Solar Powered chair with Line Follower System and RFID Authentication

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***Abstract*--When we look around, we find many people with special needs to carry out their day-to-day activities. We empathize with them for not leading a normal life like any other. Although many ways are learned to wear off their dependability, it remains a concern that another person is needed to assist them. As technology advances, there are permutations of innovations that are coming forward to help out disabled people. We thought about how can we contribute in our way to enhance the capability of their living individually. We came up with a solar-powered wheelchair with innovative and unique features. The paper presents the following semi-automatic control system. This work stands out as unique in terms of enhanced ease of movement and operations. The wheelchair is on command with an RFID system providing the instance of the path to travel to reach a specified destination. The movement of the chair is controlled by an IR array thereby following a strict line of movement. The addition of Solar panels is a big advantage to make the wheelchair energy-free. This work presents the research on the calibration of the sensors, overall function, and energy management of the proposed control system.**

***Keywords: Arduino, RC-522, IR sensor array, ESP32-cam, Solar panels*.**

I. INTRODUCTION

As coined by Oxford Dictionary, disability is defined as an impairment that can be cognitive, intellectual, limitations, sensory, exercise, or a mixture of all these. This incapacity limits a person's activities. It may happen at birth or even in adulthood.

There is an overall estimate of 26.8 million being differently-abled people, which makes up around 2.21% of the population according to the 2011 census.

There are a considerable number of differently-abled persons using wheelchairs in their day-to-day activities. Manual and electric wheelchairs are often satisfying in most cases. But in most severe cases it is difficult to navigate independently, which includes problems like vision impairment, spinal cord injuries, and many more. Consequently, they rely on relatives, nurses, and caretakers. To reduce the dependence on another person, Smart wheelchairs are being innovated over the years using certain control systems and different sensors. Thereby assisting the users by eliminating the use of their effort. The advantage often comes with a drawback. The cost for affording smart wheelchairs is expensive when compared to normal wheelchairs. This parameter is taken into consideration, hence making it cost-effective.

The Objectives of the project are:

- To design a wheelchair that works on renewable energy to be eco-friendly and economical.
- To model a self-driven wheelchair that can be operated with Rf-id authentication.
- To utilize the ideal time of the wheelchair in charging the battery using solar energy.
- To incorporate the line following system to move the wheelchair in a specified direction.
- To introduce a wheelchair with surveillance and an easy control system to reach the required destination.

II. LITERATURE SURVEY

The freedom of mobility gives a sense of confidence and dignity to an individual who is impaired. If we observe the 2011 census Out of 2.21% of the disabled population, 0.6% (~60 lakhs) are suffering from movement disability [1]. It is believed that there would be a distinct increase in this count over the past 10 years. Since there are different kinds of impairments, it becomes difficult to develop a universal model. This work concentrates basically on the movement of the wheelchair without special attention required to reach a destination. There are considerable innovations based on different sensors taking into account the analog input from the users [2][3][4]. The paper published by Monika Jain & Hitesh Joshi [4] gives insights into devices that are mainly equipped for speed control and require considerable accuracy in the sips and puffs each time. Sharp sips and puffs are used to change the direction of the wheelchair, the steering is accomplished by lower/softer levels of sips and puffs [3]. This limits special cases as they require external support to start. The TTK (tongue touch keypad) is the only commercially available tongue controller system. It consists of 9 switches that are embedded in the dental mouthpiece and are fitted to the roof of the mouth [4]. This type of technology is technically speaking is efficient but quite costly to afford. Although in terms of control gives a free hand to users, a straightforward approach to reaching somewhere in unknown terrains with limited strain is what this paper is focusing on. For example: In a hospital relocate a person to a different chamber for scanning, operation or regular check-ups, etc,

India is situated in the sunny belt (tropical) endowed with vast solar energy potential. The Government of India launched the Jawaharlal Nehru National Solar Mission (JNNSM) in 2009. Its target was to start Grid-connected Solar Projects of 20 GW by 2022. In May 2015 the government increased the target to 100 GW by 2022 [5]. This free-energy source will come into effect as the future of smart devices all over the world. We

have devised a solar-powered chair that uses a line follower system for assistance in the track along with backing up the path by the RFID technology. It is highly accurate in its function and being cost-efficient is an advantage.
Comparative analysis is performed in reference to papers [8], [9], [10], [11], [12], and [13] with the proposed work. A table showing the same is given in the RESULTS section.

