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Autonomous Navigated IOT Enabled Smart Wheel Chair - A Healthcare and Mobility solution

Journal of Electrical Systems

Abstract: - WHO disability statistics indicate that about 8 million people worldwide, or 1% of the total population, suffer from a mobility handicap. It is also known that the elderly residents in the area cannot move independently. Many hospital patients can force their hand with assistance but cannot move independently. We also understand that real-time health monitoring is necessary for patients, the elderly, and individuals with impairments. Therefore, this work aims to develop and provide a smart wheelchair that can be controlled with a single hand gesture and tracks many health indicators, such as blood pressure, body temperature, oxygen saturation, and pulse rate, using an Internet of Things-based real-time health monitoring system. Users can effortlessly maneuver the wheelchair using simple gesture control enabled by the Internet of Things (IoT), promoting independence and enhancing general well-being. This innovative approach to healthcare and mobility meets users' urgent requirements and establishes a new benchmark for assistive technology, a significant advancement in technology and healthcare. The benefit of this strategy is that the caregiver can view all of these health indicators and the wheelchair user's GPS location using a smartphone application. Taking care of oneself while employed by a firm might be easy.

Keywords: Smart Wheel Chair, Gesture Controlled, Healthcare Device, Internet of Things (IoT), Internet of Medical Things (IoMT). Mobile Application

I. INTRODUCTION

Globally, the population of the aged and crippled has grown dramatically in recent years. Mobility is one of the main barriers to living freely for older and disabled people. They need on assistance from others to survive each day. According to numerous research studies, children and adults benefit from access to independent mobility. The rise in accidents, mishaps, wars, and handicapped people is the main impetus for creating a new control system for a mobility aid device. The interaction between people and computers needs to be improved because some problems still need to be fixed. One of the mobility solutions developed to address this problem is robotic and intelligent wheelchairs. Some robotic wheelchairs come supplied with control interfaces that use switches or joysticks.

We used a gesture interaction strategy, Figure 1, that was created by utilizing the hand to control the smart wheelchair in this study. Hand gesture recognition is a critical method used in human-robot interface systems. Since hand gestures are a widespread and efficient means of communication in daily life, they can be used to control a robotic wheelchair. This research aims to develop an indoor/outdoor hand-gesture control system for a

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robotic wheelchair by Enhancing Mobility, Gesture Control Implementation, IOT integration for connectivity, and Safety and health monitoring.

The world's population is growing. Cities with expanding populations must manage the extreme strain of urban existence. The essential level has not yet been attained despite adding medical facilities and resources almost daily in cities. The intense pressure on urban healthcare administration to find the appropriate solutions to the increasing problems has sparked technological advancement. Due to the increased number of persons with medical challenges, remote healthcare has become ingrained in our daily lives. IoT-based wearable sensors have become increasingly popular in recent years, and they are now more accessible and helpful for personal healthcare and activity awareness. Researchers suggested integrating such cutting-edge technology for data administration, recording, and ongoing patient monitoring in medical applications [1]. We can track the person in the wheelchair by adding this wearable to the gesture device. To support the disabled, aged, and patients, we propose in this study an interface between an IoT-based health monitoring system and a gesture controlled wheelchair.

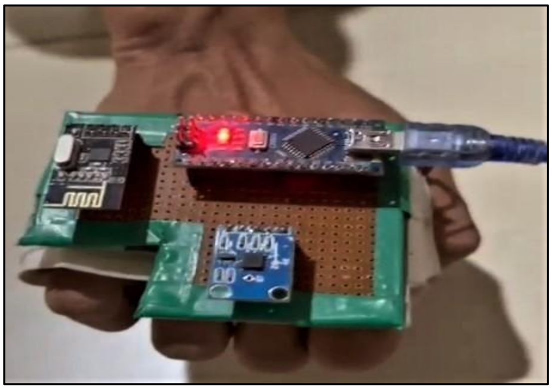

Figure 1 Wearable Gesture Controlled System

The convergence of these technologies in the context of a smart wheelchair has not received as much attention as it should, even though gesture control and Internet of Things applications for mobility aids have been studied separately in previous studies. Regarding smart wheelchairs that are specifically made to meet the mobility and healthcare requirements of people with physical limitations, this study fills a research gap by offering an all-inclusive and integrated solution that blends IoT with gesture control. Autonomous navigation using real time mapping and reactive navigation through 2D LiDAR is the novelty of this work. By bridging the gap, this work advances state-of-the-art assistive technology and provides a unique and effective solution that could significantly enhance users' quality of life.

