Design of An Intelligent Wheelchair for Handicap People Conducting by Body Movement

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***Abstract*— The increasing development of the biomedical system and smart technology has a major impact on smart devices. A smart wheelchair is one of them to be improved with the blessings of this modern technology. In this paper, a smart wheelchair topology is proposed which is operated by a hand movement device and a smartphone. It comes with a lot of advanced features for people with disabilities who cannot walk or travel without the help of others. It is a hand-held wheelchair in which the gyro sensor and accelerometer are used and the Bluetooth phone control module is used to make it automatic. Users will wear a gesture system in their hands, and by moving the hand, the wheelchair will move forward, backward, left, and right. Arduino Mega and Arduino Nano are used as controllers. In this paper, the minimum threshold angle is compared with a microcontroller-based wheelchair where this proposed wheelchair started working with 5^0 fewer angles for forwarding and backward movement and 3^0 fewer angles for the left and right movement. Moreover, the linearity of this proposed wheelchair is -0.7, 0.045 & -0.03 when the sensitivity is 0.6102, 0.5214 & 0.55 for X, Y, Z axis respectively. The Sonar sensor is used here to prevent a safe movement. Using this design dimension and configuration, a prototype was eventually built and evaluated at various stages for performance evaluation.**

Keywords—Arduino NANO, IoT, android app, smart wheelchair

I. INTRODUCTION

Science and technology have been evolving regularly. Smart technology is enriching the standard of living of human beings. In this modern age, the world is becoming smart with the rapid development of science and technology. Smart houses, smart cars, smart apps, smart technologies make life simpler and quicker than it has been in decades. Yet there are growing classes of people who are unable to benefit from new technology advances because of their disability. Particularly disabled people with limited mobility are still living a miserable life. A Smart wheelchair is a new tool designed to enhance the life of a disabled person.

The wheelchair is one of the foremost commonly used assistive gadgets for enhancing personal mobility, which may be a precondition for enjoying human rights and living in dignity. Wheelchairs assist people with disabilities to become beneficial individuals in their communities. Almost 10% of the worldwide population about 650 million people have disabilities. Studies indicate that of these some 10% require a wheelchair [1]. Wheel-chairs are driven manually with the assistance of another individual or by implies of self – propelling. To diminish the complexities for those who don’t have the quality to move their chairs by themselves the wheelchairs are electrically powered [2]. IoT plays a major role in the part of an embedded system like a low-cost intelligent traffic surveillance system that provides 98.26% accuracy in vehicle detection [3].

The wheelchair is navigated using multiple-input and obstacle is detected by using IR sensors and used for home automation for the disabled person. The Wheelchair can be moved by the command given by voice. Moving head or hand in four fixed positions which is captured using the accelerometer sensor built-in android phone [4]. ATMega328 is used as a processor and motor driver L298N is used as a motor driver in a smart wheelchair where DC Gear Motor, Ultrasonic Sensor, TTP224 Capacitive Touch Sensor, Bluetooth Module and IP Camera are also used. The accelerometer sensor is used to move the wheelchair in five individual directions according to head gestures [5]. Arduino UNO is used to control the wheelchair-using relay as a motor driver. To use the green energy and to lessen the environmental danger Solar panel is used as the power source. Two motor and LDR sensors are used for light detection and some more sensors like the Seat belt sensor, an ultrasonic sensor is also used in an automatic wheelchair [6]. A wheelchair control by head motion is improved that enabled by a microcontroller system. A prototype of this system has been developed and implemented. A digital system including an accelerometer, a microcontroller, and a mechanical actuator are used in the prototype [7]. A prototype of the smart wheelchair is designed and developed with a conventional manual wheelchair. Electrical and mechanical advancements are added to the wheelchair. Voice and gesture control are implemented in this advanced technology [8]. To create a gesture sensing application that includes different parts of the body except for the legs and hands is the main idea behind of research on a smart wheelchair. No monitoring is required for this device. A choice is made to suggest strategies to effectively notice movements from the organs that currently function appropriately and handle the sensed information for movement [9]. A smart wheelchair is controlled by voice and gesture movement for the physically disabled persons. Smartphones are used for the control of the wheelchair. Smartphone offers SMS, Email, news for sending data to the wheelchair. 8 sensors are used including two IR sensors and the rest of all are for temperature, smoke detection, and LDR sensor [10]. A novel P300-based threshold brain switch is presented which provides the effectiveness for patients with SCIs [11]. An even related potential (ERP) BCI-based-environmental control system is proposed to deliver assistance for paralyzed patients [12].

