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Autonomous Obstacle Avoidance Vehicle using LIDAR and an Embedded System

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Abstract: Self-driven vehicles have many type of algorithms which simulate the driving behaviour in the real world majorly in autonomous miniature vehicles. In the last decade, several approaches have been proposed for obstacle avoidance in self-driving vehicles. In this, our team is implementing a vehicle which is capable of navigating in an unknown environment and detecting obstacle by using Raspberry Pi 3+ and a LIDAR module avoiding Computer Vision (CV) techniques. The further enhancement is being done by implementing a mapping feature to generate an image of environment during navigation.
Keywords: Autonomous vehicle, Raspberry Pi, LiDAR, obstacle avoidance.

I. INTRODUCTION

An embedded system is one kind of a computer system mainly designed to perform several tasks like to access, process, store and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. One of its most important characteristics of these systems is, it gives the output within the time limits. Embedded systems support to make the work more perfect and convenient. So, we frequently use embedded systems in simple and complex devices too. The applications of embedded systems mainly involve in our real life for several devices like microwave, calculators, TV remote control, home security and neighborhood traffic control systems, etc.

An embedded system uses a hardware platform to perform the operation. Hardware of the embedded system is assembled with a microprocessor or microcontroller. It has the elements such as input/output interfaces, memory, user interface and the display unit. The software of an embedded system is written to execute a particular function. It is normally written in a high-level setup and then compiled down to offer code that can be stuck within a non-volatile memory in the hardware. An embedded system software is intended to keep in view of the following three limits • Convenience of system memory

1) Convenience of processor's speed
2) When the embedded system runs constantly, there is a necessity to limit power dissipation for actions like run, stop and wake up.

A system which is essential to finish its task and send its service on time, then only it said to be a real time operating system. RTOS controls the application software and affords a device to allow the processor run. It is responsible for managing the different hardware resources of a personal computer and also host applications which run on the PC. This operating system is specially designed to run various applications with an exact timing and a huge amount of consistency. Particularly, this can be significant in measurement & industrial automation systems where a delay of a program could cause a safety hazard.

II. RELATED WORKS

Saeed Asadi, Bagloee, Madjid, Tavana, Mohsen Asadi, Tracey Oliver[1]. In this authors proposes the challenges and opportunities pertaining to transportation policies that may arise as a result of emerging autonomous vehicle (AV)technologies. A conceptual navigation model based on a fleet of AVs that are centrally dispatched over a network seeking system optimization. This study contributes to the literature on two fronts: 1.It attempts to shed light on future opportunities as well as possible hurdles associated with AV technology. 2.It conceptualizes a navigation model for the AV which leads to highly efficient traffic circulations. Todd Litman[5] This paper explores autonomous vehicle benefits and costs, and implications for various planning issues. It investigates how quickly self-driving vehicles are likely to be developed and deployed based on experience with previous vehicle technologies, their benefits and costs, and how they are likely to affect travel demands and planning decisions such as optimal road, parking and public transit supply.O.Khatib[6] In this paper a manipulator programming system COSMOS(Control in Operational Space of a Manipulator with Obstacles System) is used which has two level architecture designed for increasing real time performace. Obstacle avoidance problem is treated in two stages: 1.At high level control, generating a global strategy for manipulator's path in terms of intermediate goals.

2.At low level, producing the appropriate commands to attain each of these goals taking into account detailed geometry and motion of manipulator and making use of real time obstacle sensing. K.Bimbraw[7] The basic chronology leading to the development of autonomous cars is discussed. Autonomous vehicles developed from the basic robotic cars to much efficient and practical vision guided vehicles are also discussed.The historical antecedents, contemporary advancements and developments, and predictable future of semi and fully autonomous cars for public use are also presented.