II. LITERATURE REVIEW:

The following sections are for the design techniques put out by various writers, which are compiled and presented.

Xin Chen: To help patients, people with physical limitations, or older people move around, the typical manual wheelchair is frequently seen in hospitals, rehabilitation centers, senior residences, and airports. The thesis here says first, a CAD model of the typical wheelchair is acquired. Following that, a design for optimization is implemented using this model. People can easily transition from a wheelchair to any nearby chair with the help of a sliding seat. In contrast, a reclining backrest is likewise intended to increase user comfort [2]. Computer simulations are run to test this architecture under static and dynamic conditions. Determined is the sliding seat's displacement range, below which the wheelchair won't tip over. The optimization design displays notable advancements that have quickly been introduced to the mechanical wheelchair to make it more useful and comfortable for users.

Figure. 2: Wheelchair frame [2]

Ahmad Muhammadan Bin Ismail: The use of manual wheelchair propulsion in daily life is growing. Therefore, it's critical to conduct a preliminary analysis of human factors engineering while building a wheelchair to make it more ergonomic for users to perform daily tasks [3]. The primary goal of this research is to make the current wheelchair more practical for daily use. It focuses on applying simulation in analyzing the wheelchair model's crucial components and analyses it in terms of daily use. Consider the seating support and wheel casters as the most important sources of stress on the wheelchair. This stage involves utilizing the information from the questionnaire to create a design that uses case data and is appropriate for the project. Based on the suitability of the design, only three sketches out of many were chosen. Three sketches are created in the Solid Works program, and after that, the three designs are put through a simulation process using FEA tools, namely the ALGOR program. The three designs are then examined using constant force with three different types of materials. Based on the analysis, the safety factor was computed using the Stress Von Misses method. The results showed that Design 3 with E-Glass fibre had the highest safety factor value, 2.77, followed by Design 3 with Steel ASTM A36, 2.44, and Design 2 with E-Glass fibre, 1.95. The highest number of safety factors is E-glass Fiber in design 3. So, the best selection of material is E-Glass Fiber for Design 3.

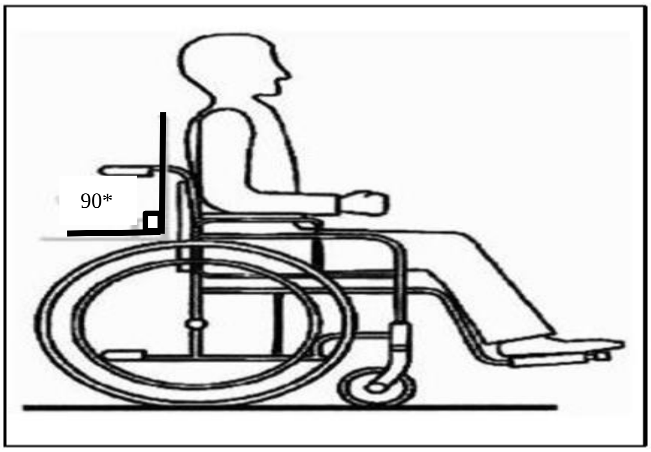

Figure. 3: Traditional wheelchair design [3]

Qiang Gao: A novel wheelchair, Figure 2, with a body posture adjustment function, is proposed based on existing designs of multifunctional wheelchairs that meet the demands of older people and disabled people [4].

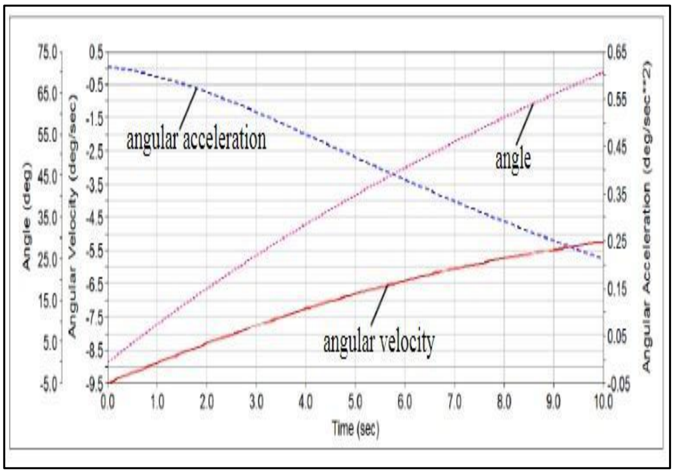

Figure 4: Kinematic Characteristic Curve for Backrest [4].