III. PROPOSED MODEL

The below block diagram presents the blocks of various components of the proposed model.

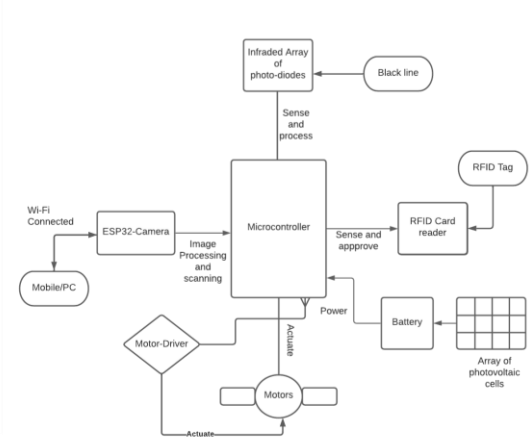

Fig 1: Basic Block diagram

The Block diagram consists of the following main components: -

- Arduino mega microcontroller-2560 (2)
- solar panels- 12V, 5W
- battery-related components
- wheelchair
- DC Motors chassis and Motor drivers
- RC-522 Module
- LCD/Device
- IR sensor array
- ESP32-Cam

IV. WORKING

The powered wheelchair is incorporated with a line following system which acts as a backbone to the movement. The RFID technology comes into use for the authentication of a particular route which is correlated using the unique code of the RFID Tag and the command to be followed by the motor driver.

A. Flowchart:

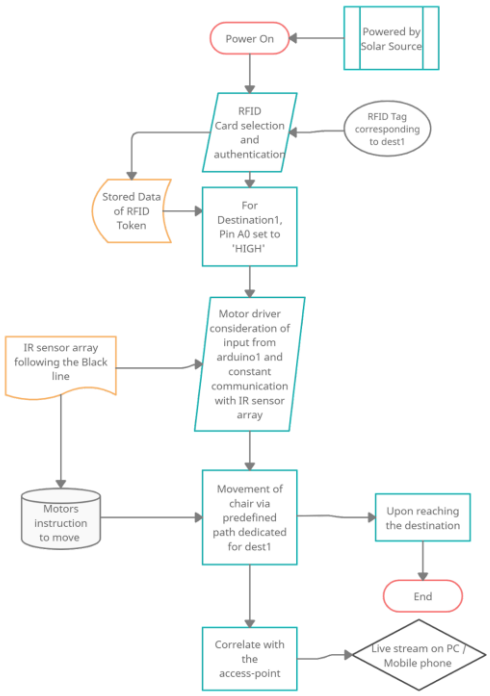

Fig 2: Flow Chart

B. Circuit Diagram:

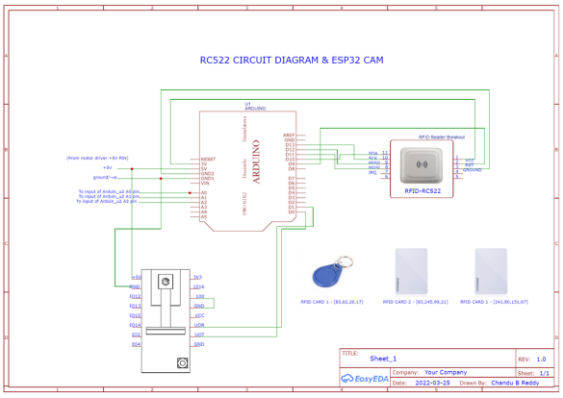

Fig 3: Circuit Diagram 1

The circuit diagram consists of RC-522 and ESP32-Cam. The RC-522 consists of a card reader and a set of cards/tags. The card reader generates low-frequency electromagnetic waves that are transmitted over the coil. It uses the principle of electromagnetic induction producing EM waves into free space. The RFID tag has a unique identification number embedded into its chip, which is a hexadecimal code of 8 characters. When the EM waves come into contact with the coil of the RFID tag, the chip is in an inactive state. the card reader gets information about the RFID unique card id. the programmer can control the Analog pins of Arduino in response to the right tag that is placed on the card reader, related to the particular route. The ‘route’ refers to a set of instructions that the motor driver is coded with to follow a certain path. the RFID tag code is already pre-determined and particular Analog pins set as output are turned ‘HIGH’ that in turn act as input to other Analog pins of different Arduino.

