sensor is placed on the cushion to monitor the pressure level [11]. Postolache O *et al.* described an embedded system for respiratory function monitoring and indoor air quality from remote place [12]. Technology based on EMFi and microwave Doppler radar was implemented in wheelchair for monitoring the operations. Fan.Jinhui *et al.* projected an effective method to control an intelligent wheelchair with a control algorithm which is an omni-directional based platform [13]. According to the disable sitting postures the algorithm controls the wheelchair velocities and direction of movement.

Postolache O *et al.* designed a wheelchair based on the IEEE 1451.4 platform for perfect measurement of Cardio-respiratory and estimated motor activity [14]. The IEEE 1451.4 architecture is a multi-sensor based operations with an RFID reader which detects the wheelchair user. Communication takes place through Bluetooth (wired). Soussi *et al.* introduced a powered wheelchair based on fuzzy logic. The wheelchair is presented a tool to help the disable to drive their wheelchair during their ergo-therapist treating without any difficulty [15]. The sensors are integrated with wheelchair to assist the disable people during their navigation.

A 3D simulator with fuzzy logic is used to test the efficiency of a wheelchair during driving. Faria *et al.* approached an intelligent wheelchair which is interfaced with Brain Computer Interface (BCI). It is used to drive the wheelchair by cerebral palsy

affected patients. The device works on signal preprocessing which is based on Hjorth parameters, data mining algorithm such as neural networks, support vector machines and naive Bayes for variable selection [16]. The patient's who are affected by fourth and fifth cerebral palsy degrees were experimented on GMF (Gross Motor Function) measure.

Niitsuma.M *et al.* proposed a smart wheelchair which integrates with autonomous mobile robot navigation technology based on the personal mobility tool (PMT). To direct the wheelchair direction an intuitive and non continuous input method was introduced [17]. A pressure sensor and an acceleration sensor were used to give direction to the PMT. An output interface which realizes informative communication within a user and PMT is used to help the user interpret robot behaviors. An improved vibrotactile interface is introduced in the smart electric wheelchair to provide the environmental information for disabled people. Heitmann.J *et al.* introduced a new approach for proportional head control for robotic wheelchairs. To monitor the pressure distribution variation due to the intended head motions of the disabled, an array of force sensors embedded into the headrest [18]. To control the wheelchair direction and speed the proportional signals were used which is converted from the force signals. A prototype interface was developed to generate signals similar as the standard joystick control box signals.

## 2. PROPOSED SYSTEM

The sensor based wheelchair overcomes the drawbacks of existing system and problems faced by the disable people. The places are assigned in button and based on the disabled people requirement the wheelchair moves to the assigned place. The Infra-Red (IR) sensor acts as the obstacle detector and it is used to drive the wheelchair with the help of a DC brushless motor. To give power to wheelchair movement the Li - battery package is used. The smart Q heart rate sensor is placed in the patient's fingertip which measures the pressure (pulse) range. If they suffer from any health problem the pulse range varies and an automatic call to the doctor with a buzzer sound in the hospital takes place. The GSM modem is used to direct the call. The electrolarynx is placed in the patient's throat. Based on the disable needs the vibration is converted into clear speech.

By connecting the electro larynx with the controller the user needs are exposed in speaker with the help of RF transmitter and receiver. With this the helper at home satisfies the patient needs. As shown in Fig. 1, the PIC16F877A microcontroller is used to operate the wheelchair with all embedded functions.