The present paper first demonstrates the overall design of the wheelchair and the creation of its 3D model, followed by the kinematics analysis of the wheelchair's backrest adjustment mechanism and the verification of the smoothness of its reclining process with the creation of a virtual wheelchair prototype for motion simulation in ADAMS, and finally the finite element analysis of the wheelchair's important structurally essential components.

Saurabh Chauhan: By 2025, it is predicted that 25% of all cars will be powered by electricity. The motor is a significant element that is a crucial part of the electric vehicle [5]. The torque that the driving motor produces significantly impacts how fast, how quickly, and how well an electric car performs. The subsequent study tries to simplify the calculations necessary to determine the motor's capability for a vehicle with specific specs.

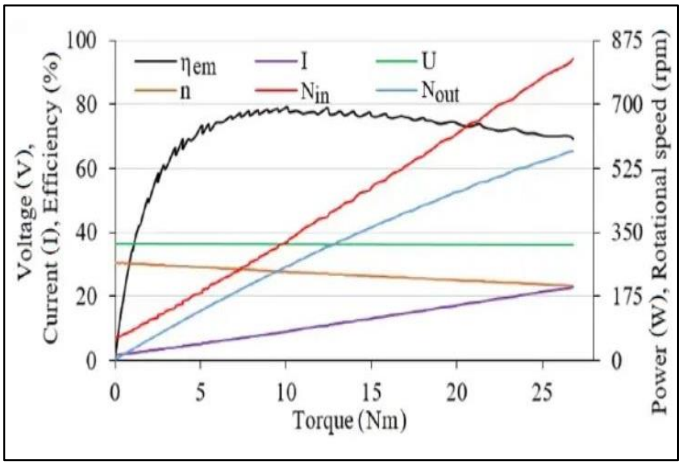

Figure 5: Torque Characteristics for EV [5]

Aibhlin Esparza: Photoplethysmography (PPG) is a straightforward and affordable optical measurement technique for heart rate monitoring. PPG is a non-invasive device that measures volumetric fluctuations in blood circulation using a light source and a photo detector at the skin's surface [6]. Researchers worldwide have recently shown great interest in deriving other valuable data from the PPG signal in addition to heart rate estimation and pulse oximetry readings. Important health related information can be found in the second derivative wave of the PPG signal. The evaluation of several cardiovascular-related disorders, including atherosclerosis and arterial stiffness, can thus be aided by examining this waveform for researchers and doctors. Additionally, analyzing the second derivative wave of the PPG signal can help with the early detection and diagnosis of some cardiovascular diseases that might develop later in life. Continuous and real-time monitoring is a crucial strategy made possible by the most recent technical advancements in sensor technology and wireless communications for the early detection and analysis of such disorders. This article aims to briefly cover some of the developments and obstacles facing wearable PPG-based monitoring technologies before discussing some potential clinical contexts in which this technology might be used.

Hasnayen Ahmed, Kazi Ehsanul: Driving a manual wheelchair or using crutches is a challenging effort, and there are currently no automatic wheelchairs previously designed for physically disabled people to purchase and use. This research aims to suggest an automated wheelchair system that will benefit users. The whole body design, simulation, and fabrication of the suggested wheelchair have been completed [7]. Mild steel has been chosen as the frame material above aluminium, cast iron, and stainless steel because of its high sustained stress, low cost, and availability. The wheelchair is designed with a frame, two front caster wheels for easy turning, four rear wheels with two shaft units, and a chain-driven gear train providing power assistance to the rear wheel from the motor shaft. The smaller cassette on the motor shaft is attached to the chain that joins the sprocket gear. The DC gear motor in this wheelchair transmits power to the driving wheel through a chain. The rear spindle's sprocket begins to revolve whenever the motor shaft does, which causes the wheel to start moving. Extensive testing was undertaken to verify design fidelity. A big customer base could benefit from more freedom thanks to this wheelchair.

