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Design and Fabrication of Microcontroller Based Multipurpose Robot

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Abstract: The purpose of this work is to develop a versatile multi-purpose robot that utilizes a microcontroller as its central control unit. The robot is designed to perform a range of tasks including grass cutting, floor mopping, pesticide spraying, water spraying, floor cleaning, and UV light sterilization. By integrating various modules and sensors, the robot can adapt to different environments and efficiently carry out these tasks.

For grass cutting, the robot incorporates a sharp cutting mechanism and obstacle detection sensors to navigate and maintain a uniform grass height. The floor mopping module includes a mop attachment and water reservoir for thorough cleaning. The pesticide spraying operation ensures precise delivery of pesticides to target areas while prioritizing user safety. The water spraying feature utilizes a reservoir, nozzle, and pump system for effective plant watering or outdoor cleaning. The floor cleaning module consists of brushes, vacuum suction, and cleaning solution dispensers for comprehensive indoor surface cleaning. Lastly, the UV light sterilization module employs UV-C lights to eliminate harmful bacteria and germs, promoting hygiene.

The microcontroller serves as the brain of the system, enabling the robot to switch between operations based on user commands or pre-programmed schedules. It incorporates algorithms for navigation, obstacle avoidance, and task prioritization. The robot can be controlled remotely through a user-friendly interface, allowing users to monitor and adjust operations as needed.

This multi-purpose robot offers a versatile solution for household tasks, reducing the need for manual labor and enhancing efficiency. It contributes to a cleaner and healthier environment while providing convenience to users. With the integration of a microcontroller, the robot operates seamlessly and makes intelligent decisions, making it an ideal choice for automated home tasks.

IndexTerms -

I. INTRODUCTION

The development of robotics has revolutionized various industries, offering advanced automation and efficiency. In this work, we present a multi-purpose robot that utilizes a microcontroller to integrate several essential operations, including grass cutting, floor mopping, pesticide killing, water spraying, floor cleaning, UV light sterilizing, as well as the addition of solar panels and a solar charge controller to charge the battery. By combining these functions into a single robotic platform, we aim to provide a versatile and convenient solution for various domestic and commercial settings, while also harnessing renewable energy.

The integration of a microcontroller serves as the brain of the robot, enabling it to perform complex tasks with precision and adaptability. This microcontroller acts as the central processing unit, coordinating the various components and sensors required for each operation, including the newly added solar panels and solar charge controller. With this addition, the robot can harness solar energy to charge its battery, reducing its reliance on traditional power sources and contributing to a more sustainable and environmentally friendly solution [1].

Through programmed instructions and sensor feedback, the robot can autonomously execute tasks, reducing manual effort and improving overall efficiency. The grass-cutting feature involves the integration of a cutting mechanism, which efficiently trims grass on lawns or other designated areas. Utilizing sensors and navigation algorithms, the robot can navigate autonomously, ensuring an even and well-maintained lawn, all while being powered by solar energy [2]. The floor mopping functionality includes the integration of a mopping module that effectively cleans various types of floors. The robot's microcontroller processes input from sensors and controls the movement and cleaning patterns, ensuring thorough and effective mopping, while benefiting from the energy provided by the solar panels [3].

For pesticide killing, the robot incorporates a spraying system that accurately dispenses pesticides in designated areas. This feature enables targeted pest control, reducing the need for manual intervention and minimizing exposure to harmful chemicals, all while being powered by the renewable energy harvested by the solar panels [4]. The water spraying capability is designed to assist with gardening or general cleaning tasks. The robot's microcontroller allows for precise control of water flow and spray patterns, ensuring efficient and controlled irrigation or cleaning, with the added advantage of utilizing solar power [5].

In addition, the robot includes a floor cleaning module that utilizes brushes, suction, or other mechanisms to effectively clean various floor surfaces. The microcontroller coordinates the cleaning patterns and adjusts the intensity based on the surface type, optimizing the cleaning process while taking advantage of the energy generated by the solar panels [6]. Lastly, the UV light sterilizing feature contributes to maintaining a clean and hygienic environment. The robot incorporates UV light-emitting modules that can disinfect surfaces and kill pathogens, providing an additional layer of cleanliness and safety, all while being powered by the renewable energy captured by the solar panels [7].By combining these diverse functions into a single multi-purpose robot, we aim to streamline and enhance various household and commercial operations while embracing the benefits of solar energy.

II. Bibliometric ANALYSES AND Gap identification

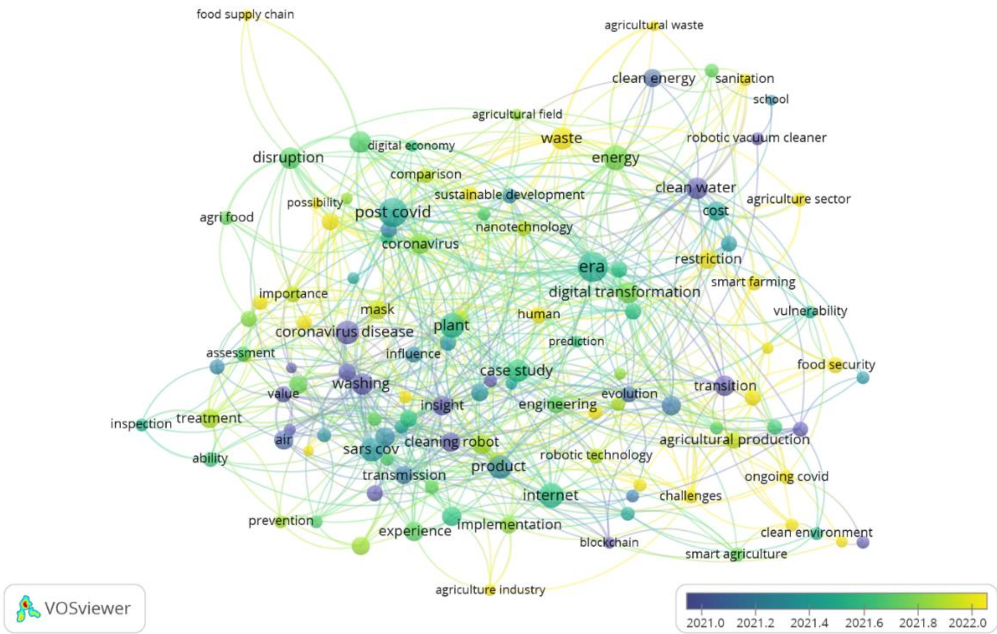

Fig. 1 Research Gap Identification with VOS viewer

Gap identification is a crucial step in research analysis as it helps researchers identify areas where knowledge is lacking or where further investigation is needed. Traditionally, researchers have relied on manual literature reviews to identify research gaps. However, with the advent of advanced tools and technologies, such as VOS Viewer, the process has become more efficient and systematic. VOS Viewer is a powerful software tool designed for visualizing and analysing bibliometric networks. It enables researchers to explore and map the intellectual structure of a specific field or research domain. By analysing bibliographic data from sources like Web of Science, VOS Viewer can identify patterns and relationships between different research articles, authors, institutions, and keywords.

