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Design and Fabrication of An Automated Solar-Assisted Wheelchair

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ABSTRACT

The mobility of physically disabled people has become an important social concern in today's society. A wheelchair is used for the mobility of disabled people. Some wheelchairs are operated manually, while others are operated by a joystick. In recent years, the use of renewable energy in various sectors has gained popularity. The solar-assisted wheelchair is an innovative mechanical device that offers self-mobility with the help of a Bluetooth control app. It allows users to control the wheelchair using an Android app, eliminating the need for a joystick and addressing related issues, while utilizing renewable energy sources. The wheelchair is powered by a solar panel that charges the battery through an electrochemical process, which provides power to the motors that rotate the wheels. As a result, the user's effort to operate and control the wheelchair's wheels and joysticks is reduced. Different buttons in Android apps allow the wheelchair to go left, right, forward, and backward. If no button is pressed, the wheelchair remains stationary due to the motor's high torque. Additionally, there is a manual brake system available for use when needed. The wheelchair also features a charging regulator and a cord for charging mobile devices. This solar-assisted wheelchair has been successfully developed and tested. The average speed of this vehicle is 2.47 km/hr on concrete roads, 2.84 km/hr on asphalt roads, 1.96 km/hr on brick roads, and 2.54 km/hr on floors. This wheelchair is especially beneficial for people with disabilities in rural areas, and it is an affordable, user-friendly, self-driven solution. It provides greater independence and is cost-effective, making it a viable option for low-income countries like Bangladesh.

Keywords: Wheelchair, Solar Power, Bluetooth Control, Automated wheelchair

1. Introduction

Since the Industrial Revolution, energy consumption has increased significantly due to the combined effect of rising individual usage and population growth. The mass production of the photovoltaic (PV) cell, which uses solar energy with low fluctuation and converts it into electrical energy, can reduce the pressure on the energy sector as well as help make the environment green [1]. The integration of renewable energy into medical assistive devices, such as solar power, is gaining momentum to enhance mobility and independence for individuals with disabilities, reflecting a growing trend in sustainable healthcare solutions [2], [3].

According to the World Health Organization (WHO), a person with a disability is defined as someone who faces issues with body function or structure, has limitations in performing activities, or struggles to complete tasks. The WHO also reports that more than 1 billion people worldwide live with disabilities, and 20% of them experience significant challenges in their daily functioning. People with disabilities are concerned about their independence. That's how the concept of a wheelchair originated. A wheelchair is a movable chair that assists persons who have trouble walking normally [4]. People who are physically disabled can become self-dependent by using a wheelchair [5]. Robotic welfare help is a common answer to this problem. Supportive robotic technology has the ability to reduce the requirement for human assistance [6]. Bluetooth, a relatively new and very successful technology, has transformed how people use digital gadgets at home and work, transforming wired electronic devices into wireless ones [7]. Android phones are in nearly every hand nowadays. According to Statista in, there will be 6.648 billion smartphone users globally in 2022, accounting for 83.72 percent of the global population [8].

There are various types of wheelchairs available on the market, including attendant-driven manual wheelchairs, hand-driven pedal-powered tricycles, joystick-controlled solar-powered wheelchairs [9], and electric wheelchairs that can be operated using a touchscreen joystick in some instances[10], [11]. Joystick-controlled wheelchairs allow movement in multiple directions, including left, right, forward, and backward. Additionally, there are Eyes-Based Electric Wheelchairs that offer hands-free operation [12]. Certain wheelchairs are now equipped with voice control functionality [13]. Recently, advancements in deep learning [14] and brain-machine interfaces (BMI) [15] have further revolutionized wheelchair technology, enabling even more seamless and efficient control. Self-driven mechanical wheelchairs, however, can be challenging to operate for extended periods, particularly on uneven terrain. Maintaining control becomes problematic if the user's hand slips. While electric wheelchairs offer ease of movement, they require charging, and frequent power outages (load shedding) are common in rural areas of Bangladesh. Furthermore, the price of many electric wheelchairs is beyond the reach of middle-class and lower-middle-class families. Joystick issues are a common problem in electric wheelchairs, with premature damage [16].

Given the high initial cost of conventional electric and smart electric wheelchairs [17], there is a critical need for

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affordable, sustainable alternatives, especially for middle-class and lower-middle-class individuals in rural areas. This study aims to develop a Smart Solar-Assisted Wheelchair, integrating renewable energy with advanced smart control technology to provide an accessible, low-cost solution for people with disabilities.