Kesavan Manic Suresh, Maryam Amur: assistive technologies and computers built in. These features provide the user with a disability, such as an impairment, a handicap, or a permanent injury, with the necessary mobility to move around freely and safely. These wheelchairs are gradually replacing conventional wheelchairs; however, many disabled persons cannot afford one due to their high prices [8]. Only 5 to 15% of the 70 million disabled individuals worldwide, according to the World Health Organization (WHO), have access to wheelchairs. As a result, we must provide a cost-effective smart that uses cutting-edge components and technology while simultaneously minimising costs and offering a wealth of functionality. - Several admirable initiatives have fulfilled this objective in recent years. They have embraced some technologies, including artificial intelligence, and created an autonomous wheelchair that uses machine learning principles to travel. Some have also used the Internet of Things to manage wheelchairs, utilizing a voice recognition system. This report will outline an inexpensive Smart Wheelchair-based Arduino Nano microcontroller and Internet of Things (IoT) technology that has some features to help disabled people, particularly poor people who cannot afford an expensive Smart Wheelchair, get the assistance they need to complete daily tasks without help. This work will make the Smart Wheelchair affordable to many disabled people. It will be based on Arduino Nano, ESP-12e module to give Wi-Fi access, MPU6050 to detect falls with Voice message notification using the IFTTT platform, obstacle detection with buzzer and LED to work as hazards, voice recognition system, and joysticks to control the wheelchair.

Anantha Rushitha Lakshmi: People's daily lives increasingly rely on pervasive electronics. Smart devices improve people's lives and are more critical in the lives of physically seasoned and older individuals. For the aged and physically disabled, secure and unhindered mobility is essential [9]. The project focuses on developing an Intelligent Wheelchair (IWC), which emphasizes a particular issue in an exceptionally mild and noticeable manner. The primary operating system for Wheelchair is RTOS. It includes touchscreen-based route routing, fall detection, and obstacle avoidance. As a result, moving a wheelchair requires voice commands, which will benefit the elderly and disabled. The Node MCU detected the commands successfully, and the Arduino microcontroller used in this project delivered its purpose.

Rakhi A. Kalantri, D.K. Chitre: While typical manual or powered wheelchairs can often meet the needs of people with impairments, certain members of the disabled population find it difficult or impossible to utilize wheelchairs. To reduce the amount of human intervention, sensors and clever control algorithms have been used in considerable research on computer-controlled chairs [10]. The wheelchair for physically challenged people is described in this project. Our objective is to create a system that enables the user to engage with the wheelchair robustly at various levels of control and sensing. A wheelchair-integrated infrared sensor and head movements are used to recognize dependent users. Using an acceleration sensor and head movements, a wheelchair can be maneuvered, and obstructions may be avoided.

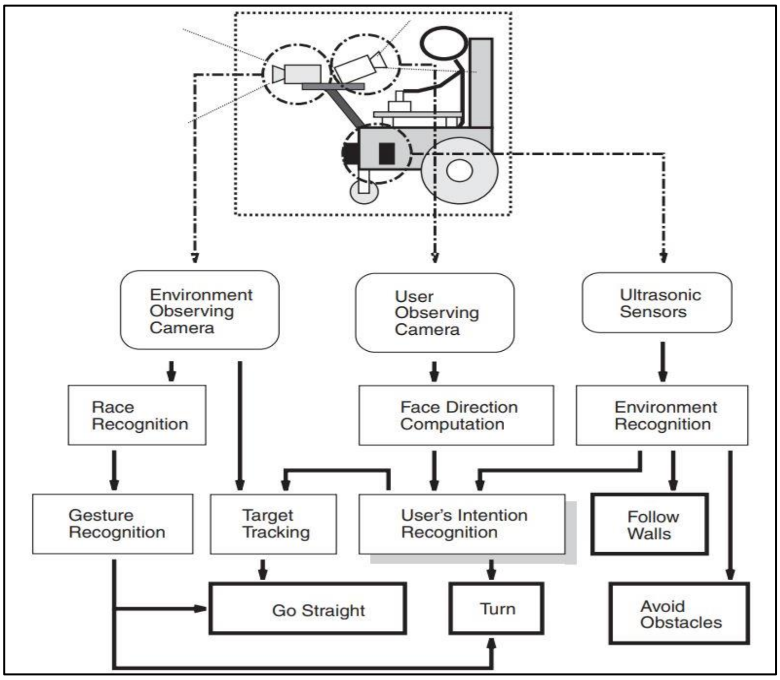

Figure 6: Wheel Chair integrated with different sensors [10]