In the context of gap identification as shown in the figure.1, VOS Viewer can provide valuable insights into the existing literature and highlight areas that have not been extensively studied or are underrepresented. By visualizing the co-occurrence of keywords or the clustering of research articles, researchers can identify knowledge gaps and potential areas for future research.

Using VOS Viewer, researchers can generate interactive visualizations that showcase the intellectual landscape of a research field. These visualizations can help identify clusters of closely related research topics, as well as areas with fewer connections or limited research activity. By examining these patterns, researchers can identify specific research gaps and formulate research questions that can contribute to the advancement of knowledge in their field.

Overall, VOS Viewer serves as a valuable tool for gap identification, enabling researchers to gain a comprehensive understanding of the existing literature and identify areas that require further exploration. Its visualizations provide researchers with a clear picture of the research landscape, empowering them to make informed decisions about the direction and focus of their own research projects.

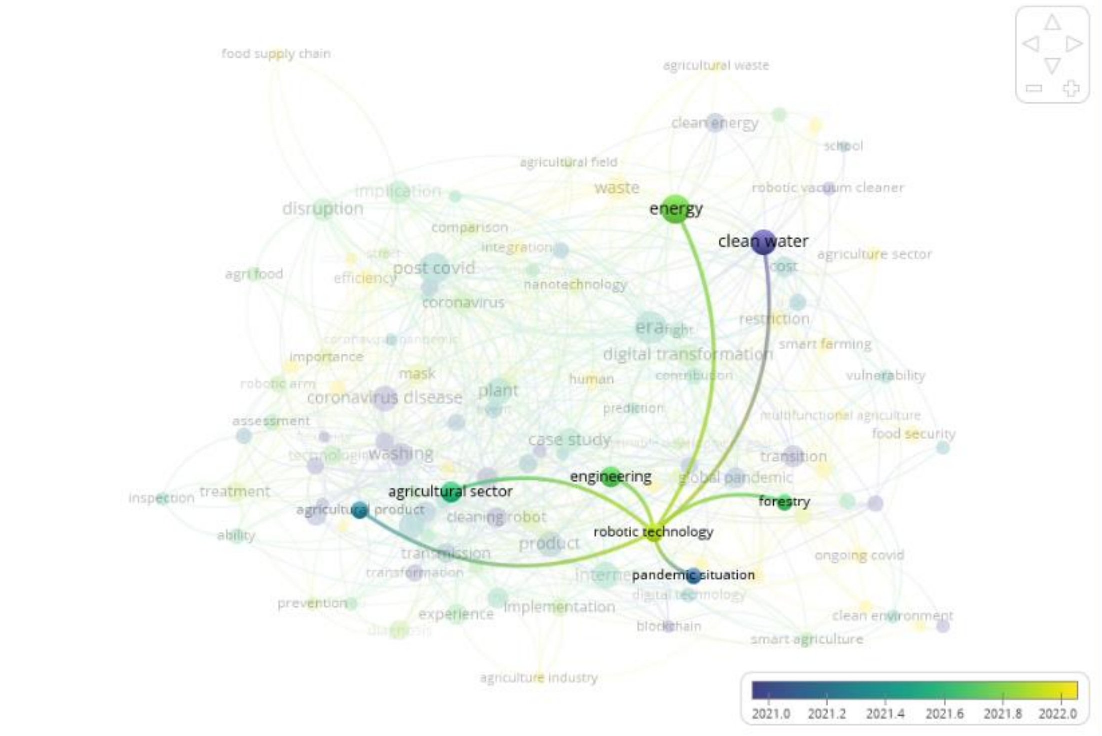

Fig .2 Research Gap identified in the study of Robotic Technology

The research gap identified in the study of Robotic Technology as shown in the figure.2 encompasses multiple domains, including forestry, pandemic situations, engineering, agriculture sector, and energy. This network of research gaps signifies the need for further investigation and innovation in the application of robotics to address challenges and opportunities in these diverse areas, contributing to advancements and solutions in the respective fields.