This Solar assisted wheelchair uses Bluetooth connectivity to link to an Android phone, allowing users to control its movement with a simple app. This smart control system enables intuitive control of direction, such as turning and maneuvering, all from the convenience of a mobile device. The system is powered by an Arduino Uno, which not only manages the wheelchair's functions but also ensures it operates at a constant speed, enhancing user comfort and safety. By using solar energy to reduce electricity dependency, this wheelchair lowers ongoing operational costs while promoting greater independence for users. This innovative design offers a smart, sustainable mobility solution, empowering individuals with disabilities, particularly in rural communities.

3. Design and fabrication

To reduce costs, the vehicle design should prioritize simplicity, easy assembly, local materials, even force distribution on the wheel, and an effective braking system for stability.

3.1 Design

Keeping in mind the above considerations, a model of the Solar-assisted wheelchair has been designed.

Rear wheel dia $= 23.6inch\ = 60cm$

Front wheel dia $= 7.9\ inch\ = 20cm$

Taking,

Constant speed of wheelchair $= 2.5\frac{km}{hr} = 0.7ms^{-1}$

Velocity v = $\frac{\pi\times Dia\times rpm}{60}$ (1)

As motors are connected to the rear wheel

$$\Rightarrow 0.7 = \frac{3.14\times 0.6\times N}{60} \Rightarrow\ N\ =\ 22.29 \backsimeq 22\ rpm$$

Taking a person weight $=\ 80kg$ &

Weight of the system $=\ 40kg$

So total weight $=\ (80\ +\ 40)kg = 120kg$

So, weight on each wheel $=\ 60kg,$

$Torque\ =\ Force\ \times\ Radius$ (2)

$= 60\times 9.8\times 0.30 = 176.4\ Nm$

Sprocket and gear of motor are linked with chain,

And attached to the shaft of rear wheel,

Gear Dia $d_1 =\ 3.5\ cm$ & Sprocket Dia $= 17cm$

Using Driving and driven gear formula,

$\frac{Torque\ wheel}{Torque\ (Motor)} = \frac{Dia(wheel)}{Dia\ (Motor)}$ (3)

$\Rightarrow\ \frac{T(W)}{T(M)} = \frac{D(W)}{D(M)} \Rightarrow\ T(M)\ =\ 36.31$

So, MY1016Z2 motor has 40 Nm torque has been selected. It operates in 24v, 13.4 Amp and the power rating is 250 watts (0.33 Horsepower).

Let, the rotational speed of the sprocket n_1=22 rpm

Available Sprocket Dia, $d_2 =\ 17\ cm$

Motor gear rotational speed (rpm) = n_2

So, $\frac{n_1}{n_2} = \frac{d_1}{d_2} \Rightarrow \frac{22}{n2} = \frac{0.035}{0.17} \Rightarrow n_2 = 106.85$

=107 rpm

Motor power = $\frac{2\pi NT}{60}$ (4)

$= \frac{2\times 3.1416\times 107}{60}$ = 11.20 watt

(1) For charging time Calculation

As two batteries are connected in parallel connection,

So, voltage v=12v, Current I= I_1+I_2 =60Amp,

So, Battery capacity = 72watt hr

Estimated charging time = 720/80 hr (By Solar panel)

(No load to full load) = 9hr

During the rainy season, LT01 AC90-240V 50/60 Hz charger will be used. Charging of capacity

= 24 V × 1.8 A =43.2 watt

So, Charging time $= \frac{30\times 1.2\ watt\ hr}{43.2\ watt}$ =8.33 hr

(2) Discharging time calculation

As two motors are used, The total power of motor =11.20 × 20 watt =22.4 watt, So Discharging time = 720 watt hr / 22.4 watt = 32.14 hr, =32 hr 8 minute 24 second.

(3) Sprocket design

Let, Sprocket teeth number $= n_2$

$\Rightarrow \frac{n_1}{8} = \frac{17}{3.5} \Rightarrow \frac{n_1}{8} = 4.85 \Rightarrow \frac{n_1}{8} = 4.9$

n_1 = 8 × 4.9=39.2 ≈ 40

3.4 CAD Model

The wheelchair frame is 20 inches wide, the seat height is 19 inches from the ground, and the distance between the seat and the solar panel is 29 inches.