Sandeep Kumar, P. Raja: This study aims to develop a low-cost prototype of a self-propelled, power-assisted smart wheelchair for the disabled living in underdeveloped areas. All the required technologies are included in the wheelchair to assure user safety and convenience [11]. The wheelchair will be made user-friendly to lighten the burden on caregivers and to increase the disabled person's confidence by enabling self-dependence. People who are disabled can use wheelchairs—anyone, whether young or elderly, can utilize them. A chair with four wheels is typically used for a person's movement when they are unable to walk or even when they are crippled, deformed, or paralyzed from the legs. Mem sensors and wheelchair control make up the system's two major components. An ultrasonic sensor and 3-axis accelerometer make up the MEMS sensor, which is linked to the hand of a wheelchair and translates ultrasonic measurements into digital data for the 8051 controllers.

III. RESEARCH METHODOLOGY:

3.1 Design & Material Selection: The entire mechanical design of the systems is created using SOLIDWORKS. The software is initially used for project management, planning, visual ideation, modelling, feasibility analysis, and prototyping. After that, the programme is utilized to design and construct mechanical components.

Combining solid part modelling with surface modelling results in various intricate geometries. To examine the curvature, continuity, and cutting, we have a range of techniques at our disposal, including Gaussian and spatial filter analysis tools [12]. To give the conceptual design of curves and surface data a name, the project can be started from scratch, utilize the existing components while changing the designs of the individual elements, and then be merged into the SolidWorks programme. The software is excellent for generating wheelchair models and is quite helpful.

The selection of materials for the wheelchair frame partially affected its comfort due to its elastic and vibration-absorbing qualities. When it comes to absorbing vibration, there is a slight difference between stainless steel, aluminium alloy, and pure titanium. However, in Figure 3, stainless steel has an elastic rate of 193GPa, aluminium alloy has an elastic rate of 72GPa, and industrial pure titanium has an elastic rate of 105GPa. As a result, the vibration of a wheelchair made of aluminium alloy is minimal when the same load is applied to these three different materials [13]. When you consider aluminium alloy's affordability, light weight, and effect on comfort due to material influence, it makes a lot of sense to use it. The market for wheelchairs will have a very bright future if titanium can reduce costs, which is an increasing trend in the usage of light metals in wheelchairs.

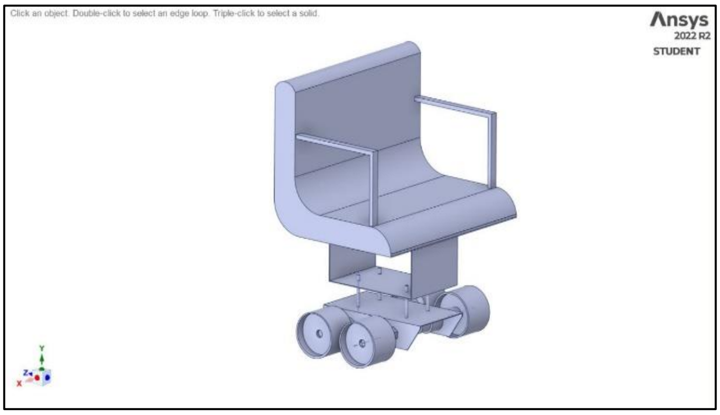

Figure 7: 3D CAD Model of Prototype Wheel Chair

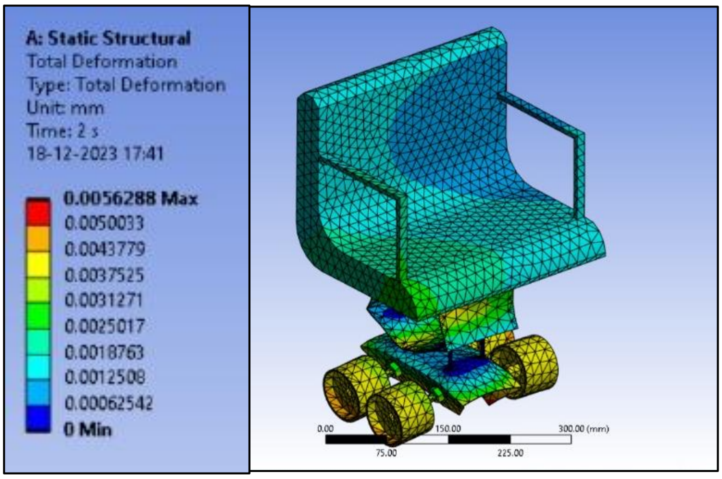

Figure 8: Stress Analysis of Prototype Wheelchair.