Q.Memon, M.Ahmed, S.Ali, A.Rafique, and W.Shah[8] In this a prototype vehicle has been designed for two applications. The one major issue is during heavy traffic a driver has to continuously push brake, accelerator and clutch to move to destination slowly for which they proposed a solution to relax the driver in that situation by making vehicle smart enough to make decisions automatically and move by maintaining a specified distance from vehicles and obstacles around. The second issue is when two vehicles have the same destination but one of the drivers doesn't know its route. The driver can make his vehicle follow the front vehicle if they are known and share their location to reach the same destination. H.Flamig[9] This paper discusses the implementation of autonomous vehicles from the field of logistics and freight transport and examining current fields of application and, wherever possible, the navigation and safety concept required for autonomous driving as well as control. In this paper the development history of Automated Guided Transport(AGT) systems and Automated Guided Vehicles(AGV) are also discussed. B.-C.-Z. Blaga, M.-A. Deac, R. W. Y. Al-doori, M. Negru, and R. Danescu[10]. In this paper, the authors presented a novel methodology for developing the assistance system for a 1/10 scale car, in which they used a simulated GPS to position the vehicle and to navigate on the test track. They also proposed a method for lane detection and tracking that is robust and accounts for the cases when one or both lines of the lane are missing or not seen in the image and also presented a new solution for detecting road traffic signs. In addition, they implemented an application for map visualization, that enables us to test the correctness of our algorithms. The developed miniature vehicle is capable of successfully navigating from a start point to a goal, while taking into account the lanes, intersections, traffic signs, and can perform lateral parking.

Taihu Pire[11] In this paper an obstacle avoidance robot using only a single stereo camera as a sensor is proposed. A stereo camera is taking left and right images which produces depth maps. Using the captured depth images, the distance of nearby objects is possible to be determined. This research has three major drawbacks as it requires a powerful processor (Intel Core i5 2.67 GHz), a minimum size of object that can be detected and a high latency process. Yan Peng[12] This paper discusses an algorithm based on 2D LIDAR and verified it on a MATLAB simulation. The basic idea is to use three steps before deciding whether an obstacle is real or not and how to avoid it.

These three steps include filtering, preprocessing and clustering. The obstacle avoidance algorithm continually calculates the angle at which the vehicle should turn. The LIDAR SICK LMS511 that is used is very expensive and the MATLAB simulation makes that implementation unsuitable on real environment conditions. Takahashi[13] This paper also proposes obstacle avoidance module using LIDAR in which they emphasize on position prediction of moving obstacles. It is based on an embedded microcontroller that predicts the trajectories of obstacles and detects a particular type of objects. The maximum relative speeds of the obstacles towards the mobile robot is limited to 5 km/h. Widodo Budiharto [14] This paper proposed a surveillance robot, based on a Raspberry Pi and three ultrasonic distance sensors.

The obstacle avoidance method is based on a backpropagation neural network, a gradient descent process which brings the network closer to a minimum error with each change. Ultrasonic sensors have a very limited coverage compared to LIDAR, which has 360 degrees of coverage. Also, the training of the robot in this implementation is very slow, causing the robot to malfunction in the early execution. G. Li, E. Geng, Z. Ye, Y. Xu, J. Lin, and Y. Pang[15]. In this paper, an RSSI real-time correction method based on Bluetooth gateway is used to detect the RSSI fluctuations of surrounding Bluetooth nodes and upload them to the cloud server.

The terminal to be located collects the RSSIs of surrounding Bluetooth nodes, and then adjusts them by the RSSI fluctuation information stored on the server in real-time. The adjusted RSSIs can be used for calculation and achieve smaller positioning error. Moreover, it is difficult to accurately fit the RSSI distance model with the logarithmic distance loss model due to the complex electromagnetic environment in the room.

Therefore, the back propagation neural network optimized by particle swarm optimization (PSO-BPNN) is used to train the RSSI distance model to reduce the positioning error.

N.A.Mahiddin[16] In this paper a trilateration technique is implemented to determine the position of users in indoor areas based on Wi-Fi signal strengths from access points (AP) within the indoor vicinity. In this paper, percentage of signal strengths obtained from Wi-Fi analyzer in a smartphone were converted into distance between users and each AP. A user's indoor position could then be determined using a formula proposed based on trilateration technique.