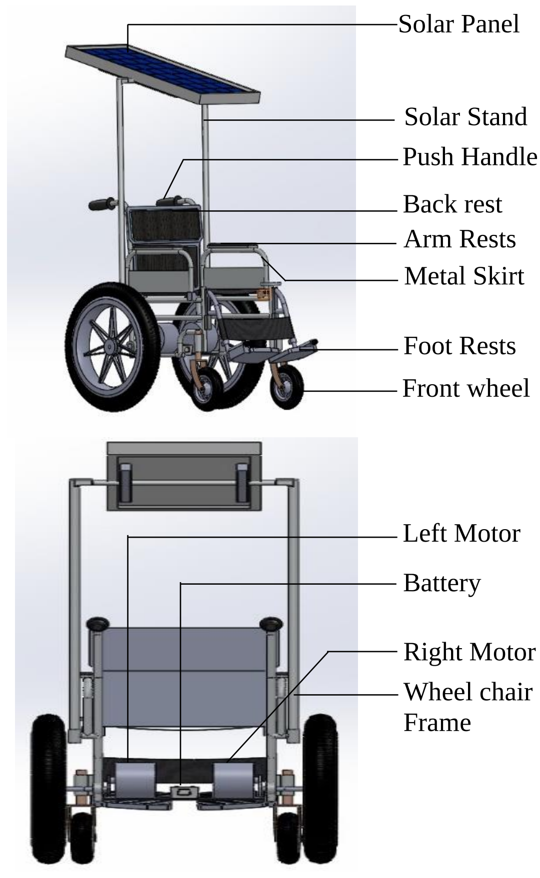

Fig. 1 CAD Model of Solar Assisted Wheelchair

3.5 Electrical Components

The main electrical components include two DC gear motors, two 12V batteries, one Bluetooth module, one solar panel, one battery charge controller, and two motor driver

ICs. The specifications of these components are selected based on technical calculations and the availability of materials in the local market. Cost and weight are key factors considered when choosing the components.

(1) DC Motor & Motor Driver

The MY1016Z2 motor and BTS7960 motor driver are employed in this system design, capable of transporting specified weights and meet system requirements, can rotate in bidirection and H bridge motor driver has 8 control pins for getting signals from connected Arduino Uno.

(2) Rechargeable Battery

For storing the solar energy, the China 6-Dzm-30 (12V30AH) battery was chosen for this design due to its availability and low cost,

(3) Arduino Uno & Bluetooth Module

In comparison to the ATmega328, the Arduino Uno is specifically a microcontroller board. The boot-loader code preprogrammed into the onboard microcontroller chip allows programs to be uploaded into the microcontroller memory [18] which is linked to a Bluetooth device for left and right motor drivers and an LM2596 buck converter. As a Bluetooth Module, the HC-05 lets the system build a seamless wirelessly serial connection [19]. The Arduino Software (IDE) communicates with the Arduino Uno, Motor Driver, and Buck Converter by connecting to them and uploading programs [20] .

(6) Solar Panel & Battery charging controller

A solar cell utilizes the photovoltaic effect, a physiochemical phenomenon to convert light energy directly into electricity [21]. When light shines on a solar cell, it generates both a current and a voltage, which is used to create electricity [22]. Solar panel poly with such a peak power of 80 Watt has been chosen as the solar panel and battery charging controller has been chosen for preventing overcharging.

3.6 Methodology

The base of the wheelchair is where the motors, batteries, driving wheels, casters, and electronics are located. The microcontroller has been configured to operate the motor driver IC in response to the Android app's input commands. The motor is controlled by the motor driver IC, connected in such a way that the wheelchair may travel in four directions: forward, right, left, and back. There is no need to look ahead or monitor the phone, as releasing the press button automatically engages the brake due to high torque. Two different systems work on this solar-assisted wheelchair.