3.2 Motor Selection & Power analysis:

The motor is the most crucial component since it must have the torque and payload capacity for the wheelchair to travel precisely and support a certain average weight on the bog. Various criteria must be considered when choosing drive wheel motors for mobile vehicles to calculate the maximum torque needed. Some well-known equations, such as Newton's First Law of Motion and Force Calculation in terms of Frictional Backlashes.

The torque needed for the entire journey was estimated, according to [14], at around 27.24 N/m, and the force required to move the object from one location to another was 148.96 Newton. And given the weight it had to carry, we assumed that was appropriate. Around 130 kg must be taken by the same wheelchair, with 50 kg being the weight of the wheelchair and 80 kg being the user's weight. Additionally, we rounded up the RPM to 200 RPM from 187 RPM.

Power of the Electric Motor: Calculating the energy needed to operate the wheelchair, which the electric motor will supply, is crucial. These required parameters can be found according to [15] as follows:

$Power(Watts) = Total\ Weight \times Gravitational\ Force(g) \times AssumedSpeed \times Assumed\ Gradient$……………………………………………………………………………………………………….……………….(i)

Where,

Total weight = 130kg

Gravitational force (g) = 9.81m/s

Assumed speed = 5 x 1000 3600 m/s = 1.38 m/s

Assumed gradient (slope) = 3%

Therefore, the total power to be delivered is

$$Power = 130 \times 9.81 \times 1.38 \times 0.03 = 52.79\ Watt \ldots\ldots (ii)$$

Therefore, the power required is approximately 60 watts (for a single motor). Since there are two DC motors for the wheelchair, the power required is approximately 120 watts. Thus, a 24- Volt 120 W motor was enough to propel the wheelchair.

The Battery System: The system voltage is 24 Volts, and Power is 120 watts, then the load current (IL) is

$$IL = \frac{Power}{Voltage} = \frac{120}{24} = 5\ Amps \ldots\ldots (iii)$$

It was estimated that the wheelchair should run for 8 hours continuously daily. Then the load current that is provided for the wheelchair is computed using.

$$Load\ Current = 8 \times 5 \times 1.2 = 48.00\ Ah/Day \sim 50\ Ah/Day \ldots\ldots (iv)$$

Assume a 10% overall loss in the system,

$$Battery\ Size = 50 \times 1.2 = 60\ Ah/Day \ldots\ldots (v)$$

The energy required for the motor

$$Vi_t = 50 \times 24 = 1200\ Wh/Day \ldots\ldots (vi)$$

Therefore, 60 Ah/day, 24 Volt power was required for the system.

The selection of the motors is the most crucial step after all these calculations and considerations. The factors in play here are more subjective, including the kind of motion needed based on the weight bearing capability, the amount of money required, the available space for the motors, the current consumption, and many other factors. For this reason, the optimum motors that were needed for the wheelchair project that we built were as follows: - A DC Planetary Gear Motor are :

GB82K, GB82P, GB62P, GB103K .

Health Monitoring System:

The measurement of blood pressure (BP) is essential for managing and treating many therapeutic situations in health monitoring. High blood pressure is linked to a variety of chronic diseases and may be a leading cause of mortality and morbidity worldwide. There is a lot of interest in consistently and accurately measuring blood pressure using portable or wearable technology for elderly patients and outpatient care.

Photoplethysmography (PPG), which we used in our experiment, is one possible configuration. It is most frequently used in pulse oximetry in clinical settings to measure oxygen immersion [16]. PPG innovation is becoming more quickly available, affordable, practical, and well-integrated into valuable devices. This example of PPG invention highlights a useful and inexpensive technology that may be linked to several aspects of cardiovascular monitoring, such as measuring blood oxygen saturation, heart rate, blood pressure, cardiac yield, breath, etc. [17]. In this system, the pulse oximeter sensor MAX30100 and the temperature sensor LM-35 are used to monitor the patient's health parameters while seated in a wheelchair Figure 7.

