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Solar Powered Smart Floor Cleaning Robot Using WiFi and Ultrasonic Sensor

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Abstract: ***Automation has become a major factor in modern life, contributing to the reduction of human effort through efficiency in performing day-to-day activities. One of the activities that requires a lot of time, effort, and repetition is floor cleaning, especially in large residential areas, offices, institutions, and commercial buildings. This has, over the years, prompted the development of automated cleaning solutions, especially with the advancement of robotic technology, providing efficient solutions for floor cleaning. In light of the above, the aim of the proposed research is to design and develop a solar-powered smart floor cleaning robot that can efficiently carry out the cleaning operation with minimum human involvement. The proposed system will utilise ultrasonic sensors that will detect obstacles during the cleaning operation, preventing the robot from colliding with objects while it moves around the floor. This will allow the robot to detect objects around it, enabling it to change direction accordingly. Moreover, the proposed system will utilise a Wi-Fi module, enabling the robot to be monitored and controlled remotely through a smartphone or the internet, thereby enhancing the convenience of the user by allowing them to remotely control the operation of the robot. Moreover, the robot uses solar power as its source of energy, which reduces the dependency on conventional sources of power and increases the awareness and usage of alternative sources of energy. The combination of solar power and other smart technologies, such as sensing and wireless communication, makes the system energy-efficient and environmentally friendly. Therefore, the proposed system can be concluded as a cost-effective, green, and smart solution for floor cleaning in both residential and commercial areas.***

Index Terms: ***Solar Energy, Floor Cleaning Robot, WiFi Control, Ultrasonic Sensor, Smart Automation, Obstacle Detection, Renewable Energy, Autonomous Cleaning System***

I. INTRODUCTION

Automation has emerged as an important feature of modern technology and has been effectively employed in various industries such as homes, industries, health care, and transportation systems. With the development of smart technologies and robotic systems, various activities can be carried out automatically with minimal human intervention. Automation not only minimizes human effort but also enhances the efficiency and productivity of performing daily activities. An important daily activity that needs to be performed efficiently is floor cleaning, which is essential in various environments such as homes, offices, hospitals, and industries.

Floor cleaning has traditionally been carried out manually using various equipment such as mops, brushes, and vacuum cleaners. However, floor cleaning using manual methods requires considerable human effort and involves a lot of time and effort, especially in environments such as offices, institutions, and public areas. The involvement of human beings in the process also reduces the efficiency and consistency of the floor cleaning process. Hence, there has been an increasing need for the development of automated systems that can efficiently carry out floor cleaning activities while minimizing human effort. In the last few years, robotic floor cleaning systems have attracted considerable attention due to their capability to execute cleaning activities autonomously. The robot can move on the floor, clean dust and dirt, and even avoid obstacles with the assistance of sensors and intelligent systems. However, most of the existing floor cleaning robots are dependent on battery power, which restricts the usage period and makes the system dependent on electrical charging systems.

In this context, the research aims to develop a new concept of designing and developing a solar-powered intelligent floor cleaning robot with WiFi and ultrasonic sensor integration. The ultrasonic sensors allow the robot to sense obstacles and avoid collisions while moving on the floor, thus ensuring safe movement in various environments. The integration of WiFi technology in the robot allows users to monitor and control the system remotely through a smartphone or computer interface, thus enhancing user convenience and flexibility. The usage of solar power makes the system less dependent on traditional electrical power and encourages the utilisation of renewable energy resources, thus making the system more sustainable and environmentally friendly.

The main aim of this project is to develop an efficient and cost-effective eco-friendly smart floor cleaning robot that can carry out automatic floor cleaning operations with minimal human intervention. The proposed system has been designed for the improvement of floor cleaning while conserving energy and using green technology.

II. LITERATURE REVIEW

In the last few years, some researchers have focused on designing robotic systems to carry out cleaning operations to minimize the amount of work required by humans and to maximize efficiency. There are a number of designs of an automatic cleaning robot that use sensors, microcontrollers, and intelligent navigation systems to enable the robot to move on its own on the floor.

There are already some robotic cleaning systems that use infrared sensors and ultrasonic sensors to detect obstacles on their path. These sensors enable the robot to detect objects and avoid them by changing its direction automatically as it moves on the floor. In this way, the robot is able to move on the floor safely and efficiently in buildings and other establishments. In addition to the above-discussed sensor-based navigation, several researchers have also proposed WiFi-based robotic cleaning systems, allowing the user to observe and control the robotic cleaning system from a distance through a smartphone, tablet, or computer device. Wireless communication enhances the flexibility of the cleaning robot, allowing the user to control the robotic cleaning system from a distance.