(1) Power System

Using photovoltaic effect; the potential difference is produced at the junction of two different materials because of electromagnetic radiation [23]. A battery converts chemical energy into electrical energy [24]. The solar panel is connected to a battery charge controller, a DC motor controller, and a battery bank. This charge controller controls

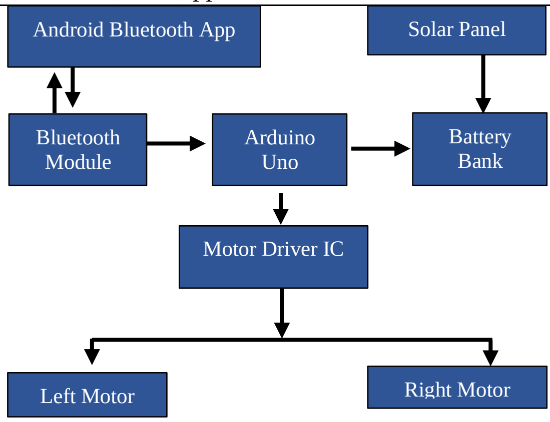

Fig.2 Solar-Assisted wheelchair Controlling diagram

the charge of the battery, which helps to increase battery life. The motor controller connects with the left and right motors, which drive the left and right wheels chronologically. A battery is used to convert chemical energy into electrical energy [24]. The solar panel is connected with a battery charge controller, a DC motor controller, and a battery bank. This charge controller controls the charge of the battery, which helps to increase battery life. The motor controller connects with the left and right motors, which drive the left and right wheels chronologically.

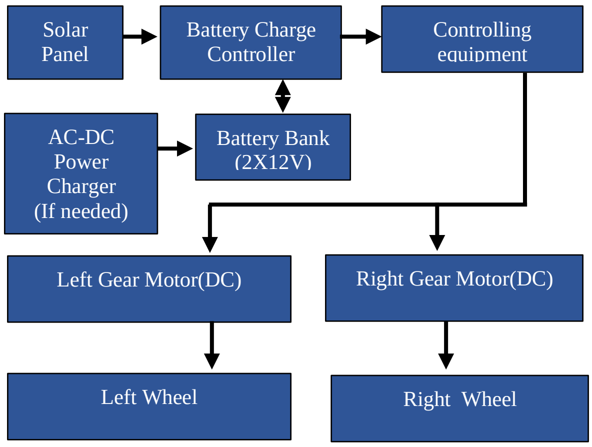

Fig.3 Solar-assisted wheelchair functional block diagram

(2) Bluetooth Control System

The Android screen will identify the push button by the user finger and respond to each movement, transmit information to the Bluetooth transmitter, and transmit this data over Bluetooth. The Bluetooth module receives the data and sends it to the microcontroller on the receiving side. The microcontroller's job is to accept incoming data and determine if it's control or PWM data [25]. The data received will be decoded by the microcontroller, and output will be generated appropriately. Two motor drivers receive the output. Two digital inputs (0 & 1) and one analog PWM input are available on the motor drivers. The motor will revolve clockwise or counterclockwise depending on whether the input is 01 or 10. The motor will be in offcondition when the control input is 00 and in high impedance off state when the control input is 11. When one wheel is rotating clockwise and the other is rotating counter-

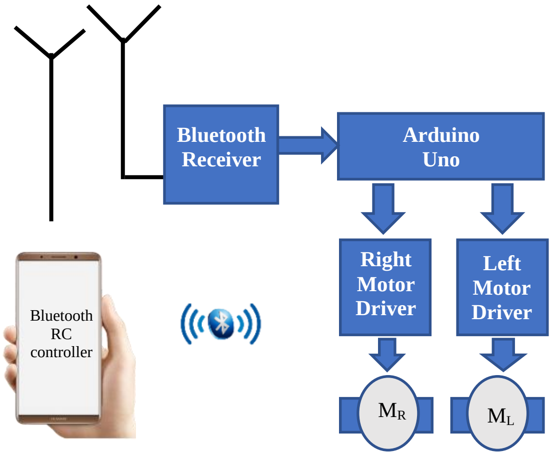

Fig.4 Bluetooth control system for Solar Assisted Wheelchair

clockwise, then the wheelchair moves linearly. If the left wheel stops and the other wheel rotates, the wheelchair will turn left. If the right wheel stops and the other wheel rotates, the wheelchair will turn right. It works with the help of an Android app in the Google Play Store named Bluetooth RC Controller.

3.7 Construction

Various factors are taken into account during construction. The frame's maximum load capacity is 120 kg, these includes reliability, cost efficiency, weight, design, etc. The construction is design-based, although certain changes were made due to better performance during construction. A hand brake is added to this constructed model. The solar-assist Wheelchair has been constructed successfully.