This paper mainly focuses on a wheelchair of semi-autonomous category which offers the person flexibility to move according to their choice. This wheelchair is operated by detecting the movement of the hand and providing such a paralyzed patient with a degree of independence and freedom of movement. It has an option to avoid collision and obstacle detection. The Sonar sensor is used here for obstacle detection and emergency stop. In this research, different speed rates using the 6050gyro sensor are also used. It is a hand gesture and an android wheelchair control that can be used so easily by any disabled person. The RF module for the communication protocol is used in this smart wheelchair. The wheelchair is operated by two controllers, Arduino Nano and Arduino Mega. This, wheelchair can be controlled by android via Bluetooth. This research mainly aims at providing an eco-friendly environment and economically efficient as well.

Section II describes the methodology of the paper where design & fabrication is portrayed in section III. Section IV analyzes the performance. Finally, section V concludes the paper.

II. Methodology

The schematic diagram of this project is drawn on Proteus 8 professionals. The diagram will give us a clear idea about the research. Fig 1 is an image of the Wiring diagram of the Wheelchair body circuit.

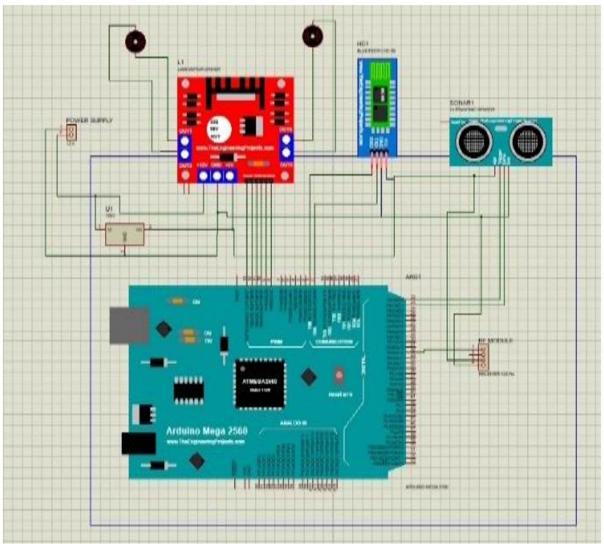

Fig. 1. Wiring diagram of Wheelchair body circuit.

The diagram is divided into two different portions like the main wheelchair circuit diagram and hand gesture diagram. Fig .2 shows the Wiring diagram of hand gesture.

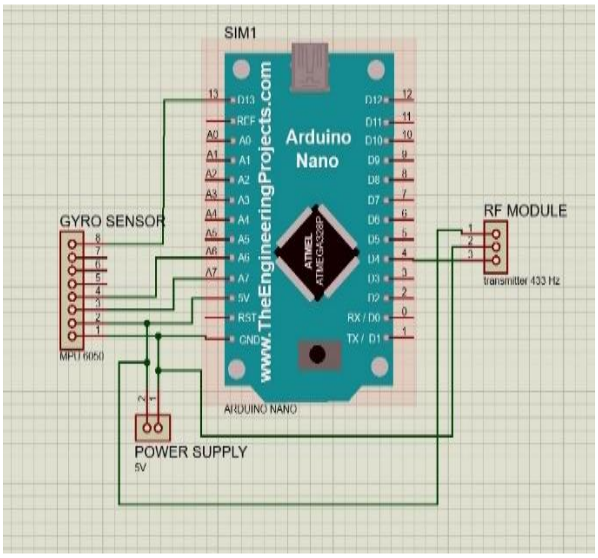

Fig. 2. Wiring diagram of hand gesture

In this paper, few methods are applied like Gesture control, Smartphone control through Bluetooth, Speed control and obstacle avoiding system. Here the methodology in this system is described through a flow chart. Fig .3 shows the Flow Chart of the system.