The majority of the existing robotic cleaning systems are designed to work with rechargeable batteries. Continuous charging of the batteries results in the consumption of electrical power, leading to a reduction in the efficiency of the cleaning robot. This dependency on electrical power is considered one of the major limitations of the existing robotic cleaning systems. In order to overcome this limitation, the use of renewable energy sources such as solar power can be considered as an effective solution. Solar power can be used to minimize the usage of electricity and also to support environmentally friendly technology. Therefore, the proposed system in this research focuses on the design and development of a solar-powered smart floor cleaning robot using WiFi and ultrasonic sensor technology. The use of these technologies can improve the system's performance in terms of efficiency and effectiveness in automated floor cleaning applications.

III. PROPOSED SYSTEM

The proposed system is a solar-powered smart floor cleaning robot. The system is specifically designed to perform the operation of floor cleaning with the least human involvement. The main purpose of the system is to reduce human involvement to a minimum level and make the process of floor cleaning efficient by incorporating smart technology with the use of alternative energy. The system is developed to provide an eco-friendly and cost-effective method of floor cleaning for use in homes, offices, and industries.

The system consists of a microcontroller, which is the central processing unit of the system or the brain of the robot. The microcontroller is responsible for controlling all the activities of the robot. The activities of the robot include the processing of input signals received from the various components of the system. The input signals are continuously monitored by the microcontroller to make the required decisions. The ultrasonic sensor is integrated into the system to aid the robot in navigation. The ultrasonic sensor is used to detect the distance between the robot and other objects. The sensor sends ultrasonic waves to the objects, and the reflected waves are received by the sensor. If an object is detected within a certain distance, the robot is programmed to change direction to avoid the object. This ensures the safe movement of the robot on the floor.

The system is also equipped with a Wi-Fi module to aid the robot in communication. The WiFi module is used to communicate with the robot wirelessly. This enables the robot to be controlled remotely using a smartphone, tablet, or computer. The WiFi control system enhances the flexibility of the robot's operation. The system enables the user to control the robot's performance. The robot also has a motor-operated cleaning system to carry out the actual cleaning process. The motors power the wheels of the robot as well as the cleaning system to clean the floor. The cleaning system consists of brushes or mopping tools to clean the dust and dirt on the floor surface. The use of solar power is an additional power source to reduce the dependency on traditional electrical power. The use of solar power encourages the use of renewable energy.

The proposed system has the potential to design an efficient smart floor cleaning robot using solar power, wireless communication, and smart sensing technologies.

IV. SYSTEM ARCHITECTURE

The system architecture of the proposed solar power-based smart floor cleaning robot consists of various hardware components that interact with each other to provide the faclility of automatic floor cleaning. The major hardware components used in the proposed floor cleaning robot include a solar panel, a rechargeable battery, a microcontroller, an ultrasonic sensor, a WiFi module, a motor

driver, DC motors, and a cleaning mechanism.

These hardware components interact with each other to provide the facility of automatic floor cleaning.

The solar panel is used to provide a power source to the proposed floor cleaning robot. The solar panel collects solar power from the sun's rays, which is then converted into electrical power. The collected electrical power is then stored in a rechargeable battery, which is the power supply unit of the proposed floor cleaning robot. The power stored in the rechargeable battery is then provided to the floor cleaning robot to operate the various electronic components, sensors, the Wi-Fi module, and the DC motors. The role of the microcontroller is to act as the main controlling unit of the system. The microcontroller is required to process the input signals received from the sensor, control the movement of the motors, and also handle the communication between the different parts of the system. The microcontroller is continuously receiving data from the ultrasonic sensor. The data is then processed by the microcontroller to obtain the movement of the robot.

The role of the ultrasonic sensor is significant in the system. The ultrasonic sensor is used to detect obstacles. The sensor transmits ultrasonic waves into the surroundings. The ultrasonic sensor calculates the time required by the ultrasonic waves to return after hitting the obstacle. The sensor then calculates the distance between the robot and the obstacle. If an obstacle is found within a specific distance, the direction of the robot is automatically changed by the microcontroller. A WiFi module has been included in the system to facilitate wireless communication between the robot and the user. This will enable the user to control the robot wirelessly using a smartphone, tablet, or computer. The user can send the commands to the robot through the WiFi connection, which will help to control the cleaning operation.

The motor driver circuit has been included to control the DC motor, which is used to move the robot. The DC motor is the only motor used to move the robot. The motor driver circuit receives the command from the microcontroller and drives the motor to move the robot in the required direction. The cleaning mechanism has been placed at the base of the robot, which is used to clean the floor surface by removing the dust, dirt, and other particles.