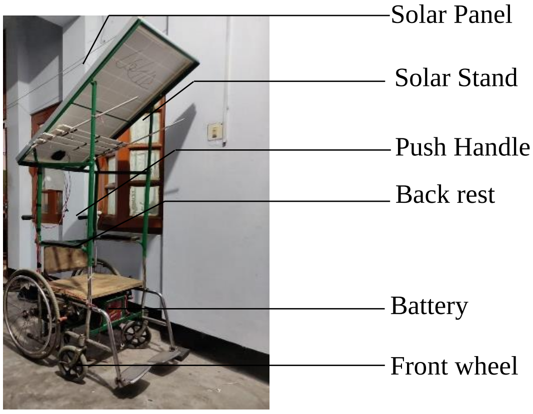

Fig.5 Fabricated Solar Assisted Wheelchair

4. Results & Discussion

A solar-assisted wheelchair for disabled people has been designed to reduce the cost of the wheelchair and to make easier movement for handicapped people. It is less expensive than a modern wheelchair. Operating this type of solar-assisted wheelchair is more accessible than a joystick-driven wheelchair and a self-driven manual wheelchair. Using this wheelchair, the user doesn't face any pain like back pain, elbow pain, etc. There is also a manual braking system in the vehicle to stop if needed. As it is operated with the help of solar energy, it can be used in areas where electricity is unavailable. As the solar can charge the battery, there is no need for electricity. And during the rainy season, one can use an electric charger to charge the battery during the rainy season. If the road is smooth, then this wheelchair can run smoothly. In this construction, a small error happened due to the small, uneven distribution of load, and the foot of the wheel is not at the same height as the ground. The parts of the wheelchair are easily replaceable. Handicapped people who have no strength in their arms but have strength can easily use this type of wheelchair. Average speed is suitable for handicapped people. If the wheelchair moves too fast, then the impaired people won't feel comfortable. As time is also important, the speed is taken by considering the comfort of impaired people as well as time value. The speed is set based on the user's average feedback and the standard speed of conventional electric wheelchairs.

4.1 Economic Analysis

Table 1 provides the anticipated cost of this wheelchair based on the market prices of these parts available in Bangladesh Electronics Market.

Table 1 Estimated cost of the wheelchair

Items	Quantity	Cost (BDT)	Cost (USD)
Solar Panel 80Watt	1	3200	26.67
MY1016Z2 Motor	2	2x3500	58.33
Physical Structure	1	6000	50
Rechargeable Battery	2	2x3800	63.33
Arduino Uno	1	850	7.08
Charge controller	1	400	3.33
Motor Driver	2	2x750	12.50
Bluetooth Module	1	350	2.92
Buck Converter	1	150	1.25
Total		27050	225.42

Table 2 Cost comparison between Solar Assisted wheelchair VS Electric-only Wheelchair

SI No.	Component	Solar-Assisted Wheelchair	Electric-only Wheelchair
01	Initial Cost	BDT 27,050	BDT 90,000
02	Electricity Costs per Year	Included with Solar Panel	BDT 5,000
03	Total Annual Cost	BDT 4,430	BDT 23,000

The average lifespan of an electric wheelchair is around 5 years, based on market surveys. For the solar-assisted Wheelchair, market surveys suggest the solar panel lasts 20 years, the motors 7 years, the battery 4 years, and other electronic components around 5 years. It is assumed the electric wheelchair is used for 4 hours per day, with an electricity cost of BDT 12 per kWh. The economic benefits of a solar-assisted wheelchair are significant, particularly in sunny regions where the use of solar power eliminates the need for electricity, resulting in lower operational costs. Over time, this leads to considerable savings. In contrast, an electric-only wheelchair comes with higher ongoing operational costs due to its electricity consumption and initial cost making it a more expensive option in both the short and long term.

4.2 Performance Test of a Solar-Assisted Wheelchair

The maximum speed found is 2.84 km/hr for asphalt roads. The minimum speed for brick roads is 1.96 km/hr.

Table 3 Speed for concrete road

Exp. No.	Distance Travelled (m)	Time Required (sec)	Speed (m/s)	Speed (km/hr)
01	30	42.8	0.70	2.52
02	30	43.1	0.69	2.48
03	30	44.3	0.67	2.41

Average speed for concrete road is 2.47 km/hr.