There are 3 different tags for 3 routes considered for the prototype. The routes correspondingly have their set of instructions Arduino is coded with.
Another main aspect that needs to be considered is the wheelchair which is self-driven for a certain input, surveillance plays an important role to monitor the process. the ESP 32 camera is a low-cost DIY component that has inbuilt Wi-Fi and Bluetooth with a camera (2-4MP). the ESP 32 camera uses a Wrover model (AI thinker) to record real-time data of the camera and display the video data in the device that is connected to the same Wi-Fi network. When the ESP 32 camera is connected to a Wi-Fi-Network, It generates an IP address that can be used in any web browser (only devices connect to the same Wi-Fi network) to open a web interface of the live cam thereby acting as a surveillance camera.

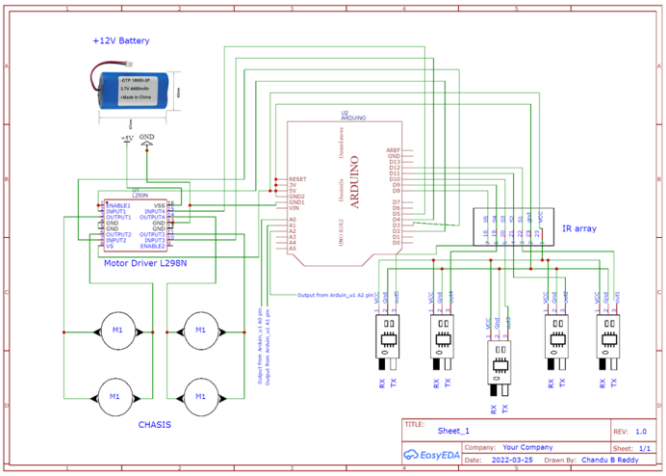

Fig 4: Circuit Diagram 2

The +12v battery acts as the source for the whole circuitry of a wheelchair. The three cells with specifications of 3.7v and 1200mAh are connected in series to generate a +12v supply.

The +12v batteries are periodically recharged using the solar panel of 12V and 5 watts. There are 4, 12v motors that are being controlled by a motor driver in the above circuit diagram. The output of 3 analog pins of other Arduino act as inputs to three pins of the Arduino in circuit diagram 2.

The motor driver consists of four controls signal that receives ‘HIGH’ and ‘LOW’ signals in different permutations for the chair to move forward, backward, right, and left direction respectively. Hence using them to monitor the direction of the chair in the right direction.
The IR sensor array consists of five different IR sensors (transmitter and photodiode) embedded parallelly in an array with a spacing of 4cm width. The sensor's control signals are S1, S2, S3, S4, and S5 respectively. They are placed less than 5cm above the ground plane to detect the surface. The potentiometer is provided to increase the range of each sensor.

The arena is embedded with ‘black’ tape that acts as a black body, absorbing all rays that IR sensors emit and not allowing them to reflect. When one of the 5 sensors senses the Blackline, it transmits a control ‘LOW’ signal. The logic ‘0’ and ‘1’ of each control signal is utilized to form instructions to the motor driver.