With the help of solar power, WiFi technology, and intelligent sensors, the proposed system has been able to provide an efficient, eco-friendly, and automated floor cleaning system.

V. METHODOLOGY

Fig. 1. Solar Powered Smart Floor Cleaning Robot

The methodology of the proposed system is based on designing and implementing a solar-powered smart floor cleaning robot. The proposed system is based on a combination of sensors, control units, and mechanical components. The solar panel collects solar power and converts it into electrical current. The collected electrical current is stored in a rechargeable battery, which is used to supply power to the
microcontroller, sensors, WiFi module, and motors.

The microcontroller is considered to be the brain of the proposed system and is used to control all operations of the proposed system. Ultrasonic sensors are continuously used to scan and detect obstacles in the area. The sensor collects distance information and sends it to the microcontroller to process and decide the movement of the robot.

In case there is an obstacle, the microcontroller sends signals to the motor driver to reverse the direction of the robot. This ensures that the robot does not collide with anything and moves safely on the floor.

The cleaning mechanism used on the robot helps to remove dust and dirt from the surface while the robot moves on it. The WiFi module helps to control the robot remotely using a smartphone or computer.

This process helps the robot to perform its functions automatically while using solar power to save energy.

A. Hardware Components

The proposed solar-powered smart floor cleaning robot is designed using a combination of sensors, control units, and mechanical components to perform automatic cleaning operations. The major hardware components used in the system are described below.

1) Microcontroller Unit: The central control unit of the robot is a microcontroller, such as Arduino or ESP8266. It coordinates all sensing, processing, and control operations of the robot. The microcontroller receives signals from the ultrasonic sensors and sends control signals to the motor driver for movement and obstacle avoidance.
2) Solar Panel and Battery: A solar panel is used to convert sunlight into electrical energy. The generated energy is stored in a rechargeable battery which provides a stable power supply to the microcontroller, sensors, WiFi module, and motors. This makes the system energy efficient and environmentally friendly.
3) Ultrasonic Sensor: Ultrasonic sensors are used for obstacle detection. These sensors measure the distance between the robot and surrounding objects by transmitting ultrasonic waves and receiving the reflected signals. When an obstacle is detected within a certain range, the robot automatically changes its direction.
4) WiFi Module: A WiFi module such as ESP8266 is used to enable wireless communication between the robot and the user. It allows remote monitoring and control of the robot through a smartphone or computer.
5) Motor Driver Circuit: A motor driver circuit such as L298N is used to control the DC motors. The motor driver receives signals from the microcontroller and drives the motors in forward, backward, left, or right directions.
6) DC Motors and Wheels: DC geared motors are used to move the robot across the floor surface. The motors are connected to wheels that allow smooth movement and directional control.
7) Cleaning Mechanism: The cleaning mechanism consists of rotating brushes or a wiping system that removes dust and dirt from the floor while the robot moves.

VI. RESULTS AND DISCUSSION

The solar-powered smart floor cleaning robot was designed and developed. It was tested in an indoor environment to assess its performance. The robot was able to move smoothly over the floor surface and clean the floor effectively. The ultrasonic sensor was able to detect obstacles placed in its path and change its direction accordingly to avoid collisions with obstacles.

The WiFi module was used for wireless communication between the robot and the user. Through this module, it was possible to control and monitor the robot remotely using a smartphone or computer. This enhanced flexibility in using the robot for floor cleaning.

The solar panel was used to support the robot with extra power. This reduced the dependency of the robot on external power sources. The floor cleaning mechanism was effective in removing dust and particles from the floor surface.

From the experiment and testing of the solar-powered smart floor cleaning robot, it was evident that it was capable of performing floor cleaning efficiently and effectively while at the same time being energy efficient through the use of solar power.

VII. APPLICATIONS

The proposed solar-powered smart floor cleaning robot can be applied in various settings where there is a need to clean the floor regularly. The system can maintain cleanliness and hygiene while minimising human effort. Some of the significant applications of this system are as follows.

A. Residential Homes

The robot may also be utilized at residential houses to carry out automatic floor cleaning activities. It helps to reduce human effort and save valuable time by allowing it to work independently without supervision. It may be easily monitored and controlled through WiFi connectivity via a smartphone, thus making it convenient and efficient to use at home.

B. Offices and Commercial Buildings

The cleaning robot may be effectively utilised in offices, shopping malls, and other commercial establishments where the floor area is large and needs to be cleaned frequently. Manual cleaning of large floor areas is often time-consuming and labor-intensive. With the use of an automated floor cleaning robot, organisations may be able to improve the efficiency of floor cleaning and maintain good hygiene standards. The cleaning robot may be utilised to clean the floors continuously with minimal human intervention.