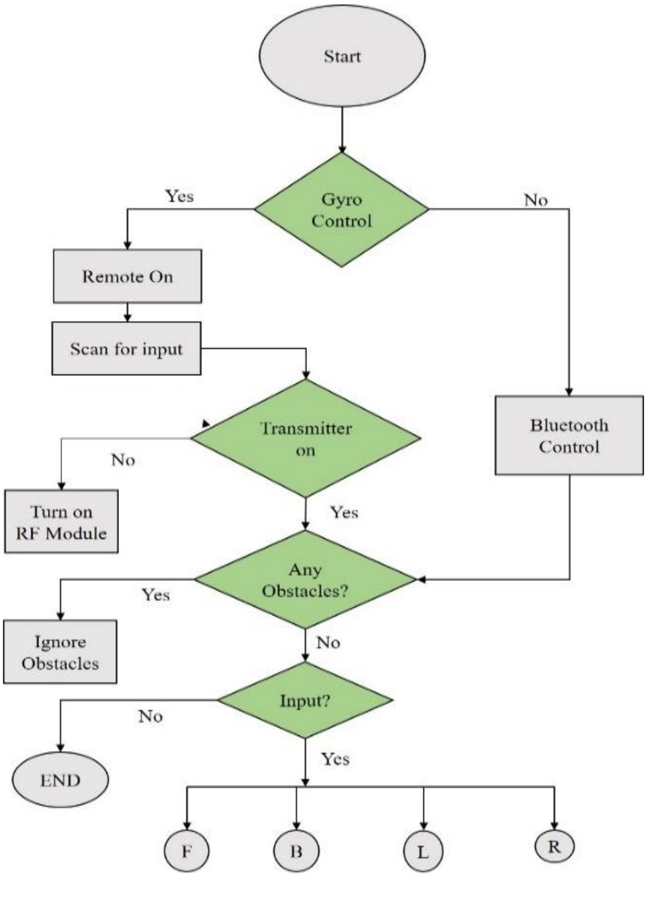

Fig. 3. Flow Chart of the proposed system

The Block diagram represents the main components and basic functioning of the project. The system consists of two major parts, 1. Hand gesture Unit, 2. Wheelchair control Unit. The hand gesture unit sends a signal to the wheelchair control unit. The hand gesture unit consists of 6-axis Motion Tracking sensor MPU6050, Arduino Nano, RF transmitter, and power supply. The Wheelchair unit consists of Arduino Mega, Bluetooth module, Sonar sensor, Signal receiver, Power supply, Motor driver, and motors. Fig .4 describes the block diagram of Wheelchair Control Unit. Fig .5 is the block diagram of the Hand gesture unit.

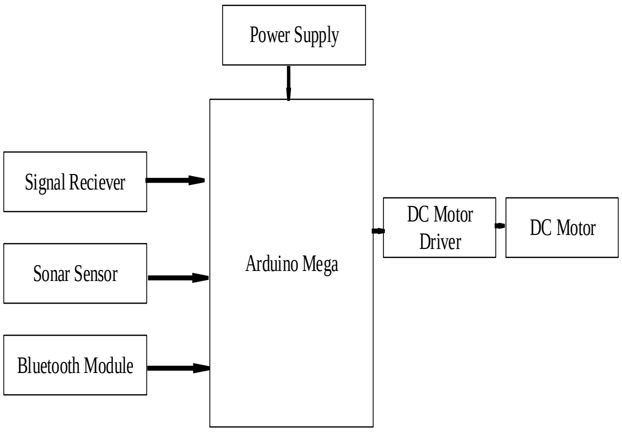

Fig. 4. Block Diagram of Wheelchair Control Unit

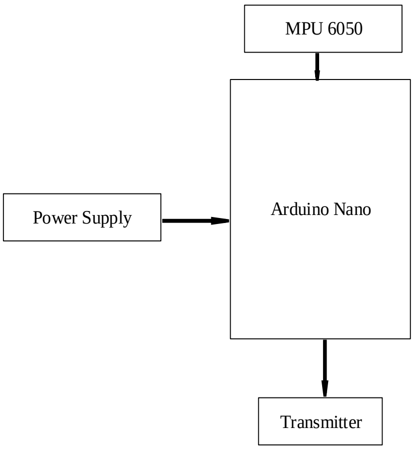

Fig. 5. Block Diagram of Hand gesture unit

III. DESIGN & FABRICATION

The system architecture and design of the following project are briefly described in this section. A smart wheelchair is a combination of sensors, actuators, a protocol for networking and mechanical structure.