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III. SYSTEM ARCHITECTURE

The block diagram of the design is as shown in the figure 1. It consists of power bank, Raspberry pi3 board, LIDAR, L293D and motors. Here the environment information provided by the sensor is used by Raspberry pi to control the vehicle movement and avoid obstacles during navigation. Raspberry pi 3 is used because of its low cost and its advanced features. SD card provides initial storage for the operating system. Lidar sensor used is RPLidarA1 which is two dimensional and provides 360 degrees information of the environment.

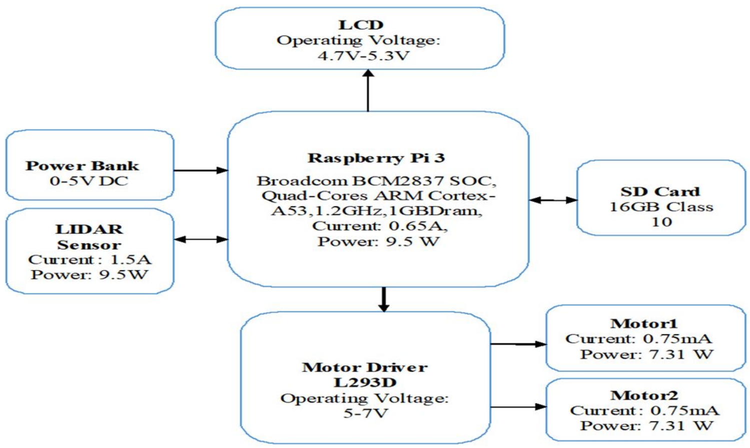

Fig.1: Block diagram of Proposed System

A. Raspberry Pi 3 Model B

The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word-processing and games. It also plays high-definition video. We want to see it being used by kids all over the world to learn how computers work, how to manipulate the electronic world around them, and how to program. The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high -definition video, to making spreadsheets, word-processing, and playing games.What's more, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. We want to see the Raspberry Pi being used by kids all over the world to learn to program and understand how computers work. There are currently four Raspberry Pi models. They are the Model A, the Model B, the Model B+ and the Compute Module. All models use the same CPU, the BCM2835, but other hardware features differ.

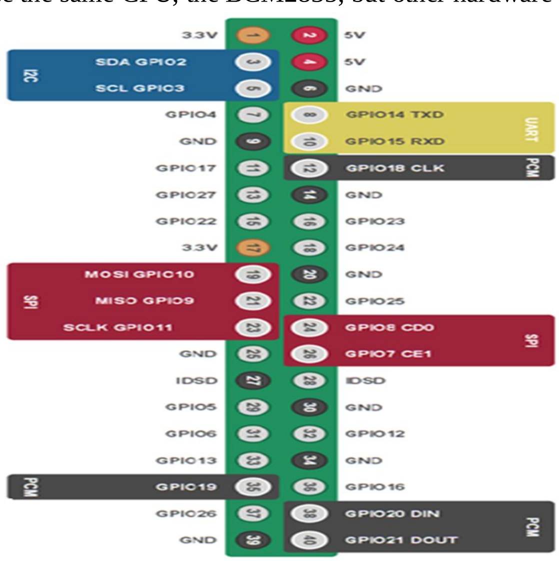

Fig.2: (a) Pin Description of Raspberry Pi 3

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B. Lidar Sensor -RP LIDAR A1

Lidar (an acronym for “Light Detection And Ranging”) refers to a remote sensing technology to measure distance by illuminating an object with a laser beam and analyzing the reflected light and its time-off light. In order to acquire a 3D visualization of the environment, a set of Lidars is coupled and synchronized with rapidly rotating mirrors. Unlike the camera-based system, Lidar is only functional for short ranges or distances and with certain materials. Although the cost of the Lidar system is relatively significant, it is on a downward trend, becoming cheaper and more efficient.Lidar sensor provide data for software to determine where obstacle exist in the environment in 360 degrees of visibility and where the vehicle is in relation to those potential obstacles.
The basic architecture of LIDAR is shown in figure 3 which contains transmitter, receiver and data acquisition&control system.The transmitter consists of lasers, wavelength control system and provides the laser pulses and detemines the performance of lidar system.The receiver consists of telescopes,photon detectors,filters and collects detect returned photon signals and distinguishes the returned photons.The data acquisition and control system consists of multi-channel scalar, discriminator, software that records return data and time of flight and provides system control and coordination enabling various data acquisition modes.