C. Hospitals and Healthcare Centre's

A high degree of cleanliness and hygiene must be maintained in hospitals to avoid the spread of infections and ensure a healthy environment for patients, doctors, and visitors. Maintenance of cleanliness on the floors of the hospital corridors, visitor halls, and patient rooms must be done on a regular basis. The proposed solar-powered smart floor cleaning robot can be useful in maintaining the cleanliness of the floors of the hospital, and the ultrasonic sensors and WiFi facilities will be useful for efficient cleaning operations.

D. Educational Institutions

The proposed robot can be employed by educational institutions such as schools, colleges, and universities to maintain hygiene in classrooms, corridors, labs, and other common areas. Educational institutions cover vast areas, and thus, the floors are required to be cleaned frequently to maintain hygiene within the campus.

E. Hotels and Public Facilities

Hotels, airport floors, and other facilities may use the proposed robot to keep floors clean in areas with high traffic where cleanliness is paramount. Such areas have a large number of visitors on a daily basis. For this reason, it is essential to keep such areas clean through the use of an automated floor cleaning system.

VIII. ADVANTAGES

A. Reduced Human Effort

The proposed smart floor cleaning robot greatly reduces the need to clean the floors manually. When considering large spaces like homes, offices, or business establishments, it is evident that manual floor cleaning is tedious and requires much effort. By automating the process of cleaning, this robot helps maintain clean floors while minimising the need for human intervention, thus allowing people to focus on other important activities.

B. Energy-Efficient Operation Using Solar Power

The use of solar energy makes the proposed system energy efficient and environmentally friendly. The solar panel will offer the system an alternative source of energy, which will, in turn, reduce the dependency on the conventional energy obtained from the electric grid. This will not only reduce the energy consumption of the system but also cut down on the operational costs while promoting the use of solar energy for daily use.

C. Obstacle Detection and Safe Navigation

The robot uses ultrasonic sensors to detect obstacles on its path during operation. This helps the robot avoid any collision with objects such as furniture, walls, and any obstacles on the floor. This makes the cleaning process much safer and more reliable, allowing the robot to navigate smoothly in the indoor environment.

D. Remote Monitoring and Control

This is because WiFi technology is integrated in the robot, and it enables the user to control and monitor it remotely through devices like smartphones. This makes it more convenient and flexible for users since they can start or stop the robot without having to physically touch it.

E. Time Saving and Efficient Cleaning

This will help in saving a considerable amount of time compared to traditional manual cleaning methods. The cleaning robot can work continuously and can clean large areas. This will enhance the efficiency of cleaning and maintain cleanliness.

IX. DISADVANTAGES

A. Limited Battery Backup

However, it is to be noted that even though the robot is using solar power as an energy source, its performance may be dependent on the storage capacity of the battery. If the battery is not charged properly, it may not be able to operate for a longer duration.

B. *Dependence on Sunlight*

This is because the system is using solar energy, and the efficiency of the battery charge may depend on the presence of sunlight. In cases where there is overcast weather, the solar panel may not charge the battery properly, hence affecting the efficiency of the system.

C. *Limited Cleaning Capability*

The robot is primarily designed for basic floor cleaning. It may not be able to remove hard stains or clean complicated surfaces compared to manual cleaning methods.

D. *Initial Installation Cost*

The initial cost of developing or acquiring the robotic system might be high compared to conventional cleaning devices. The system includes various components, including sensors, microcontrollers, and WiFi modules, which add to the system cost.

E. *Maintenance Requirements*

Similar to other electronic gadgets, the robot also requires periodic maintenance to ensure proper performance and durability. The maintenance of a robot may involve replacing the batteries, calibrating the sensors, and cleaning the mechanical parts. Periodic maintenance of a robot ensures smooth operation for a long period of time.

X. FUTURE SCOPE

The solar-powered smart floor cleaning robot has great prospects for further development and enhancement in the future. New and advanced technologies like artificial intelligence and machine learning can be integrated to improve the robot's performance. By using AI-based algorithms, the robot can learn the environment and improve its path of cleaning. Other advanced versions of this robot can be developed by including camera modules and other sensors to enhance its ability to detect objects and improve its mapping ability. New versions of this robot can be developed by integrating new technologies like SLAM (Simultaneous Localization and Mapping) to improve its mapping of the environment and enhance its ability to navigate accurately within the environment. Other versions of this robot can be developed to improve its charging and battery life to enhance its operation time. Other versions of this robot can be developed to improve its mobile application to enhance its performance.