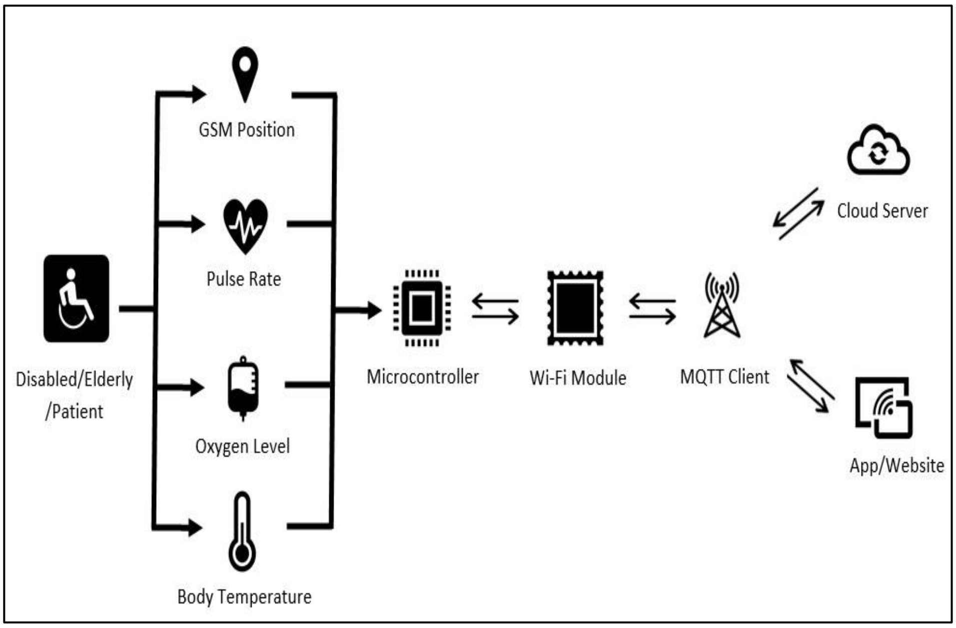

Figure 9: Health parameters from patient to the caretaker.

3.3 Electronics & Internet of Things:

RPLIDAR A1 is a low cost 360 degree 2D laser scanner (LIDAR) solution developed by SLAMTEC. The system can perform a 360-degree scan within a 6-meter range. The produced 2D point cloud data can be used in mapping, localization and object/environment modelling. RPLIDAR A1's scanning frequency reached 5.5 hz when sampling 360 points each round. It can be configured up to 10 hz maximum. RPLIDAR A1 is a laser triangulation measurement system. It can work excellently in all kinds of indoor environment and outdoor environments without sunlight.

Figure 10: RPLidar A1 used in IoT system

3.5 Web & App Development: Our system is implemented on a wheelchair that the user physically steers. A wearable IoT cloud-based health monitoring system uses a linked network of wearable sensors, such as blood pressure and heart rate monitors, to track the subject's health. Your mobile phone can connect to IoT devices [21], allowing you to manage or watch over your data anywhere. The wearable sensors' sensor data will be sent to the cloud. By entering in with the patient's unique ID and password, we will develop a web or Android application, allowing family members to view graphs of their patient's health status in real-time from any location in the world [22]. Additionally, a GSM module will be used to send an emergency message to the contacts saved in the databases (such as the family doctor, family members, etc.) in the event of any emergency (such as a rise in heartbeat or fall in a heartbeat) to alert them to take immediate safety steps.