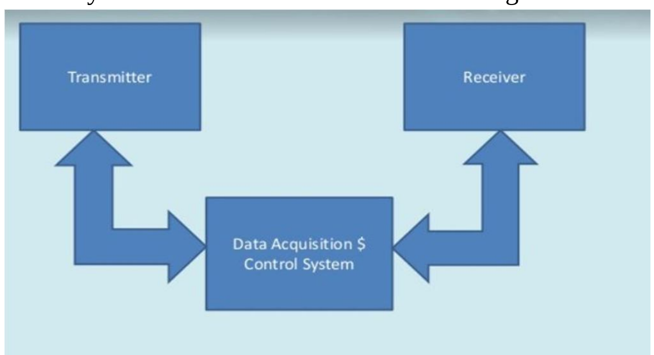

Fig.3: Basic Architecture of LIDAR

C. DC Motor

DC motors are configured in many types and sizes, including brush less, servo, and gear motor types. A motor consists of a rotor and a permanent magnetic field stator. The magnetic field is maintained using either permanent magnets or electromagnetic windings. DC motors are most commonly used in variable speed and torque.
Motion and controls cover a wide range of components that in some way are used to generate and/or control motion. Areas within this category include bearings and bushings, clutches and brakes, controls and drives, drive components, encoders and resolves, Integrated motion control, limit switches, linear actuators, linear and rotary motion components, linear position sensing, motors (both AC and DC motors), orientation position sensing, pneumatics and pneumatic components, positioning stages, slides and guides, power transmission (mechanical), seals, slip rings, solenoids, springs.
Every DC motor has six basic parts shown in figure 4 - axle, rotor (armature), stator, commutator, field magnet(s), and brushes. In most common DC motors, the external magnetic field is produced by high-strength permanent magnets. The stator is the stationary part of the motor -- this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotates with respect to the stator. The rotor consists of windings (generally on a core), the windings being electrically connected to the commutator.

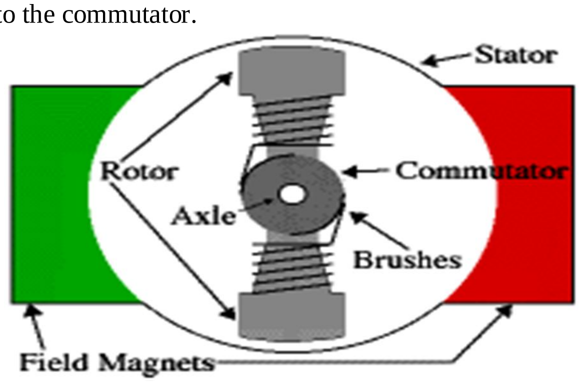

Fig.4: Basic parts of DC Motor

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D. L293D Motor Driver Circuit

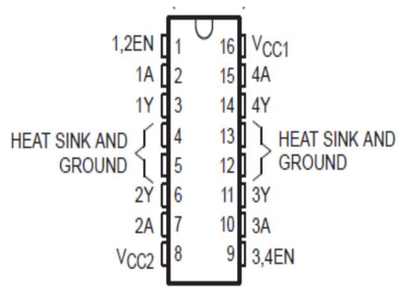

Fig 5:L293D Motor driver circuit

In this system, the driver circuit drives the motor by connecting the chip pins with appropriate GPIO pins of Pi. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

E. LCD 16x2

LCD or Liquid Crystal Display is an electronic display module which is used as an output device. A 16*2 LCD has 16 columns and 2 rows. It can display 16 characters on each of the two lines. It is an Alphanumeric Display and hence can display Alphabets, Numbers, and Symbols. Each character is framed by a 5*8pixel box. It operates in 4.7 V - 5.3 V voltage range with consumption of 1mA current without backlight. It has 16 pins for connection. The data lines, read, write and enable pins are connected accordingly to GPIO pins of Pi. Out of the two modes of LCD i.e., the command mode and data mode, the data mode is used where the commands to the user are displayed so that he/she can go to the next step of getting access to the place.

