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Wireless System Based Smart Wheelchair

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Abstract: In this work we report initial results of our work in the development of a wireless system based wheelchair using embedded system technology for partially paralyzed patients, victims of accidents, or people with disabilities due to old age or other factors. The proposed system includes an electronic wheelchair which includes IR Television Remote, Android Bluetooth, Hand gesture motion control and Voice command recognition. The wheelchair uses the AVR microcontroller for all signal processing and consists of a pair of motorized wheels driven by a bi-directional motor driver and a dry cell battery as main source of power. Additional features of the proposed system include wired joystick control, variable speed control, intelligent object collision avoidance, and Battery level indicator.

Keywords: Wireless Communication, Embedded Systems, Finger Gesture, Emerging Technologies, Smart Electronics & applications.

I. INTRODUCTION

Since a long time, disabled people have been the focus of various experimentation and researches in the field of science. All these researches and experimentations have one purpose, helping and assisting the disabled making their lives simple, easy and as close as to that of an able person. In other words making the disabled differently enabled. Our practical research focuses on assisting those individuals who are physically impaired. The prime aim behind this research is to design a "Wireless System Based Smart Wheelchair" which can be operated by using multiple wireless technologies in order to counter the different categories of physically disabled people as are seen in our society. As we have different categories of disabled persons, so for the sake of simplicity in our research, we have divided them into two different categories.

A. Partially Paralyzed Patients

The first category of disabled people includes half paralyzed patients and they are capable to move their hands. So for them, we provide Bluetooth technology (i.e. "Smartphone" as a transmitter) .By using this feature, disabled people can easily operate their wheelchair independently by just simply using the android application in their smart phone. But if the patient doesn't have the capability to do so or if he cannot afford a smart phone then we also provide IR Technology (i.e. "TV Remote" as a transmitter) and by using this, a patient may also easily operate his/her wheelchair without others help.

B. Fully Paralyzed Patients

The second category of disabled people is further sub divided into "two" categories.

The first sub category includes those fully disabled people who don't have the capability to grip a TV Remote or smart phone but they have the capability to move their hands, head or even finger so for them we provide "Gesture Control" (i.e. based on RF Technology) Basically we have designed a finger gesture which include a ring in which an accelerometer is mounted so by wearing this ring, any disabled people can operate our smart wheelchair by just tilt his/her finger in downward direction for moving forward or tilt his finger in the upward direction for going backward similarly for left and right.

The second sub category includes fully disabled people who even not have the capability to move their hands or even finger rather they just have the capability to speak, so for them we provide "Speech Recognition" feature (i.e. based on Bluetooth Technology). By using this feature, a patient can easily operate his/her wheelchair by just giving the commands (e.g. "Forward", "Backward" etc).

Additionally we are also providing a wired connection i.e. based on "joystick" control for partially disabled patients in order to facilitate them and provide more convenient means for controlling their wheelchair even if they doesn't have any wireless transmitter.

The rest of the paper is organized as follows. Section II summarizes the technical specifications of different components used in the system. Section III gives an insight on the working controlling mechanism in the wheelchair. The discussion on working of the wheelchair

is provided in section IV. We summarize unique and innovative feature of our proposed wheelchair in section V. Section VI concludes the paper.

II. SPECIFICATIONS

In conventional Electric Wheelchair, there is a single control system to operate wheelchair i.e. joystick, laptop, etc and having drive system/chassis, battery, controller, and electric motor. [1] but our Wireless System based smart wheelchair can be operate by three different transmitters which provides highly flexibility to the user and this is our main focus to embedded different sensors and modules on a single board. Figure1 shows the different transmitter blocks.

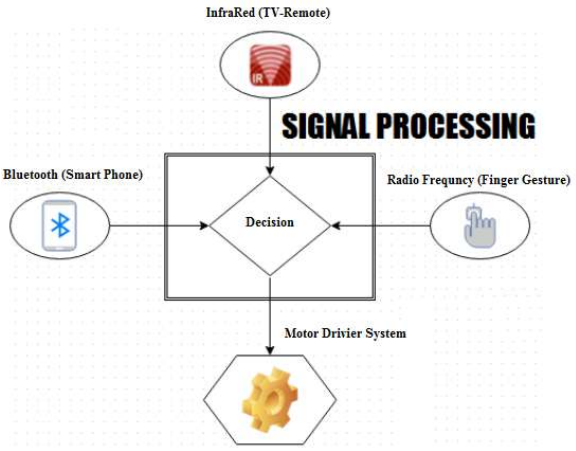

Fig.1 Smart wheelchair transmitter blocks

The further description about these transmitter blocks and other specifications are as follows;

A. Bluetooth Module

To implement the feature of android controller in a Smart Wheelchair, we are using an android app of serial communication which consists of 6 buttons. Whenever user presses the button, this app generates a digital command and through Bluetooth of Android phone it transmits. For connecting Android phone with smart wheelchair we are using bluetooth module which works on 2.4 GHz and working principle behind bluetooth is GFSK(Gaussian Frequency Shift keying). This module receives the commands at a baud rate of 9600 and transmits towards controller. Figure 2 shows a simple bluetooth connection between smart phone and Smart Wheelchair.