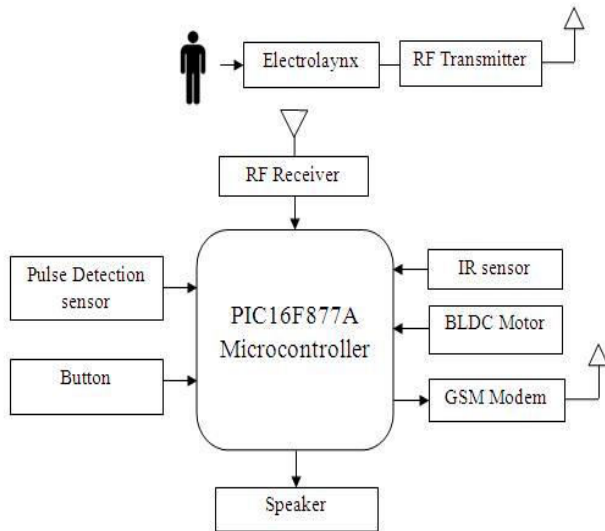


Fig. 1: Overview Setup of the wheelchair

The overall action is done by PIC16F877A 40 pin PDIP microcontroller which is an 8 bit controller with the RISC (Reduced Instruction Set Computer) architecture. It is cost effective and efficient for low end applications and operates at a frequency of 0 to 20 MHz with power supply of 2 to 5 V. It has multi-functional ports (PORT A to PORT E), three 16-bit Timers/counters, a multifunction port for USART communication, 10 bit Multi channel ADC converter, Program memory (ROM) is about 8K size and data memory (RAM) is of 368 bytes size. Besides having power saving modes, it has an in-circuit programming option. Being a low power consuming controller and more economical than other sophisticated controllers, it is best suited for the proposed wheelchair.

## 2.1. WHEELCHAIR MOVEMENT:

The button is assigned in sensor based wheelchair and the disable people press it, the wheelchair automatically moves to that appropriate place. The IR sensor sends the radiation (signal) from the IR transmitter and it receives it in the IR receiver end. If the obstacle is detected, the bounce back signal is not received by the IR receiver end. Based on its received signal, the brushless DC motor drives the wheelchair.

The PIC microcontroller controls the overall operation. Brushless DC electric motor is an electronically commutated motor which is a synchronous motor. It is motorized by a DC electric supply through an integrated inverter/switching power supply, which produces an alternative electric signal to drive the motor. The BLDC motor's stator is manufactured with laminated steel stacked up to hold the windings. The stator windings are either arranged in two patterns. They are star pattern (Y) or delta pattern (Δ). The typical BLDC motor rotor is made with permanent magnets. In wheelchair a Li-battery package is used to give power. The Li-battery package made with lithium metal or lithium compounds as an anode. They withstand apart from other batteries in their long life high charge density and cost per unit. Depending on the chemical compounds and design, lithium cells can generate voltages from 1.5 V to nearly 3.7 V.

IR radiation (signal) is a type of electromagnetic spectrum, where its wavelength is lesser than microwaves and longer than visible light. The infrared wavelength is nearly from  $0.75\mu\text{m}$  to  $1000\mu\text{m}$  range. The near infrared region is between  $0.75\mu\text{m}$  to  $3\mu\text{m}$ , the mid infrared region is between  $3\mu\text{m}$  to  $6\mu\text{m}$  and the far infrared is in the range of  $6\mu\text{m}$  and above. The IR sensor operation is based on the five typical systems. Below in Fig. 2 shows the operation of the IR detection system.

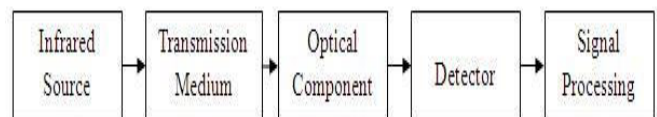


Fig. 2: Infrared Radiation Detecting System

The infrared sources such as blackbody radiators, silicon carbide, Lasers, tungsten lamps, LEDs, etc. radiates the radiated signal. The transmission mediums such as vacuum, atmosphere and optical fiber medium are used to transmit the signals. To converge the radiation (signal) the optimal lens such as  $\text{CaF}_2$ , silicon, Ge, polyethylene Fresnel lenses, etc. are used as the optimal components. The band pass filters are used to limit the spectral response. For obstacle detection the photosensitivity, Noise Equivalent Power (NEP) and detectivity are used as the infrared detectors. The Preamplifiers are used to receive the extra signals which are not received by the detectors.

## 2.2 CALL TO THE DOCTOR:

As shown in Fig. 3, the smart Q heart rate sensor is used to measure the heart rate (cardiovascular pulse) of the patient. The cardiovascular pulse wave measurement is based on the changes in arterial blood volume with pulse beat. This volume of the blood range changes is detected in fingertip using the Photoplethysmography technique. The signal is detected by the Plethysmograph (Pleth) device.