Fig.6: LCD Display

IV. WORKING OF PROPOSED SYSTEM

The proposed system uses a five stage algorithm for the localization and navigation of the vehicle. The five main stages that constitute our methodology for an autonomous vehicle are: Initialization, Localization, Obstacle Detection, Decision Making and Control (Figure 7). In the first stage, the initialization of our algorithm is performed. Route-specific metrics (starting, intermediate and final waypoints) and environment profiling are loaded as command line arguments. During the algorithm initialization, using as input the relative locations of the vehicle and the installed Wi-Fi stations a calibration procedure is being executed This process occurs only once per mission.

In the second stage, our Indoor Positioning System (IPS) implementation provides the position of the vehicle. In the third stage, we use the installed LIDAR module on the vehicle to detect surrounding obstacles. In the fourth stage, gathered information about obstacles is processed by our Decision Making algorithm. The algorithm decides which is the best move for the vehicle. In the last stage, the algorithm controls the physical parts of the vehicle (DC motors) in order to move the vehicle in the desired direction.

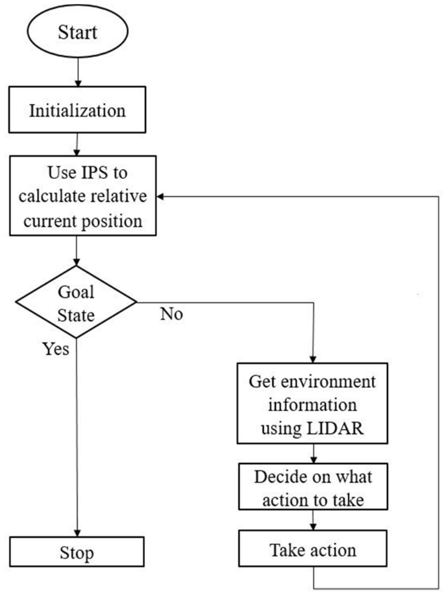

Figure 6: Proposed 5 stage algorithm for autonomous vehicle

V. RESULTS AND DISCUSSION

The project consists of Raspberry pi, LIDAR, LCD and robot arrangement. LIDAR will be placed on top of the Robot arrangement. The robot will be moving forward and LIDAR will rotate 360 degrees continuously and scans the objects around. It calculates the distance of the objects and if the object is far from the robot, Robot continues to move in the forward direction. If the object is near to the robot, the robot direction will be changed without hitting the object and will move either to left or right direction. LCD displays the status of the Robot movement. In this way, this project will act as obstacle avoidance system.

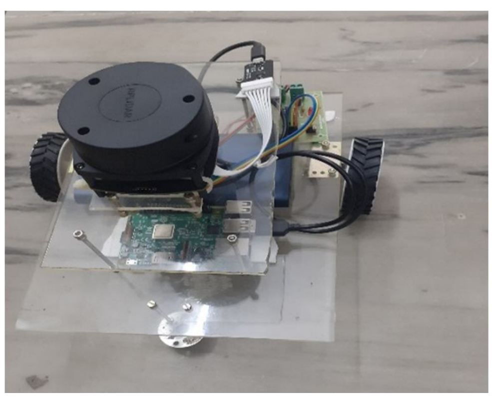

Figure 7 Autonomous Obstacle Avoidance Vehicle.

VI. CONCLUSION

The system here is an obstacle avoidance vehicle which detects and avoids the obstacles using the information provided by the sensor and moves autonomously. This autonomous obstacle avoidance vehicle works without human intervention and avoids accidents. The implemented vehicle would be capable of utilizing existing Wi-Fi infrastructure in order to locate its position in the environment and navigating safely from a starting point to a destination point while avoiding obstacles and a mapping feature can also be implemented to generate image of the environment.