Table 4 Speed for asphalt road

Exp. No.	Distance Traveled (m)	Time Required (sec)	Speed (m/s)	Speed (km/hr)
01	30	37.0	0.81	2.88
02	30	40	0.75	2.7
03	30	36.5	0.82	2.95

Average speed for asphalt road is 2.84 km/hr.

Table 5 Speed for brick road

Exp. No.	Distance Travelled (m)	Time Required (sec)	Speed (m/s)	Speed (km/hr)
01	30	53.5	0.56	2.01
02	30	54.4	0.55	1.98
03	30	56.0	0.53	1.91

Average speed for brick road is 1.96 km/hr.

Table 6 Speed for Floor

Exp. No.	Distance Travelled (m)	Time Required (sec)	Speed (m/s)	Speed (km/h)
01	30	41.67	0.72	2.59
02	30	42.30	0.71	2.55
03	30	43.01	0.69	2.48

The average speed for the floor is 2.54 km/hr.

4.2 Limitations

Some energy is lost as heat because motors are not always 100% efficient. Batteries lose capacity with time, and when they discharge, the voltage may decrease. This could have an impact on the motors' actual power usage. Temperature can also affect battery performance, thus severe weather may result in less capacity. This wheelchair cannot be used efficiently in places with a lot of traffic and is not appropriate for people with severe disabilities. The battery might not be able to be fully charged in bad weather, therefore grid electricity might be required under those circumstances. People with disabilities of different ages may require varying speeds, but this wheelchair does not offer such customization options.

5. Conclusion

For people with lower limb problems, a solar-assisted wheelchair has been created. This wheelchair uses less energy and is more eco-friendly. With a top speed of 0.82 m/s on asphalt surfaces, it is suitable for daily transportation. Those who can operate an Android mobile device will find this automated wheelchair easy to use. By using renewable energy sources, this study aims to reduce the amount of electricity consumed by conventional wheelchairs. This solar-assisted model is more affordable than other electric-only automated wheelchairs currently available on the market. To enhance the functionality of this solar-assisted wheelchair, IoT-integrated braking mechanisms could be introduced, reducing the effort required for manual braking. A suspension system could also be added for improved user comfort, and a speed adjustment feature could provide greater control and flexibility.

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References

[1] N. Pedro, F. Tiago and B. M. C., "Day charging electric vehicles with excess solar electricity for a sustainable energy system," *Energy,* vol. 80, pp. 263-274, 2015.

[2] A. Sohail, A. Ali, H. Shaukat, F. M. Bhatti, S. Ali, S. A. Kouritem, M. Noori and W. A. Altabey, "Integrating self-powered medical devices with advanced energy harvesting: A review," *Energy Strategy Reviews,* vol. 52, no. 101328, 2024.

[3] S. Fuada, M. Särestöniemi and M. Katz, "Analyzing the Trends and Global Growth of Energy Harvesting for Implantable Medical Devices (IMDs) Research—A Bibliometric Approach," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 20, no. 3, p. 115–135, 2024.

[4] Hartman, A. Gillberg, R. Lin and Nandikolla, "Design and development of an autonomous robotic wheelchair for medical mobility," International Symposium on Medical Robotics (ISMR), 2018.

[5] Akash, S. A. Menon, A. Gupta, , M. W. Wakeel, , M. N. Praveen, and . P. Meena,, "A novel strategy for controlling the movement of a smart wheelchair-using internet of things.," IEEE global humanitarian technology conference-South Asia satellite (GHTC-SAS), 2014.

[6] Kawakami, Y. Takahashi, S. Matsuo and Kei, "Energy Control System of Solar Powered wheelchair," INTECH, Rijeka,Shanghai, 2010.

[7] P. Sirisha, D. P. Bethapudi and R. M. Meghana, "WIRELESS SMART WHEELCHAIR," International Journal of creative research thoughts(IJCRT), Visakhapatnam, 2020.

[8] A. Turner, "HOW MANY SMARTPHONES ARE IN THE WORLD?," 2009 . [Online]. Available: https://www.bankmycell.com/blog/how-many-phones-are-in-the-world. [Accessed 2 April 2022].

[9] S. N. Saki, S. P. Mouri, Z. Ferdous and M. S. Kaiser, "A Study on Low Cost Solar Powered Wheel Chair for Disabled People of Bangladesh," ICCIT, Dhaka, 2015.