XI. CONCLUSION

In this paper, a solar-powered smart floor cleaning robot using WiFi and ultrasonic sensors is proposed and implemented. The proposed system aims to reduce human efforts and increase the efficiency of floor cleaning using a smart floor cleaning robot. The proposed floor cleaning robot uses ultrasonic sensors to detect obstacles and navigate safely in a particular environment. WiFi is also utilised in this proposed floor cleaning robot to enable users to monitor and control the floor cleaning robot using a smartphone device.

The proposed floor cleaning robot is also equipped with a solar panel that makes it an efficient and environmentally friendly floor cleaning device since it reduces the usage of non-renewable sources of electricity. The proposed floor cleaning robot can be utilised in various environments such as houses, offices, hospitals, and educational institutions.

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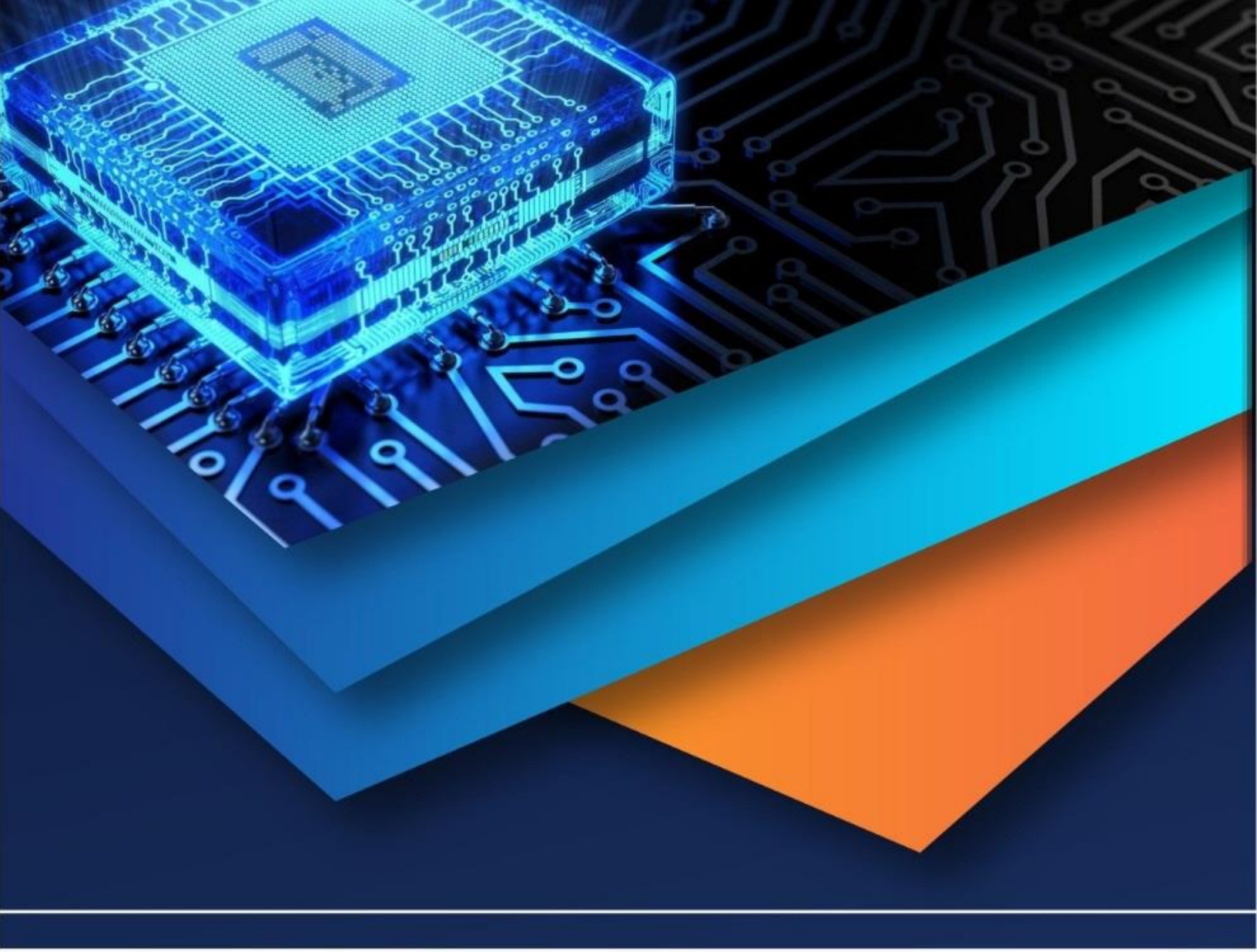

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