VII. FUTURE WORK

For autonomous vehicle to navigate precisely it requires to add more lidar sensors on vehicle at certain positions according to the distance to get more accuracy and precision and also we need to write more algorithm according to the position and make it function properly.

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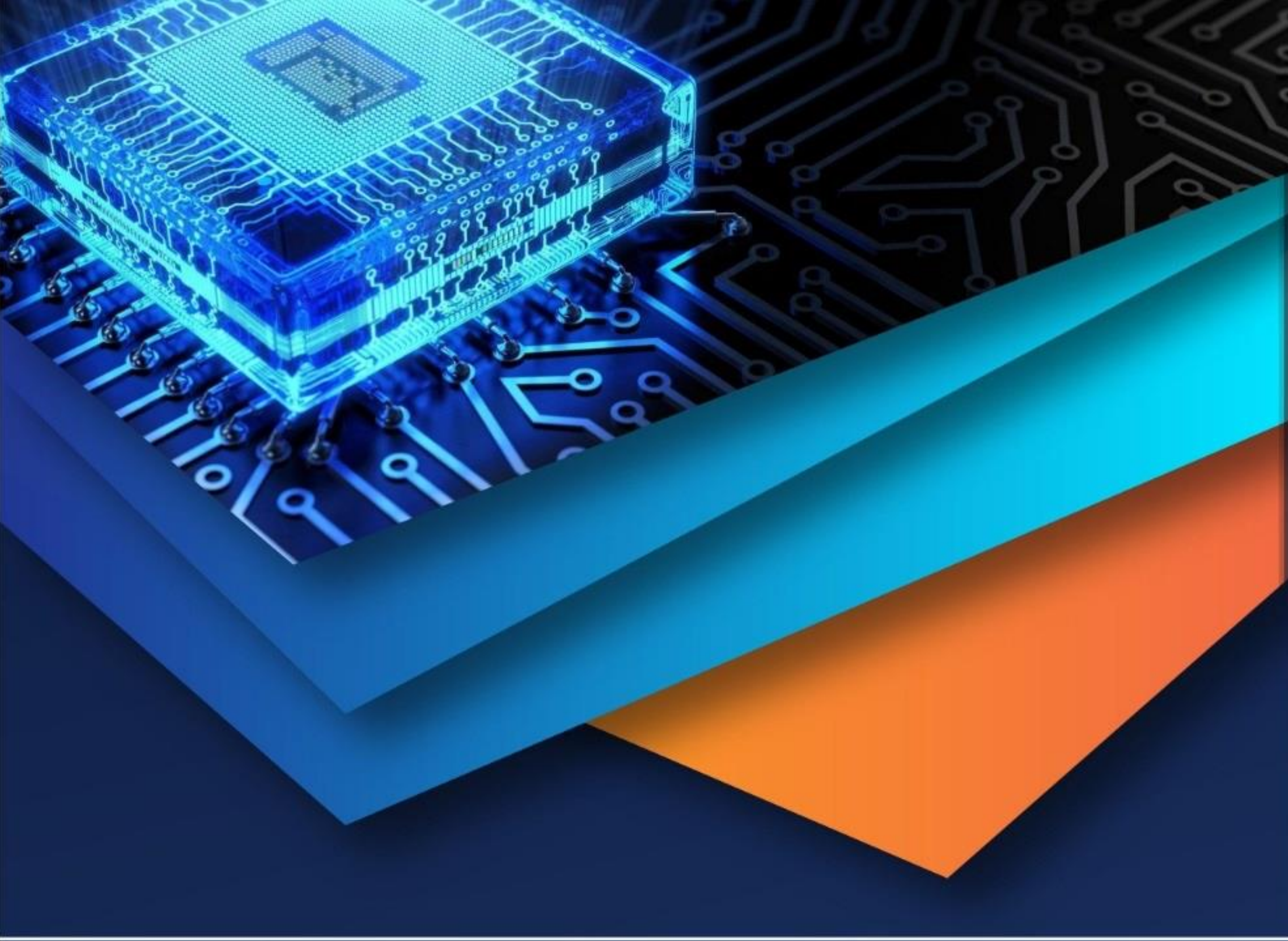

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