[10] S. Karoshi, G. Kori, A. Manoli and J. Athani, "Design And Fabrication of Low Cost Tricycle for Handicaps Using Steering Column Propulsion," IRJET, VIJAYAPURA, 2017.

[11] Y. Rabhi, M. Mrabet, F. Fnaiech, P. Gorce, I. Miri and C. Dziri, "Intelligent Touchscreen Joystick for Controlling Electric Wheelchair," IRBM, 2018.

[12] K. Arai and R. Mardiyanto, "Eyes Based Eletric Wheel Chair Control System," *International Journal of Advanced Computer Science and Applications,* vol. 2, no. 12, pp. 98-112, 2011.

[13] B. Sachdeva, Anshuman, N. Jha and A. Raj, "Voice Controlled Wheelchair System," *2024 2nd International Conference on Disruptive Technologies (ICDT),* pp. 1448-1452, 11 April 2024.

[14] J. Xu, Z. Huang, L. Liu, X. Li and K. Wei, "Eye-Gaze Controlled Wheelchair Based on Deep Learning," *Sensors,* vol. 23, no. 13, 2023.

[15] T. Kocejko, N. Matuszkiewicz, P. Durawa, A. Madajczak and J. Kwiatkowski, "How Integration of a Brain-Machine Interface and Obstacle Detection System Can Improve Wheelchair Control via Movement Imagery," *Sensors,* vol. 918, no. 24, 2024.

[16] A. Celani, "Parts that can break on an electric wheelchair and how to fix them.," Mobility Equipment for Less, 29 May 2019. [Online]. Available: https://mobilityequipmentforless.com/blogs/mobility-equipment-recyclers-blogs/parts-broken-electric-wheelchair-how-to-fix. [Accessed 07 December 2024].

[17] M. Sellars, "Best electric wheelchairs," 2024. [Online]. Available: https://mobilitydeck.com/best-electric-wheelchairs/. [Accessed 07 December 2024].

[18] D. P. B. R. M. M. Y. N. Sirisha, "Wireless Smart Wheelchair," International Journal of Creative Research thoughts(IJCRT), 2020.

[19] C. Yamini, R. M. M, D. . P. Bethapudi and Sirisha, "Wireless smart wheelchair," *International Journal of Creative Research thoughts(IJCRT),* vol. 8, 5 May 2020.

[20] . P. P. Sirisha, Yamini, Bethapudi, M. Ratna and NaveenaLakshmi, "Wireless smart wheelchair," IJCRT, Visakhapatnam, 2020.

[21] Sob, M. Pita and P.B., "DESIGN OF SOLAR -POWERED GRASS TRIMMER," *IN SAIIEneXXXt Proceedings,* vol. October, p. 1–8, 30 September 2019.

[22] "Solar Photovoltaic Cell Basics," US Department of Energy, [Online]. Available: https://www.energy.gov/eere/solar/solar-photovoltaic-cell-basics. [Accessed 3 April 2022].

[23] S. P. Mouri, Z. Ferdous, S. N. Sakib and M. S. Kaiser, "A Study on Low Cost Solar Powered Wheel Chair," ICCIT, 2015.

[24] M. . H. Masud, M. S. Akhter, S. Islam, A. M. Parvej and S. Mahmud, "Design, Construction and Performance Study of a Solar Assisted Tri-cycle," Researchgate, 2017.

[25] R. K. Megalingam, S. Sreekanth, G. A, C. R. Teja and A. Raj, "Wireless Gesture Controlled Wheelchair," International Conference on Advanced Computing and Communication Systems(ICACCS), Amritapuri, 2017.

[26] okeenea-group, "Disabled People in the World in 2021: Facts and Figures," keenea-group, 26 November 2021. [Online]. Available: https://www.inclusivecitymaker.com/disabled-people-in-the-world-in-2021-facts-and-figures/. [Accessed 2 April 2022].

[27] Wikipedia, "Wheelchair," [Online]. Available: https://en.wikipedia.org/wiki/Wheelchair. [Accessed 2 April 2022].

NOMENCLATURE

T : Torque
W : Weight
mm : millimeter
m : Meter
t : time
sec : second
Km : Kilometer
Amp : Ampere
v : Volt
rpm : revolution per minute
N : Newton
AH : Ampere Hour
Nm : Newton meter