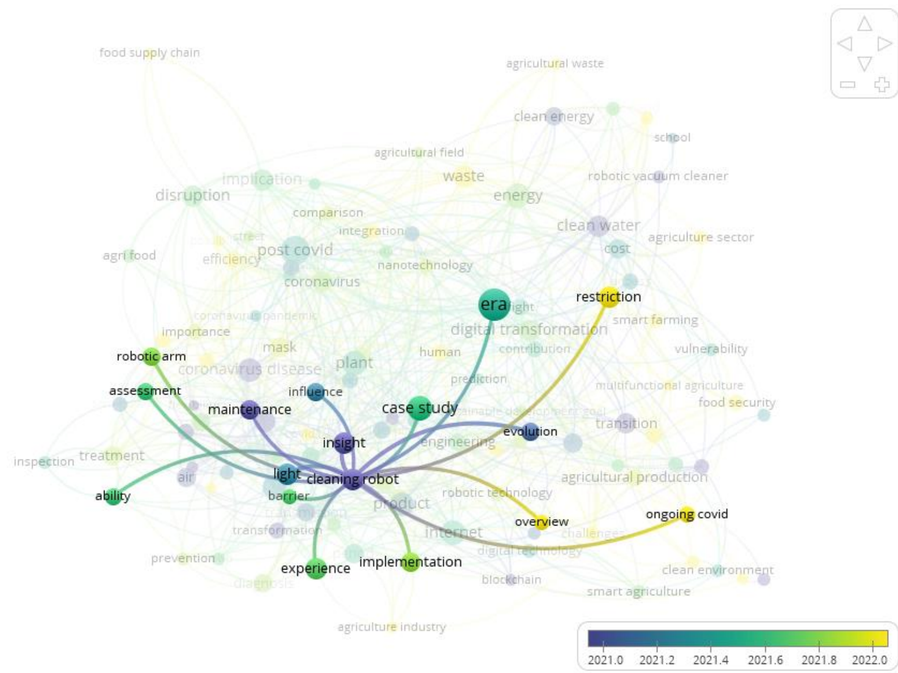

Fig.3 Research Gap identified in the study of Cleaning Robotic

The analysis of the Cleaning Robotic research domain using VOS Viewer identified several research gaps related to keywords as shown in the figure.3 such as light, UV light, era, ongoing COVID, implementation, influence, and evolution. These gaps suggest a need for further investigation into the role of light, particularly UV light, in the development and functionality of cleaning robots. Additionally, there is a gap in understanding the impact of ongoing COVID situations on the implementation and adoption of cleaning robotic technologies. Furthermore, the gaps indicate a need to explore the influence and evolution of cleaning robotic systems in the current era.

In the study of the Digital Era in Agriculture, several research gaps were identified as shown in the figure.4 through the analysis of keywords using VOS Viewer. The identified research gaps include digital transformation, clean water, cleaning robot, sustainable agriculture, energy, pandemic world, COVID, pesticides, and labour. These gaps highlight the need for further investigation and exploration in understanding the impact of digital technologies, sustainable practices, and efficient resource utilization in agriculture, particularly in the context of clean water management, robotic cleaning solutions, and the challenges posed by pandemics and labour availability.

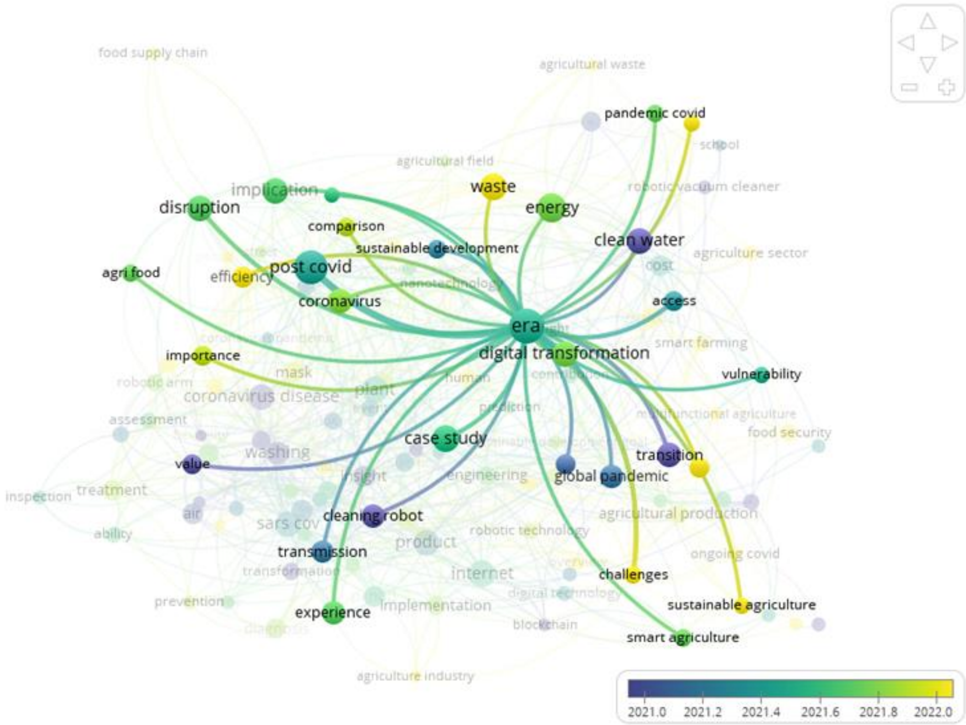

Fig.4 Research Gap identified in the study of Digital Era in Agriculture

III. Design and Modeling

3.1 DESIGN OF 3D MODEL SOLID EDGE SOFTWARE

The design of the project model was created using Solid Edge software, a powerful 3D modelling and design tool. Solid Edge offers a comprehensive set of features and tools that enable precise and efficient creation of 3D models. The design process started by outlining the project requirements and specifications, which guided the overall design concept. The software allowed for the creation of detailed 3D models, incorporating all the necessary components and features. The design included considerations for structural integrity, functionality, and aesthetics. Solid Edge's intuitive interface and parametric modelling capabilities facilitated the development of the project model, allowing for easy modification and refinement as needed