Fig.2 Bluetooth connection between smart phone and Smart wheelchair.

B. IR Module

As mentioned above, our smart wheelchair can be also operated by TV-Remote. To implement this feature we are using a common module of IR receiver, when we press a button then it generates specific voltage and these voltage signal (codes) travel in the form of Infrared light emitting from TV Remote and at the receiver side, the IR module catches this light and generate specific voltage and send it to the controller where we decode this data and set commands to operate our Smart wheelchair.

C. RF Module

RF module is used for establishing the communication between gesture control and our smart wheelchair. This RF module is operating at a frequency of 433 MHz for wireless transmission. This Module works on the principle of ASK (Amplitude Shift Keying). ASK is a digital modulation technique.

D. Gesture Control

Gesture is a type of transmitter which is consists of following components,

- An inter integrated circuit named as Accelerometer.
- RF Module for transmission.
- Microcontroller (Atmel IC).
- Capacitors, crystal, led and resistors.

Figure 3 shows the simple block diagram of "Gesture Control" feature.

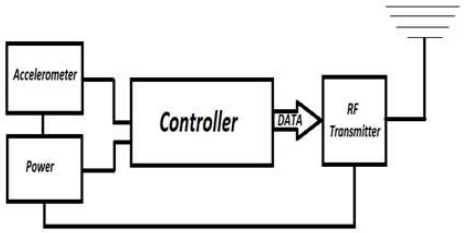

Fig. 3 Block diagram of "Gesture Control".

E. Accelerometer

It is an inter integrated circuit which is behaving as a sensor having the pins of clock and data which is connected to the analog pins of Microcontroller. This sensor senses the motion of X, Y and Z axis and gives analog voltage as an output. In microcontroller we convert these analog data into digital and assign a particular code for transmission.

An accelerometer works on the principle of piezoelectric field. Here imagine a cubical box, having a small ball inside it. The walls of this box are made up of piezoelectric crystal. Whenever we tilt the box, the ball is forced to move in the direction of inclination, due to gravity. The wall with which the ball collides, create tiny piezoelectric current. Depending on the current produced from piezoelectric walls, we can determine the direction of inclination and its magnitude. Figure 4 shows internal structure of "Piezo Electric Accelerometer".

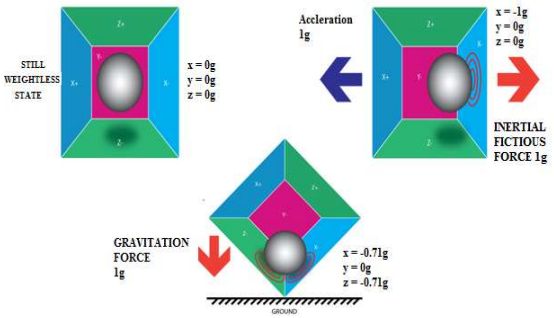

Fig .4 "Piezo Electric Accelerometer"

F. Voice Control

It is an additional feature particularly for fully paralyzed patients or for patients who want to operate the smart wheelchair by their voice command. It's a wireless communication via Bluetooth using Google voice recognition application.

G. Joystick Controller

One small joystick is also attached to provide more convenient means for controlling the smart wheelchair even if the patient doesn't have any wireless transmitter.

H. Speed Controller

We have also designed a speed controller in order to provide three different levels of speed such as High, Medium and Low.

I. Object Avoidance

Another astounding feature of the smart wheelchair is the intelligent object collision avoidance sensor [2]. It uses an ultrasonic based proximity sensor to detect and calculate the distance of any obstacle in the wheelchair's path. If during motion the wheelchair detects an object in its track (for e.g. another person walking in front), it will immediately prompt the user and will automatically stop to avoid collision. Figure 5a and 5b further shows interfaced object collision avoidance system and output displayed on user panel LCD respectively.

Fig. 5a Interfaced Object collision avoidance system

Fig. 5b Output displayed on user panel LCD

Not only this It also has a good battery backup by which patient can use it for a longer time and a battery indicator also mounted on a Wheelchair which indicates the current status of battery. In terms of Mechanical design it is a rear wheels drive vehicle having two small caster wheels are placed on front which helps in the turning of wheelchair and there is also a suspension system which maintains smoothness on a rough surface while driving. Compactness in body is also a plus point for using in home or in congested areas. Including all previous qualities it also has a comfortable seat which never makes the patient restless.