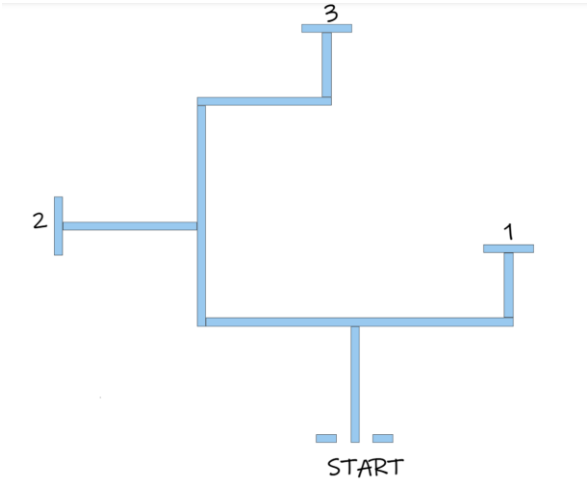

Fig 5: Arena/path

V. RESULTS

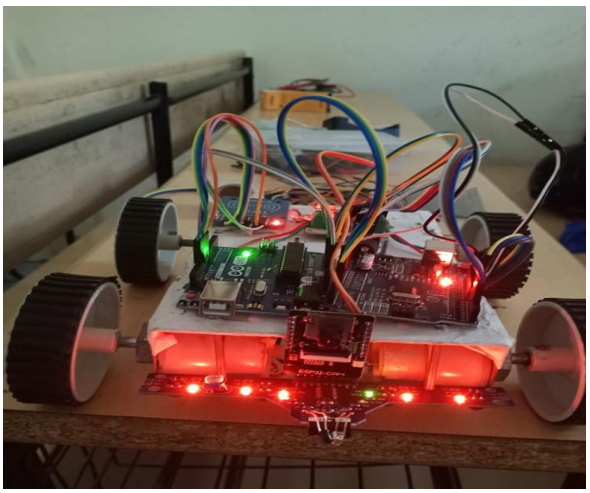
Fig 6: Initial prototype (front-view)

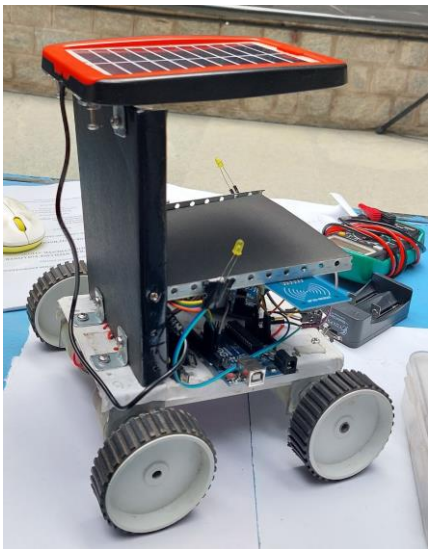
Fig 7: Final Prototype

The initial prototype above presents all the proposed functionalities without the wheelchair and load.
The proposed work is the design of the route following with the help of RFID support and Solar power. Below are the tables presenting the accuracy of operation:

1. Solar panel: Here Table [1] gives the data on its efficiency in generating power.

Table [1]: This table contains the output of the solar panel in Volts and Amps at different hours of the day taking Bangalore city as reference.

Hour of the day (Ref: Bangalore)	Without Sunlight	With Sunlight
At morning	0.34V, 0.12A	2.56V, 0.29A
At Afternoon (Peak hour)	0.74V, 0.12A	(i) 6.7V, 0.37A (ii)11.32V, 0.48A.
At evening	0.34V, 0.12A	1.9V, 0.27A

2. RC-522: The response time of the RFID reader to read an RFID tag was *10-12ms.*

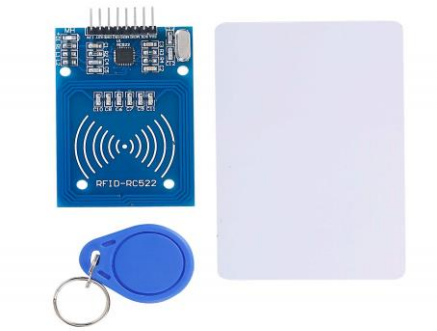

Fig 7: RFID Scanner and Tags

3. IR Sensor Array: The IR sensor array contains 5 affixed sensors, the below Table [2] presents the data of combination of control signal outputs and its corresponding instruction to motor driver.