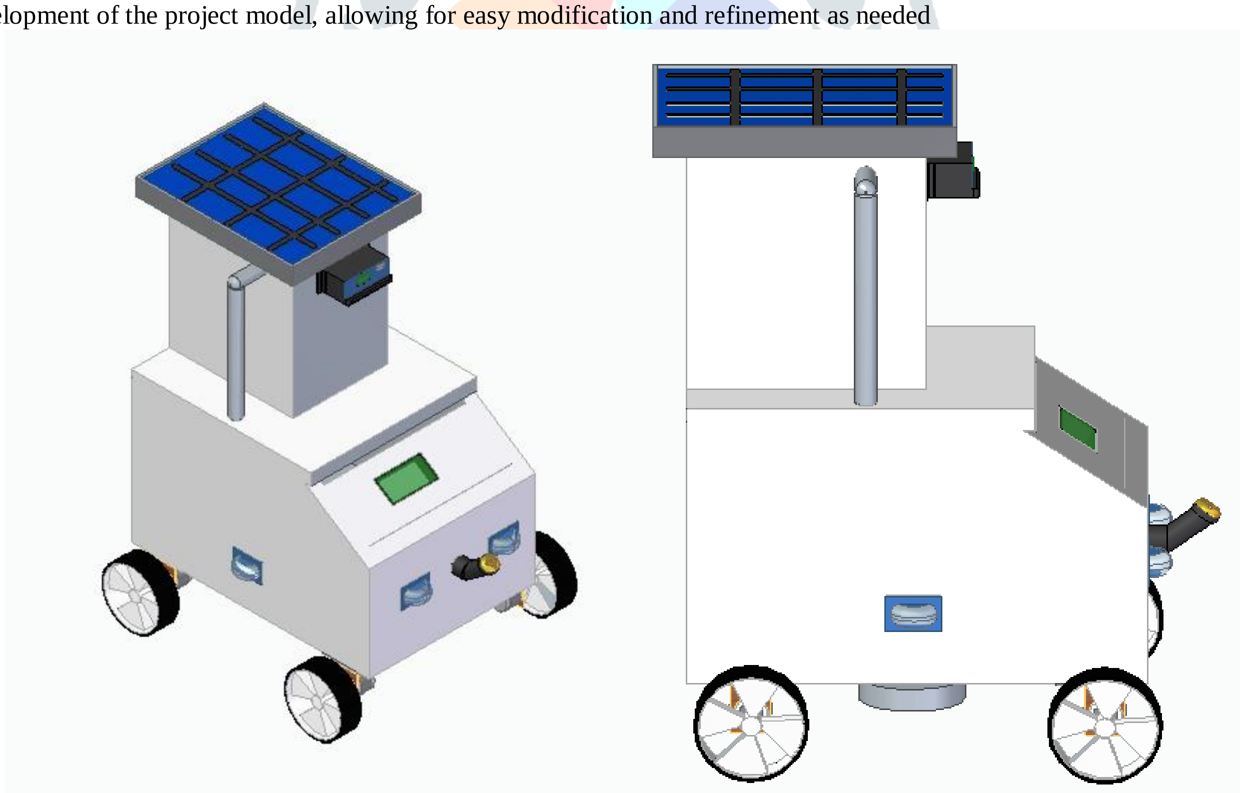

Fig.5 3D Modeling of Robot (Iso metric ad Side View)

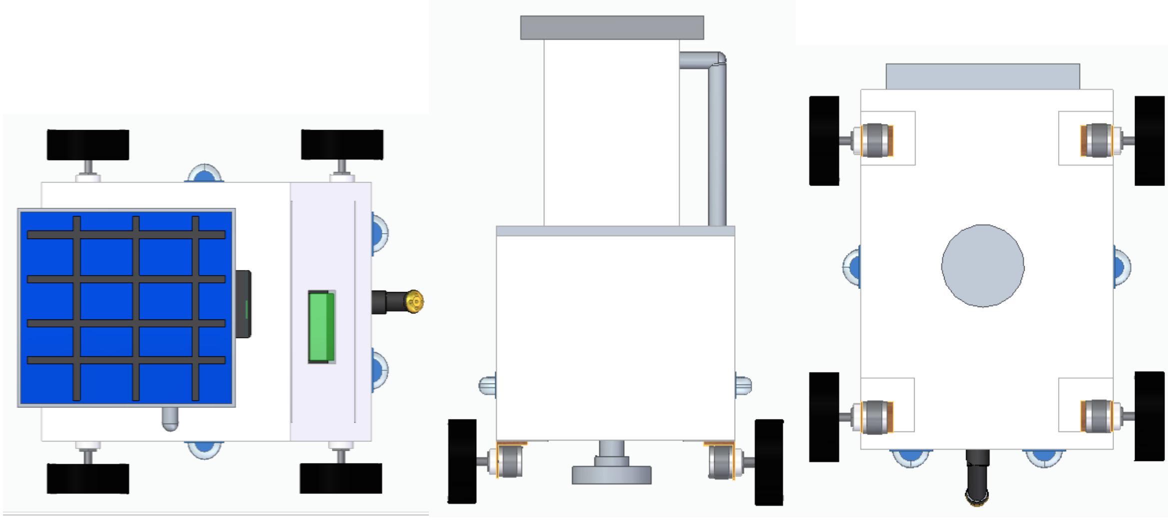

Fig.6 3D Modeling of Robot (Top, Bottom, and Back Views)

The software's advanced tools, such as assembly modelling and motion simulation, ensured that all components fit together correctly and operated smoothly. The design process involved iterating and fine-tuning the model to achieve the desired functionality and appearance. Solid Edge's rendering capabilities provided realistic visual representations of the project model, aiding in visualizing the final product. Overall, the design in Solid Edge software allowed for the creation of a well-engineered and visually appealing project model that met the project's requirements and objectives.

3.2 DESIGN OF 3D MODELLING IN AUTO CAD SOFTWARE

Designing in 3D using AutoCAD software offers a versatile and efficient approach to creating detailed and realistic models. AutoCAD is a powerful computer-aided design (CAD) software widely used in various industries for drafting, designing, and modeling. With its 3D modeling capabilities, AutoCAD allows users to create three-dimensional representations of objects, spaces, and structures with precision and accuracy. The software provides a wide range of tools and features, such as extruding, revolving, and sweeping, that enable the creation of complex geometries and intricate designs. Users can manipulate and visualize their designs from different perspectives, adding depth and dimension to their models. Additionally, AutoCAD supports the integration of materials, textures, lighting, and rendering techniques, enhancing the visual quality and realism of the 3D models. Designing in 3D with AutoCAD offers numerous advantages, including improved visualization, better communication of design intent, and the ability to detect potential issues or clashes in the early stages of the design process. Whether used in architecture, engineering, or product design, 3D modeling in AutoCAD empowers designers to bring their concepts to life and create compelling and detailed representations of their designs.

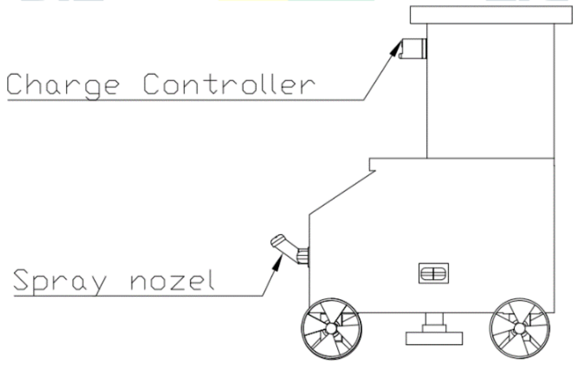

Fig.7 Left Side View of Auto Cad Model

In the Left side view of the CAD model, the charge controller and nozzle are positioned at the front of the robot. This placement allows for easy visibility of the battery charge level and enables the robot to spray water or other liquids from its front side. The charge controller is responsible for managing the charging process and monitoring the battery's charge level, ensuring efficient operation of the robot. By locating it in the front, users can easily check the battery status and take appropriate action if necessary. Additionally, the nozzle positioned in the front allows for precise and controlled spraying of water or other liquids during various tasks. This configuration ensures that the robot can effectively perform its intended functions, such as watering plants or cleaning surfaces, while providing convenience and user-friendly operation.