The mechanical design of the project is designed by SolidWorks'16. A prototype of the wheelchair is designed where aaluminum and wood are used in the design. In this paper, an aluminum angle bar is considered with the volume of $1*1*2$ mm^3. The body is built according to the design. The aluminum angle bar has a volume of $1*1*2$ mm^3. It can carry up to 450N. After that, it will start to break itself. Fig 6 shows the Orthographic view of the wheelchair and Fig 7 indicates the load testing result of the proposed wheelchair.

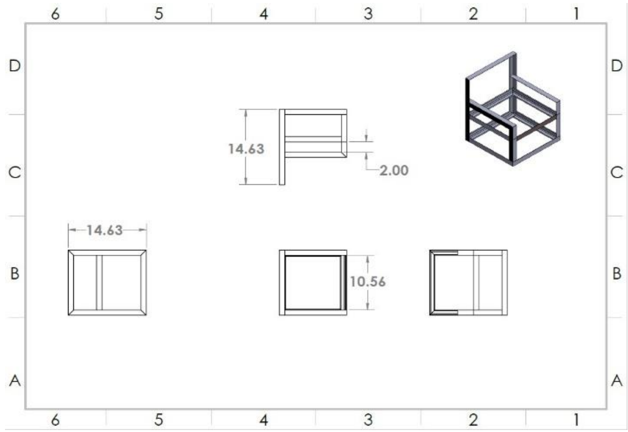

Fig. 6. Orthographic view

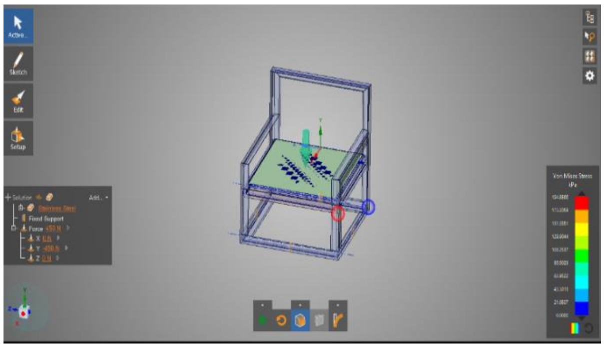

Fig. 7. Load testing of the wheelchair

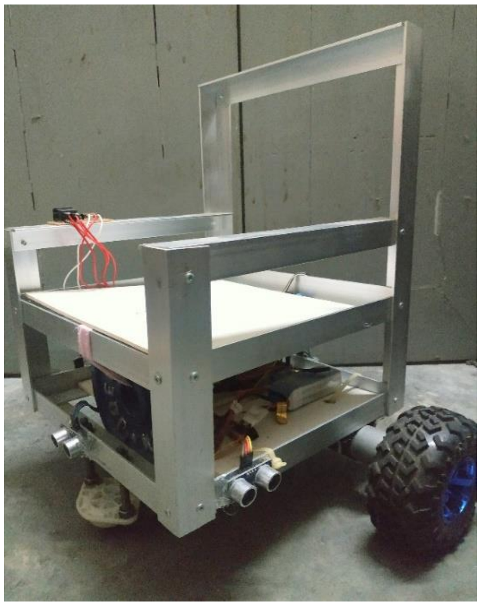

Fig. 8. Practical implementation of a prototype for the proposed wheelchair.

In this wheelchair, several sensors are used such as gyro sensor, accelerometer, sonar sensor, and tilt sensor. The sensor gives the output of the actuator and moves the wheelchair. The wheelchair is controlled by Arduino Mega and Arduino Nano. In this project, we selected the components and design of the body to meet the afforested criteria

IV. Performance Analysis

Gesture control innovation allows people to control what gadgets do without having to ever touch hardware like smartphones and tablets. All device owners have to do is use the right type of wearables such as a ring or wristband. Once they activate their gesture control devices, they have hands-free control over how their electronics behave.

For gesture control, a Gyro sensor is used in this wheelchair. MPU 6050 is used also. It is connected to an Arduino Nano. It changes value with the movement of the hand in 3 axes. By measuring the value for the different directions we set different values for four directions like forward, backward, right, and left. Table I is the gyro sensor reading.