Table [2]: The table presents control signals S1, S2…S5 for the corresponding IR sensors Ir1, Ir2…Ir5 thereby Controlling the motor driver for different inputs taken from each control signal.

Control signal	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trail 5**
S1	**1**	**1**	**1**	**1**	**0**
S2	**1**	**0**	**1**	**0**	**0**
S3	**0**	**0**	**0**	**0**	**0**
S4	**1**	**1**	**0**	**0**	**0**
S5	**1**	**1**	**1**	**1**	**0**
Instruction: (Motor driver)	↑	←	→	**start**	**decision**

4. ESP32 CAM: Esp32cam is used for surveillance and has a spectrum range of 2412~2484MHz and an overall communication range of 460 meters with Connected Wi-Fi.

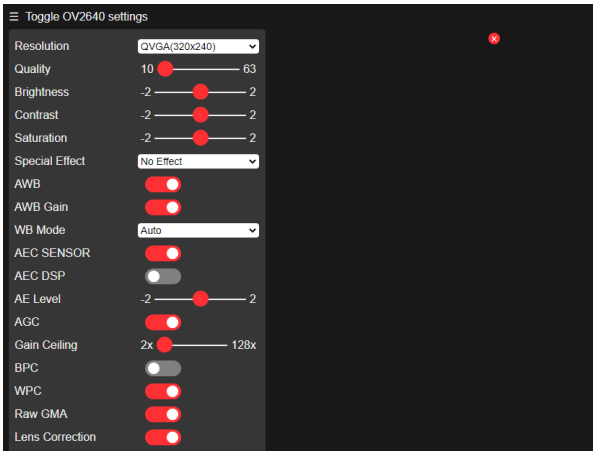

Fig 8: Web interface of ESP32cam

5. Comparative analysis of Different papers that were published in recent years based on features:

Analysing the below papers, the table is formulated showing the features:
[i] Design and Fabrication of Solar powered wheelchair with smart features of mobility - Aug-2021 [8].
[ii] Smart wheelchair integrating hand gesture navigation - Jan-2019 [9].
[iii] A Novel design of Gesture and voice-controlled solar-powered smart wheelchair with obstacle detection - Feb -2020 [10].
[iv] Design of Line following wheelchair for visually impaired paralyzed patients - Jan-2021 [11].
[v] Infrared sensor-controlled wheelchair for physically disabled people - Nov-2018 [12].
[vi] Smart solar wheelchair controlled using the android app and joystick - Jan-2021 [13].
The Below Tables [3.1] and [3.2] shows the comparative analysis of proposed work with above mentioned papers.

Table [3]: The table presenting papers [i],[ii],[iii],[iv] considering 5 features and its comparision with Proposed work.

Features	**[i]**	**[ii]**	**[iii]**	**[iv]**
Flexibility in movement	2 modes of control interface	Head and hand gesture movements	Voice and gesture Controlled	Line-following System (only 2 paths) and Bluetooth based remote control system
Security	Fingerprint sensor	–	–	–

Surveillance	Panic key	_	_	GSM
Obstacle avoidance	_	Ultrasonic sensor	Ultrasonic sensor	Ultrasonic sensor
Movement via	Mechanical and electrical interface	Accelerometer based	Accelerometer based	IR sensors and Bluetooth remote control [HC-05]

Table [4]: The table presenting papers [v],[vi] considering 5 features and its comparision with Proposed work

Features	**[v]**	**[vi]**	**Proposed Work**
Flexibility in movement	IR sensor-controlled	Android app control system	Line Following system
Security	_	_	RFID (RC-522)
Surveillance	GSM	Emergency button	ESP32-Cam live stream
Obstacle avoidance	_	Ultrasonic sensor	Limit switch & Ultrasonic Sensor
Movement via	Eye movement captured by IR	Wi-Fi control system giving instruction [ESP8266]	Automatic path choosing by IR sensor array

VI. APPLICATIONS

- Can be used in hospitals to guide the patient directly to emergency. For example, Patients take help from the ward boy or nurse as it might be difficult to navigate to the chamber in case of emergency.
- Can be used in malls, education institutes, and parks it gives easy mobility for disabled persons to move around the parks without taking any help from others.
- This technology can be used by Forklift for the automation of its processes.
- Army/Defence personnel who lost their legs in the war or bombardment can also use this system and still can contribute to the military station, as there is the ease in mobility.