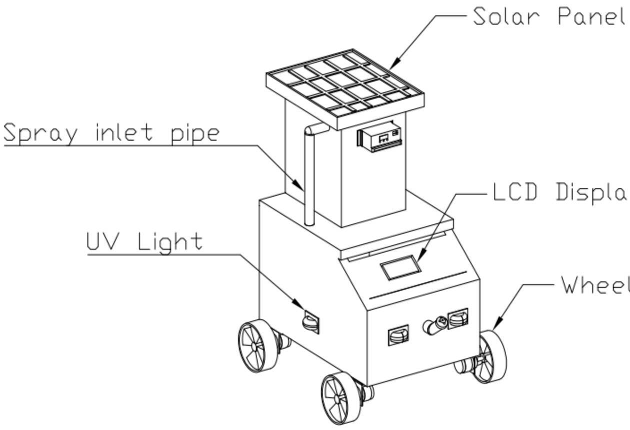

Fig.8 Iso Metric View of Auto Cad Model

In this Iso Metric view of the CAD model, the UV light, wheels, LCD display, and solar panels are arranged as depicted in the figure above. The solar panels are positioned on the top of the robot, allowing for the collection of solar energy. The UV lights are strategically placed on both sides of the robot and also in the front, ensuring effective distribution of UV light. Additionally, the spray inlet pipe is located on the outside, serving as an indicator for water or liquid flow. This design configuration optimizes the functionality and efficiency of the robot by harnessing solar energy, providing adequate UV light exposure, and facilitating proper liquid flow for various tasks.

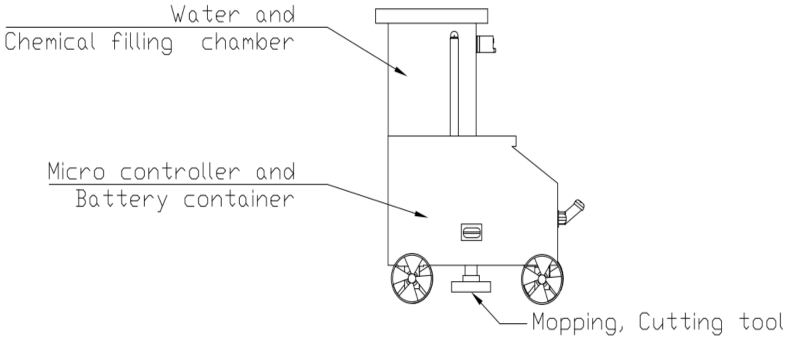

Fig.9 Right Side View of Auto Cad Model

In the right-side view, the figure illustrates the arrangement of components in the multi-purpose robot. At the top, there is the water filling chamber, which is designed to hold the required amount of water for various tasks. In the middle portion of the robot, we find the placement of the microcontroller and the battery container. The microcontroller serves as the control unit of the robot, overseeing its operations and executing programmed instructions. The battery container houses the power source that supplies the necessary energy for the robot to function. Lastly, at the base of the robot, we can observe the mopping and cutting tools. These tools are integral to the robot's functionalities, enabling it to effectively mop floors and trim grass or vegetation. The mopping tool is designed to efficiently clean various types of surfaces, while

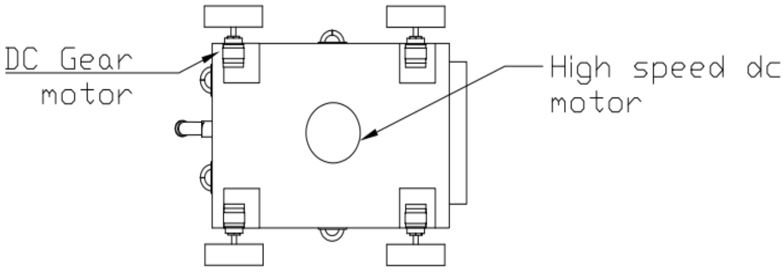

Fig.10 Bottom View of Auto Cad Model

The above AutoCAD model provides a clear visualization of the bottom view, showcasing the integration of a high-speed DC motor and a DC gear motor. These motors are connected to the wheels, enabling remote-controlled movement of the robot. The placement of these motors at the bottom of the robot ensures stability and efficient functionality. With this configuration, the robot can navigate and maneuver smoothly in various directions. The use of high-speed DC motors and DC gear motors enhances the robot's speed and torque, allowing it to perform tasks effectively. The bottom view of the AutoCAD model highlights the careful positioning and alignment of these components, ensuring optimal performance and seamless integration into the overall design.