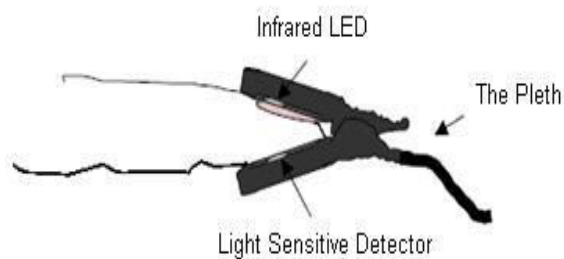


Fig. 3: Smart Q Heart Sensor

The Plethysmograph consists of LSD (Light Sensitive Detector) which detects the tissues light energy transmission by tuning the infrared LED (illuminates the tissue) as the same colour frequency. Light Sensitive Detector (LSD) and infrared LED are used in a spring loaded device which is clipped onto the fingertip. The LED emits the infrared light is scattered via the fingertip. The skin surface has a light sensitive detector which measures the transmission of light waves at a range of depth. Commonly infrared light is highly absorbed in the blood and weekly in tissues. Based on the changes in blood volume the absorption level varies. Below in Fig. 4 shows the graphical representation of the absorption due to changes in arterial blood volume.

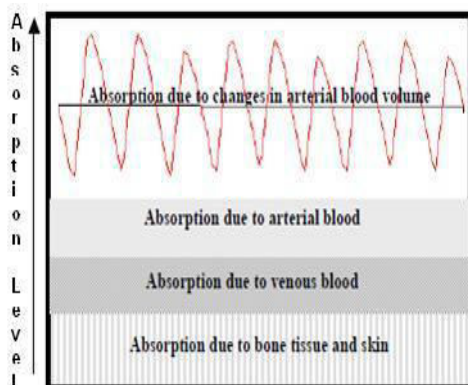


Fig. 4: Graphical representation - Absorption due to changes in arterial blood volume

Heart rate varies with age as shown below in Table 1. As shown in Table 2, there are some safe level ranges in pulse rate which determines the maximum heart rate based on the people ages. By mathematical calculations it can be represented as:

$$\text{Maximum heart rate} = 210 - (0.65 \times \text{age}) \text{ ----- (1)}$$

Table 1: Heart rate variation with age

Age	Average Heart rate (Beats Per Minute)
New Born	140
7 Years	85-90
14 Years	80-85
Adult	70-80

Table 2: Max. Heart rate and safe heart rate based on the age

Age	Maximum Heart Rate	Safe Heart Rate
12	202	182
13	202	182
14	201	181
15	200	180
16	199	179
17	199	179
18	198	178

If the heart rate exceeds above the safe range an automatic call to the doctor with a buzzer sound in hospital takes place. This automatic call takes place with the help of a GSM modem. GSM modem operates within a GSM network which works like a dial-up modem.

The major dissimilarity between them is that the Dial-up modem sends and receives data through a permanent telephone line connection whereas a GSM modem communicates through radio waves. The AT commands are used to control the modem. GSM works on four different frequency ranges with FDMA-TDMA and FDD. They are described in Table 3 which is as follows.



Table 3: GSM Frequency Range

SYSTEM	P-GSM (PRIMARY)	E-GSM (EXTENDED)	GSM 1800	GSM 1900
Freq Uplink	890-915MHz	880-915MHz	1710-1785MHz	1850-1910MHz
Freq Downlink	935-960MHz	925-960MHz	1805-1880MHz	1930-1990MHz

### 2.3. TO FULLFILL THE DISABLE NEEDS:

The electrolarynx is placed in the patient's throat. Based on the disable needs, vibration produces and it is converted into clear speech. The RF transmitter is used to send the basic needs to the controller with speaker. With this audio the helper can satisfies the disable needs. The electrolarynx is a handheld battery powered device as like the size of an electric shaver which has a vibrating plastic diaphragm. Against the patient's neck the electrolarynx end is placed and a small button is pushed when they need any help. The device causes a vibration of the vocal folds, which simulates an ordinary process.