TABLE I. Gyro Sensor reading

Direction	**Value of X**	**Value of Y**
Forward		-.3< Y < -.5
Backward		.3 < Y < .5
Left	>0.5	
Right	< -0.3	

Comparison of the required minimum threshold angle for proposed wheelchair set up and other wheelchair movement is tabling in table II.

TABLE II. Movement of the wheelchair with minimum threshold angle.

Movement of wheelchair	**Threshold angle of Hand Gesture**	**Threshold angle of microcontroller-based Hand Gesture [13]**
Forward	20^0	25^0
Backward	30^0	35^0
Stop	0^0	0^0
Left	27^0	30^0
Right	27^0	30^0

In the above table, one can easily understand that the proposed wheelchair requires less threshold angle about 5^0 for forward and backward movement and 3^0 for left and right movement. Table III describes the linearity and sensitivity of the proposed wheelchair arrangement.

TABLE III. Linearity and Sensitivity range for different axis

Parameters	**X-axis**	**Y-axis**	**Z-axis**
Linearity	-0.7	0.045	-0.03
Sensitivity	0.6102	0.5214	0.55

When the value is set for four directions, with the movement of hand gesture the wheelchair will move to the forward, backward, left, and right. The value from the gyro sensor sent to the transmitter through Arduino nano. The receiver at the wheelchair body receives the signal and commands the motor driver to run the motor as per the direction. A differential drive mechanism is used to run the motor to the commanded direction. If the hand is in a neutral position it will stop the wheelchair. With the continuous movement of a hand, the speed will be increased and decreased. Fig 9 represents the photograph of Direction by hand gesture.

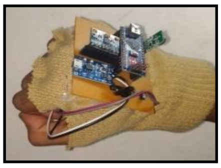	Left
	Right
	Forward
	Backward

Fig. 9. Direction by hand gesture for the proposed smart wheelchair.

The wheelchair is powered by a smartphone in this research. The Bluetooth module is used to create communication between smartphones and wheelchairs. An apk android file is developed for this wheelchair to work as a controller. The steering control of the wheelchair is set to the Android software. By touching the direction, the signal will be sent to the wheelchair via the HC-05 Bluetooth module. The Bluetooth module receives the signal and commands the engine driver to switch to the provided location. It is a very useful feature if somehow the gesture control can't perform its action. It is for the secondary purpose. The smart Phone control interface is showed in fig 10.

Fig. 10. Smart Phone control interface for the proposed model.

Obstacle avoiding is another feature of this project. It is used to avoid accidents and keep the patient safe. This feature will keep the wheelchair away from the obstacles and stops it immediately. For this obstacle avoiding system, ultrasonic sensor as well as sonar sensor is used. Four sonar sensors are used in this robot. Sensors have been set on the front side, left side, right side, backside. Whenever it gets any obstacles in its surroundings it will not execute its operation. It will stop from a limited distance. A tilt sensor is set in the project. The sensor is also known as an earthquake sensor. It is used to observe the deflection of the wheelchair. If the wheelchair falls into an accident and falls into the ground it will light up and sound an alarm and let other people know about the accident. As the proposed wheelchair is divided into two major parts like hand gesture unit and main wheelchair unit, both parts require power from a battery. A rechargeable battery is used for better performance.

V. CONCLUSION

A smart wheelchair controlling by hand movement operated with an android app has presented in this paper. The proposed wheelchair has designed by using SolidWorks with specific measurements and an android app has developed for this wheelchair. The linearity and sensitivity have measured for this wheelchair. The minimum threshold angle for movement of this proposed wheelchair has compared with the microcontroller-based wheelchair where the proposed wheelchair requires less threshold angle. The main features of this proposed wheelchair are to control a wheelchair with gesture control and a smartphone that has been successfully completed. The wheelchair is unable to track any moving object other than stationary ones. In addition, the transmission of data via Bluetooth should be made more smooth. Sensitivity to the movement of the hands should be more responsible. There are places where more effort should be made to make the wheelchair function more reliable and user-friendly. This is done at a minimum cost and can be made for every person with a disability to lessen their pain. Finally, it can be said that the proposed smart wheelchair will bring a new era of smart wheelchair development to lessen the sufferings of handicap people.

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