VII. CONCLUSION

The current technology of the world is constantly evolving in all terms. Although the technology has a good share of utility, it should be affordable for the general public to be of use hence making it cost-effective. The constraints considered for our work included mainly smart movement with minimal human interference and using a renewable source to power the wheelchair. We were successfully able to come up with a model with added features of the same that had already been innovated. The wheelchair is simple in its design and operation as well the current model is in the prototype stage, we practically found that the wheelchair is economical.

ACKNOWLEDGMENT

We are Sincerely thankful to REVA UNIVERSITY for providing the opportunity to publish our research paper titled ***"Solar* powered Chair with Line Follower System and RFID Authentication".**

We are very thankful to our project guide Mrs.Prameela Kumari N, Associate. Professor, Reva University for guiding us throughout the term of research, regular guidance helped us get the best out of the work.

We hope this paper will serve as a source for the aspirants working in similar fields/technologies and extract something useful from the work.

REFERENCES

[1] https://censusindia.gov.in/census_and_you/disabled_population.aspx
[2] R. A. Cooper, M. L. Boninger, A. Kwarciak, and B. Ammer, Engineering in Medicine and Biology, 24th Annual Conference and the Annual Fall Meeting of the Biomedical Engineering Society EMBS/BMES Conference, 2002.
[3] R. Berjoøøn, M. Mateos, A. L. Barriuso, I. Muriel and G. Villarrubia: "*Alternative human-machine interface system for powered wheelchairs*", IEEE 1st International Conference on Digital Object Identifier, Serious Games and Applications for Health (SeGAH), 2011.
[4] Monika Jain and Hitesh Joshi, *"Tongue Operated Wheelchair for Physically Disabled People"*, International Journal of Latest Trends in Engineering and Technology (IJLTET).
[5] Solar Power – Current Status, Challenges, and Policies in India Rachit S*, Vinod KG
[6] Sunshine & Daylight Hours in Bangalore, India - "*https://www.bangalore.climatemps.com/sunlight.php*.
[7] Madheswari, A. N., Latha, S., & Iswarya, M. (2017). "*Solar-powered wheelchair with voice controller for physically challenged persons". 2017 2nd International Conference on Communication and Electronics Systems (ICCES)*. doi:10.1109/cesys.2017.8321229.
[8] Vijayakumar, K., Vikram, T.R., Sadamurugan, P.(2021)."*Design and Fabrication of Solar-powered Wheelchair with Smart Features for Mobility".*Proceedings of the 2nd International Conference on Electronics and Sustainable Communication Systems, ICESC 2021.
[9] Dey, P., Hasan, M.M., Mostofa, S., Rana, A.I (2019). "*Smart wheelchair integrating head gesture navigation*".1st International Conference on Robotics, Electrical, and Signal Processing Techniques, ICREST 2019.
[10] Haque, A.B., Shurid, S., Juha, A.T., Sadique, M.S., Asaduzzaman, A.S.M (2020). *"A Novel Design of Gesture and Voice Controlled Solar-Powered Smart Wheel Chair with Obstacle Detection"*. 2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies, ICIoT 2020.
[11] Shoovo, G.R., Dey, B., Akash, K., Motahara, T., Imam, M.H.(2021). *"Design of a Line following Wheelchair for Visually Impaired Paralyzed Patient "*.International Conference on Robotics, Electrical and Signal Processing Techniques.
[12] Nadia Nowshin, Md Moontasir Rashid,Tasneema Akhtar (2018). **"** *Infrared sensor-controlled wheelchair for physically disabled people"*.Proceedings of the Future Technologies Conference (FTC) 2018 (pp.847-855).
[13] Soumya C H, Subhash K M, Reva University (2021). *"Smart solar wheelchair controlled using the android app and joystick"*.Turkish Journal of Computer and Mathematics Education (TURCOMAT).