IV. METHODOLOGY AND WORKING

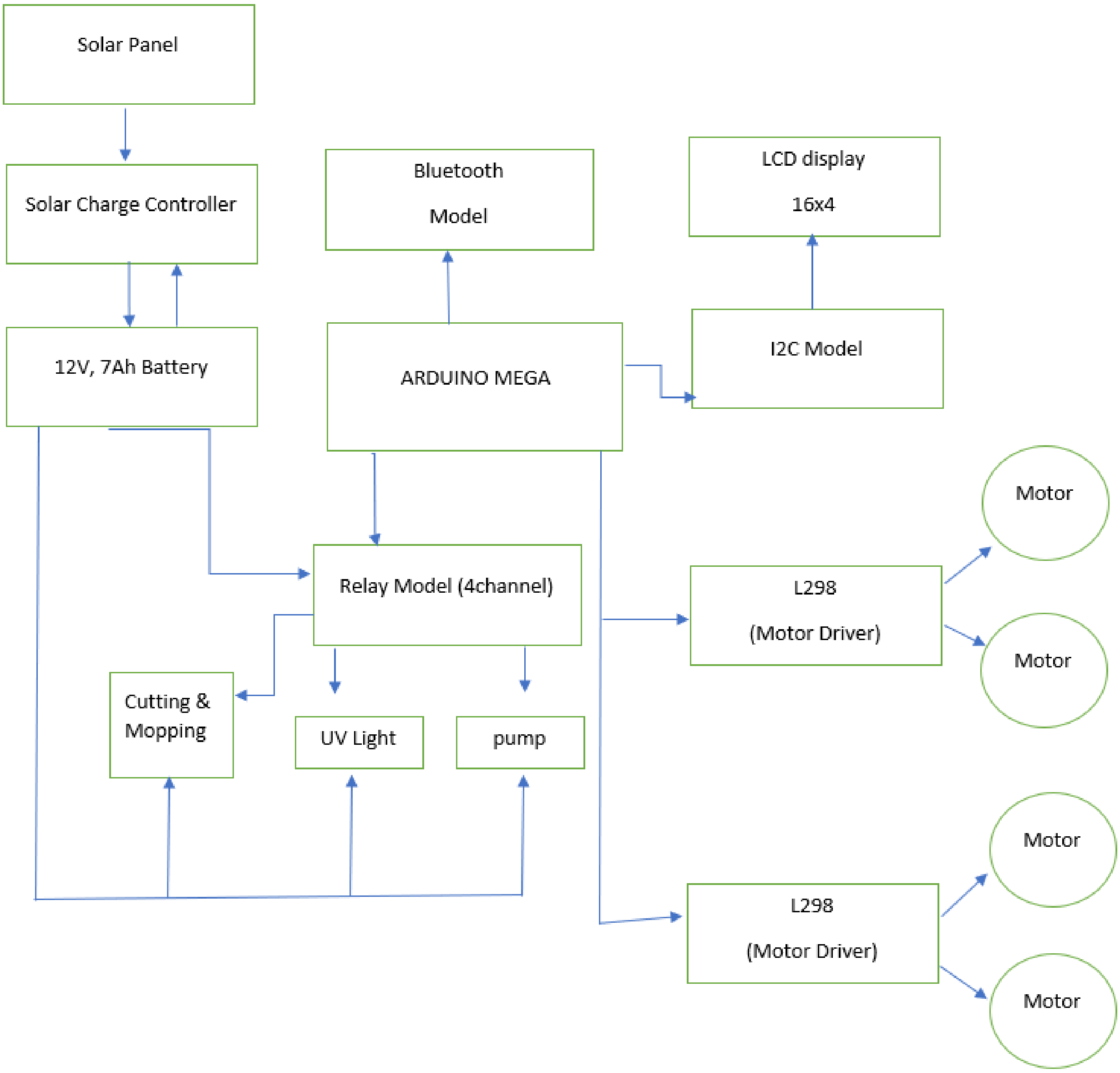

Fig.11 Block diagram of complete project

Once the 3D model is finalized, the electrical connections are established as depicted in the aforementioned block diagram and flow diagram as shown in the figure 10, and figure 12 . The entire system is designed to be controlled via an IoT platform, utilizing a smartphone interface. In order to harness renewable energy, a solar panel is employed to capture solar power, which is then directed to a battery for storage through a solar charge controller. This battery serves as the main power source for all the robot's components. To facilitate the control of various functions, an Arduino microcontroller is employed.

It oversees the motor driver and relay module. The motor driver is integrated with the motor, while the relay module is integrated with the pump and UV light. The high-speed motor is also under the control of the Arduino microcontroller. The microcontroller operates based on commands received from the Bluetooth module, allowing for seamless communication and control between the smartphone interface and the robot's different components.