### 3. SOFTWARE DESCRIPTION

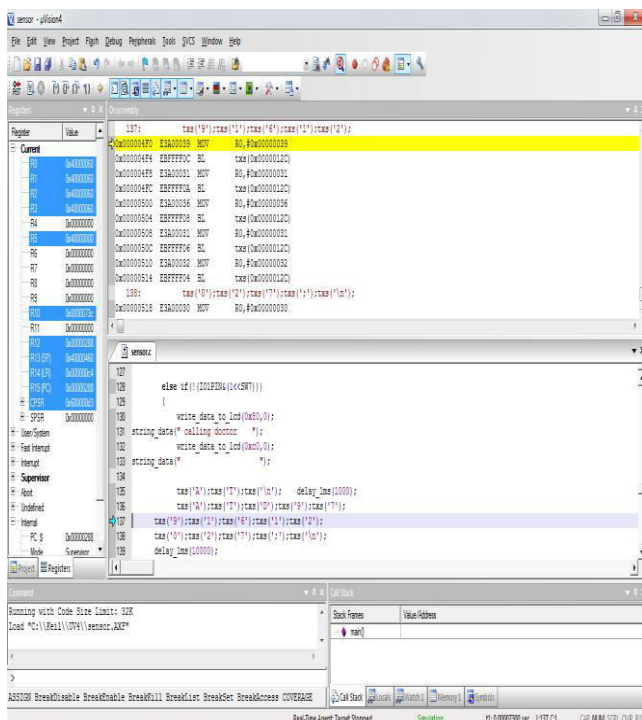


Fig. 5: Simulation Output

To run and debug the program, the Keil  $\mu$ Vision4 software is used. Keil is the latest release of complete software development environment for a wide range of ARM, Cortex-M and Cortex-R based microcontroller devices. It includes the uVision IDE/Debugger, ARM C/C++ Compiler and essential middleware components. The Keil IDE (Integrated Debug Environment) is used to enable faster and efficient development of the program. The Fig. 5 shows the simulation result by using Keil software. The movement and operation of the wheelchair is functioning by the debugged Keil program which is programmed in ARM processor.

### 4. HARDWARE DESCRIPTION

Below in Fig. 6 shows the overall setup of the sensor based wheelchair for people with disabilities. Based on the keil debugged program the wheelchair moves to the appropriate place and help the people with disabilities. Fig 6. (a) shows the front view of the wheelchair and Fig 6. (b) shows the side view of the wheelchair.

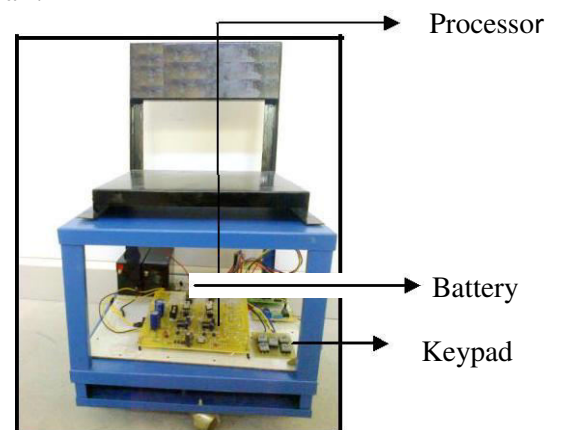


Fig. 6: (a) Front View of the Wheelchair

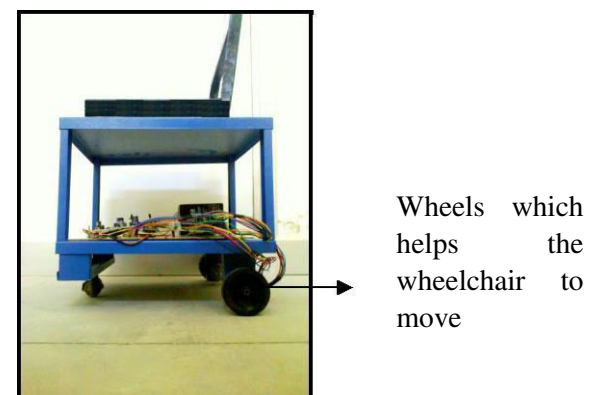


Fig. 6: (b) Side View of the Wheelchair

## 5. CONCLUSION

The sensor based wheelchair act as a boon for the people with disabilities to move their life in an easy way. The disable people can direct the wheelchair independently in hospitals with the help of a DC brushless motor and PIC microcontroller. In the case of emergency, by measuring the heart rate an automatic call to the doctor with buzzer sound takes place. The heart Q sensor is used to measure the patient's heart rate and the GSM modem is used to direct the call. The electrolarynx is placed in the patient's throat which converts the basic needs of the disabled into clear audio. By this the helper at home satisfies the disable needs. The sensor based wheelchair can be further enhanced with the wheelchair movement automatically at home and outer environment.

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