The register/login pages, dashboard section (where patients' histories can be read), section (where all health parameters can be tracked), and map section (where patients' positions may be followed in emergency scenarios) are the sections in this web application or Android application. Each health update will also be kept and made accessible to the user [23]. The database completely preserves the information from registered users. The implementation's core building blocks for this wearable and online app/app are the HTTP server and a storage server that holds the My SQL database. An example of the user interface is that the pulse metre sensor determines the heart rate after the power is turned on. The same information is provided

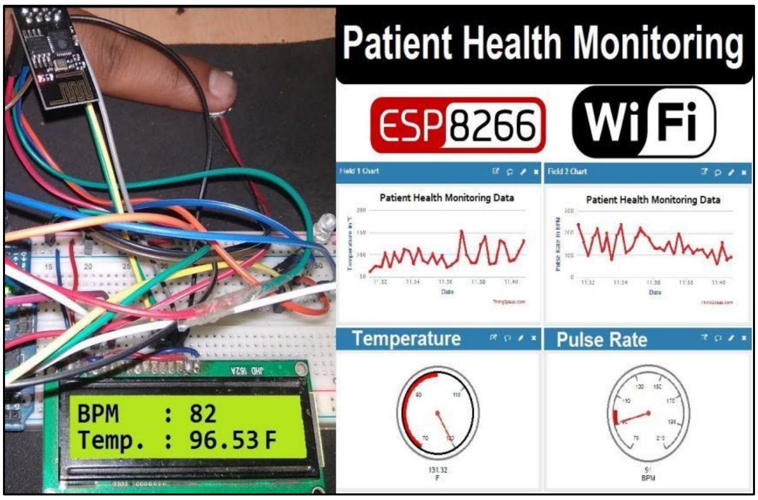

Figure 11: Health monitoring system using IoT [22]

IV. 4. RESULT

This section examines the system performance in natural operational settings. The system's performance was initially tested utilizing the patient's or disabled person's minute movements [24]. A user controlled the wheelchair prototype in the disorganized lab solely with gestures, as shown in Table 1. The web app or Android app we produced as the third item can display history and current data from the wearable, the second item we created. With the aid of the guide, the job is completed, and the results are satisfactory.

Table 1: Wheelchair Direction Algorithm using ADXL355 Accelerometer.

Hand Gesture	ADXL335 Accelerometer Values (0 – 720)			Direction of Movement
	X- axis	Y-axis	Z-axis	
Stable (0o)	360	360	360	Stop
30o Bend in the Right	>390	360	360	Right
30o Bend in the Left	<310	360	360	Left
30o Bend in Forward	360	>390	360	Front
30o Bend in Backward	360	<310	360	Reverse
10 cm above Arm Rest	360	360	>390	Emergency Stop
10 cm below Arm Rest	360	360	<390	Emergency Stop

V. 5. FUTURE SCOPE

Investigating the differences between using a smart wheelchair as mobility assistance, a training tool, or an assessment tool might be intriguing. The following future directions, which would be the top objectives for research on smart wheelchairs, are suggested and explored.

Safety Oxygen Cylinders:

Today, many wheelchair users need to transport oxygen cylinders in their wheelchairs because they need to use oxygen. To avoid potential problems, we can incorporate safety oxygen cylinders into this intelligent wheelchair, comprising an anchoring mechanism connected to the chair framework and support used to accept the cylinder partially. Benefits could consist of being Patient-safe and easy to utilize.

Seat Adjustment and Comfort Sitting:

This might be considered a future feature since impaired people can be comfortable based on their requirements. This will minimize the daily chronic back pain that the disabled feel and help to improve posture.

Solar Rechargeable Batteries:

Energy is the source of power for carrying out daily tasks. Still, as its supplies are quickly depleting, civilization has had to depend more on non-depletable resources to meet demand [25]. Sunlight is one of the limitless sources because it is abundant, healthy for the environment, and free of emissions. Everyone is, therefore, focused on making the best use of it feasible from a technological standpoint. An electrically induced wheelchair is propelled by an electric motor rather than the user's power. Electrically propelled wheelchairs have an additional electrical power source that may be built into the wheelchair or connected to the manually powered wheels, in contrast, to manually propelled wheelchairs, which are four-wheeled and not foldable.

VI. 6. CONCLUSION

The primary goal of our study is to assist people who use wheelchairs daily. For a person who requires or uses a wheelchair, we created a gesture controlled smart wheelchair. This wheelchair is more autonomous because of its intelligence. People won't need assistance with every assignment because they can accomplish their tasks independently. The health monitoring tool is beneficial because it may notify anyone about the health of disabled people (especially older people), including their children, who may live far away. A caution message will also persuade the other person to take the disabled person to the hospital in an emergency, improving the patient's chances of survival. Many wheelchairs are available in the market, but they. Either don't have health care features or aren't very smart. This wheelchair could help a great deal of people around the globe.

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