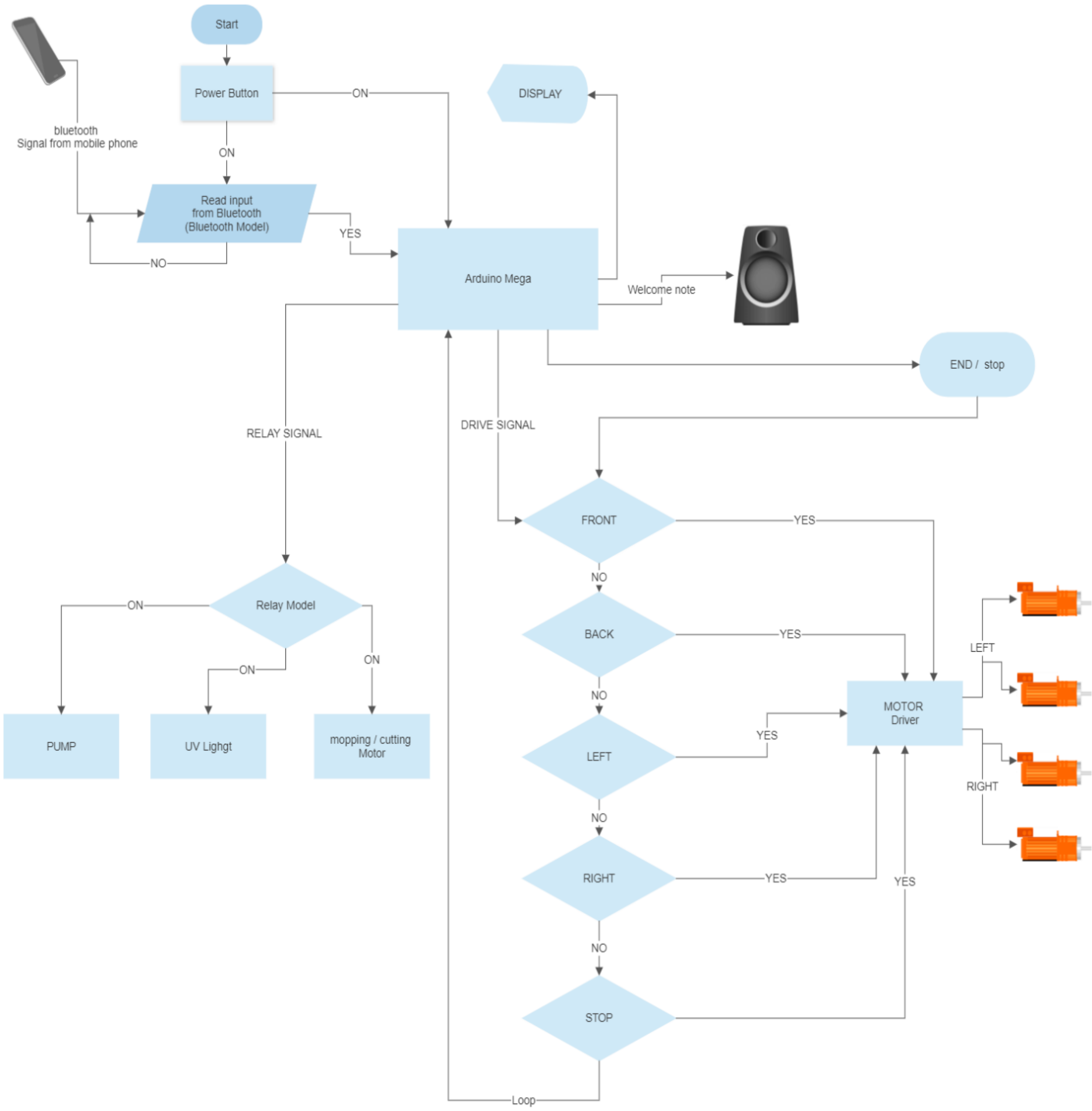

Fig.12 Flow Diagram of the Multipurpose Robot

V. RESULTS AND DISCUSSION

Based on the 3D model created using Solid Edge software and AutoCAD models analysis, we proceeded with the fabrication process to bring the final product to life. Our team carefully examined the intricacies and details of the model, ensuring that every aspect was meticulously accounted for. To materialize the design, we opted to use PVC board as the primary material for the fabrication. PVC board offers excellent durability, strength, and versatility, making it an ideal choice for our project. Its rigid nature ensures stability and longevity for the final product.

In addition to the PVC board, we sourced and selected other raw materials that were essential for the fabrication process. We meticulously analyzed each component required for the product and ensured that the materials chosen were of high quality and met the necessary specifications. Our skilled craftsmen and technicians employed their expertise to transform the digital model into a physical reality. With utmost precision, they cut, shaped, and assembled the PVC board and other raw materials, meticulously following the specifications outlined in the 3D model.

Fig.13(a) Final obtained actual model (front and side view)

Fig.13(b) Final obtained actual model (front view)

Throughout the fabrication process, we maintained strict quality control measures to ensure that each component was aligned correctly and adhered to the highest standards. Our team paid meticulous attention to detail, ensuring that the final product matched the original design, both aesthetically and functionally. The combination of advanced software, careful analysis, and skilled craftsmanship culminated in the successful fabrication of the final product. By leveraging the capabilities of Solid Edge and AutoCAD, we were able to bring our vision to life using the robust and versatile PVC board and other carefully chosen raw materials. The end result is a high-quality, durable product that satisfies our client's requirements and exceeds their expectations

5.1. PROTO-TYPE ANALYSIS

At a particular time, interval, the given readings in Table 1 were taken using Temperature Gun, Solar power meter and multimeter. Prototype analysis is a process that involves collecting and analyzing data from a prototype or experimental model to evaluate its performance, functionality, and other relevant characteristics. In this case, readings were taken using a Temperature Gun, Solar Power Meter, and Multimeter at a specific time interval. A Temperature Gun is a handheld device used to measure surface temperatures. It can be pointed at an object, and it measures the infrared radiation emitted by the object to determine its temperature. A Solar Power Meter is a device used to measure the intensity of sunlight or solar radiation. It provides information about the amount of solar energy available in a particular location. A Multimeter is a versatile electronic instrument used to measure various electrical parameters such as voltage, current, and resistance. It can be used to troubleshoot electrical circuits and components. The readings taken using these instruments can provide valuable information about the performance and functionality of the prototype being analyzed. For example, temperature readings from the Temperature Gun can help assess if the prototype is operating within the desired temperature range. Solar power meter readings can indicate the efficiency of the prototype in harnessing solar energy. Multimeter readings can reveal the electrical behavior and characteristics of the prototype.

5.2 TEMPERATURE GUN

It was used to measure the temperature of solar panel by pointing the gun over the panel, and the readings were taken in Celsius. A temperature gun, also known as an infrared thermometer or laser thermometer, is a handheld device that measures the temperature of an object without making physical contact with it. It uses infrared radiation to detect the thermal energy emitted by an object and converts it into a temperature reading. In the case of measuring the temperature of a solar panel, the temperature gun is pointed towards the panel, and a laser beam is often used to assist with aiming. The gun detects the infrared radiation emitted by the panel's surface, which corresponds to its temperature, and converts it into a temperature reading in Celsius. This non-contact method of temperature measurement is particularly useful when dealing with objects that are difficult or dangerous to access or when quick and frequent temperature readings are required. It allows for a rapid assessment of temperature without the need for physical contact or the risk of damaging the object being measured.

5.3 MULTIMETER

It was used to measure the voltage of the solar panel during the specific time interval. The given data is measured in Volts. A multimeter is an electronic instrument used to measure various electrical parameters, including voltage. In the context of measuring the voltage of a solar panel, a multimeter is used to determine the amount of electrical potential difference present in the solar panel at a specific time interval. The voltage measurement is typically given in Volts, which is the standard unit of measurement for voltage. By connecting the multimeter's probes to the appropriate terminals of the solar panel, it can accurately measure the voltage level.

5.4 SOLAR PANEL ANALYSIS

Table 1 Solar panel analysis

Time in hrs	ɛmperature in Celsius	tage in volts
9.30	26.5	9.1
10.00	27.9	9.32
10.30	28	9.15
11.00	31.5	9.10
11.30	32	8.88
12.00	32.3	8.85
12.30	32.8	9.01
1.00	32.7	8.85
1.30	32.4	9.21
2.00	32.1	9.18
2.30	32	9.12
3.00	31.5	9.06
3.30	28.5	8.27
4.00	27.3	8.15
5.00	26.2	8.1
6.00	25	7.5

5.5 CALCULATIONS

- Total power consumption = (10w * 5)= 50 w/hr
- Power required for working 1 day for 4 hrs = 50 * 4 = 200w/hr
- Power Generated in 7 days to work for 4 hrs = 200 / 7 = 28.7w

The solar panel's performance was evaluated by measuring the temperature in Celsius at various time intervals. The results are as follows: at 9.30 AM, the temperature recorded was 26.5°C, which gradually increased to 27.9°C at 10.00 AM. The temperature continued to rise, reaching 28.0°C at 10.30 AM and further escalating to 31.5°C by 11.00 AM. At 11.30 AM, the temperature peaked at 32.0°C, followed by a slight increase to 32.3°C at noon. Subsequently, the temperature climbed to 32.8°C at 12.30 PM and then remained relatively stable, fluctuating between 32.7°C and 32.4°C during the afternoon hours. As the day progressed, the temperature gradually decreased, reaching 32.0°C at 2.30 PM and 31.5°C at 3.00 PM. By 3.30 PM, the temperature had dropped significantly to 28.5°C, followed by further declines to 27.3°C at 4.00 PM, 26.2°C at 5.00 PM, and 25.0°C by 6.00 PM. These results provide valuable insights into the solar panel's performance and its ability to capture and convert solar energy throughout the day.