III. CONTROLLING MECHANISM

A. Microcontroller

This Wireless System Based Smart Wheelchair is completely based on a microcontroller IC which takes the serial input from different channels and sends commands to logical circuit. Microcontroller is a processing unit in which processing of different modules like Bluetooth, IR and RF is being done. Including this, analogue to digital conversion and voice processing is also being done by controller. Although in previous research on Smart Wheelchair laptop has been used instead of microcontroller to control wheel chair movements and to manipulate different sensors and other parameters; so in our case patient will feel more comfortable and ease in order to operate wheelchair more conveniently.[3]

B. H-Bridge

It is a logical circuit designed to change the direction of motors in clock wise or in anti clock wise. There are two H-Bridges for two separate motors. These logical circuits take the command from microcontroller and derive the motors in specified direction.

C. Power Circuit

In order to drive the motors, there is a need of power circuit which takes enough power from Power source and supplies it to the motors. This circuit is capable to bear a load of heavy motors; basically this circuit converts low voltage to high voltage for e.g. 5V to 12V.

D. DC Drive

DC Drive is a separate speed controller circuit which works on PWM (Pulse Width Modulation). It consists of power transistors which are continuously switching with a specific delay and delay is inversely

proportional to voltage so by using this technique we made three different speed levels (i.e. slow, moderate and fast).

IV. WORKING PROFILE OF THE WHEELCHAIR

The Smart Wheelchair can take input from different type of devices according to the patient's convenience. The patient could move the wheelchair using a standard IR television remote. If the patient finds carrying a TV remote inconvenient, there is an alternate option to control the wheelchair using an android smart phone using Bluetooth pair up. The patient could either use a friendly GUI based android app to control the wheelchair's movement or if not able to grip a smart phone at all then the patient could operate the wheelchair using simple vocal commands through his/her smart phone like "Forward", "Backward", "Left" and "Right". Another remarkable feature of the smart wheelchair is the hand gesture motion control through which the user could drive the wheelchair by the gesture of his/her finger by wearing a ring. The ring consists of a small antenna and MEMS based gyro sensor which detects the inclination of the user's finger and sends signal to the wheelchair's control circuitry through a 433 MHz RF module. When the user inclines his finger in downward direction the wheelchair will move forward, when the user inclines his finger upwards the wheelchair will move in reverse. Inclining the finger in left or right will cause the wheelchair to turn in that specified direction. When the receiver on the wheelchair receives the command from the user, the microcontroller triggers the motor driver circuit which then moves the wheelchair. Figure 5 simply shows the on board system of Wireless System Based Smart Wheelchair.

Figure 6 shows the complete signal flow diagram of the wheelchair's on board system

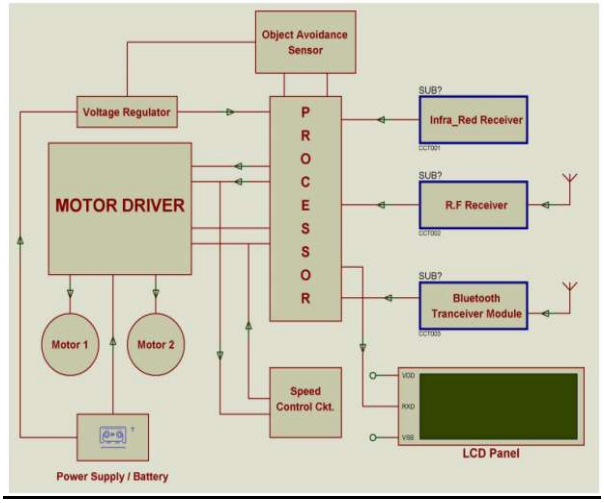

Fig .6 On board system of the Smart Wheelchair

V. UNIQUENESS

Although there are several Electric Wheelchairs Present in the market, but all of these have limited features and there is only one option to control electric wheelchair and mostly they have wired connection. Also they are too expensive. On the other hand our Wireless System Based Smart Wheelchair has multiple wireless technologies with multiple controlling features. The wireless control features make the patients completely independent. Our design also has Battery level indicator and which helps in preventing the battery from overcharging. Also our design fulfils the need of various categories of disabled people and it also has a very comfortable seat and an automatic footrest. It also contains a colorful LCD which shows all the parameters related with different sensors used in this smart wheelchair.

VI. CONCLUSION

In this paper, we have suggested a design of an innovative "Wireless System Based Smart Wheelchair" which is very useful for partially and fully disable patients. Our prime aim is to make our design highly cost effective, power efficient, durable and environmental friendly.

Not only this, we provide multiple wireless access environments for the users which are in the accordance with the patient's need and affordability. Our design is not an ordinary electric wheelchair rather it can operate through multiple wireless technologies which includes: I.R (Infra Red), Bluetooth and R.F (Radio Frequency) with different transmitters (TV Remote, Android Phone and Gesture control respectively); moreover we use different sensors in order to facilitate our valuable users and make our Smart Wheelchair more user friendly.

We hope that our research will help and motivate disable patients to live their life with dignity and pride!

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