The solar panel's performance was evaluated by measuring the voltage output at different time intervals. The recorded data revealed interesting trends in the relationship between time and voltage.Starting at 9:30 AM, when the temperature was 26.5 degrees Celsius, the solar panel generated a voltage of 9.1 volts. As the morning progressed, both the temperature and voltage showed slight fluctuations. At 10:00 AM, the temperature increased to 27.9 degrees Celsius, and the voltage rose to 9.32 volts. However, at 10:30 AM, the temperature remained at 28 degrees Celsius, but the voltage dropped slightly to 9.15 volts.

A notable increase in both temperature and voltage was observed around 11:00 AM. The temperature rose to 31.5 degrees Celsius, while the voltage reached 9.10 volts. Subsequently, at 11:30 AM and 12:00 PM, the temperature continued to rise, but the voltage experienced a decrease. This trend persisted until 12:30 PM when the temperature peaked at 32.8 degrees Celsius, while the voltage slightly recovered to 9.01 volts.

From 1:00 PM onwards, both the temperature and voltage remained relatively stable. Although the temperature hovered around 32-32.7 degrees Celsius, the voltage displayed minor fluctuations between 8.85 and 9.21 volts. As the afternoon progressed, the temperature gradually decreased, reaching 25 degrees Celsius at 6:00 PM, while the voltage dropped to 7.5 volts.

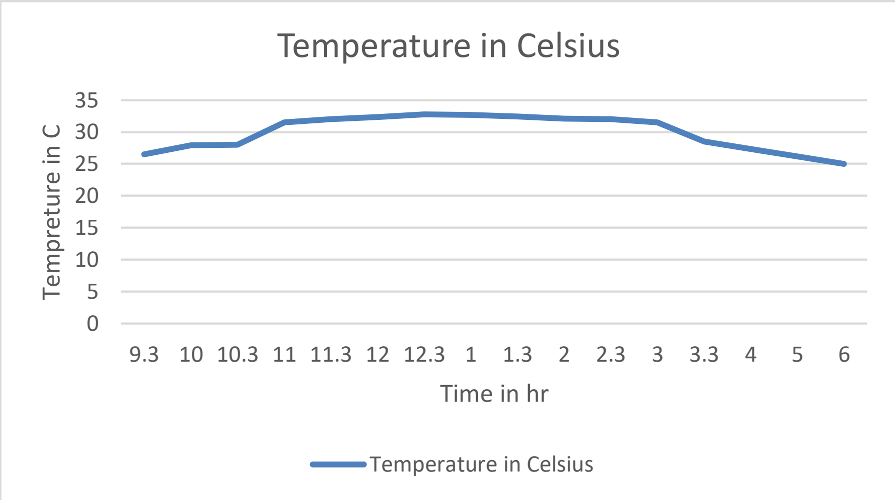

Fig.14 Solar panel Time v/s Temperature

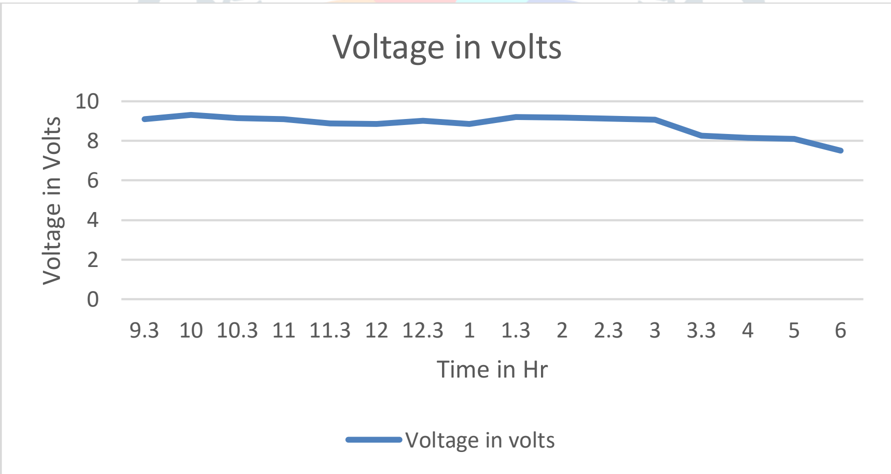

Fig.15 Solar panel Time v/s Voltage

CONCLUSION

In conclusion, the work presented in this article introduces a multi-purpose robot that integrates various essential operations while harnessing the power of solar energy. By utilizing a microcontroller as the central control unit, the robot can perform tasks with precision and adaptability. The integration of solar panels and a solar charge controller allows the robot to operate autonomously while being powered by renewable energy. This work not only provides a versatile and convenient solution for domestic and commercial settings but also promotes sustainability and environmental consciousness through the utilization of solar power. The incorporation of a microcontroller as the brain of the robot enables efficient coordination and execution of complex tasks. It serves as the central processing unit, controlling the different components and sensors necessary for each operation. By integrating solar panels and a solar charge controller, the robot can tap into the abundant solar energy available, reducing its reliance on traditional power sources and contributing to a cleaner and more sustainable future.

Through programmed instructions and sensor feedback, the robot can autonomously navigate and perform various tasks, reducing the need for manual intervention and improving overall efficiency. Whether it is grass cutting, floor mopping, pesticide spraying, water spraying, floor cleaning, or UV light sterilization, the robot's microcontroller ensures precise control and optimal performance. The addition of solar energy harvesting not only enhances the robot's functionality but also aligns with the growing demand for renewable energy solutions. By utilizing solar power, the robot reduces its environmental impact and contributes to a more sustainable energy landscape. It also offers the advantage of being able to operate in outdoor environments without the limitations imposed by traditional power sources.

The integration of a multi-purpose robot with solar energy harnessing capabilities provides a versatile solution for various tasks in both residential and commercial settings. It offers convenience, efficiency, and sustainability, aligning with the evolving needs of modern society. As technology continues to advance, further improvements in robot capabilities and energy efficiency can be expected, paving the way for a more automated and sustainable future. In summary, the work presented here demonstrates the potential of a multi-purpose robot that integrates various operations and utilizes solar energy. By combining advanced robotics, microcontroller-based control, and renewable energy sources, this work contributes to the development of intelligent and sustainable solutions for a range of applications.

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