iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** I **Month of publication:** January 2021

DOI: https://doi.org/10.22214/ijraset.2021.32833

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue I Jan 2021- Available at www.ijraset.com

Autonomous Vehicle Control using Image Processing

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Abstract: ***A significant perspective related with vehicles is their speed. A faster vehicle encourages us to arrive at our destination in lesser time, sparing our valuable time. In any case, tragically, we have been seeing the ascent in vehicular mishaps because of uncontrolled speeding by the drivers. The traffic signs alone cannot ensure the safety of vehicles since it is dependent upon the driver to adhere to the directions. Likewise, there is the situation of human-mistake where the driver essentially neglects to pay special mind to the traffic signs. This paper focuses on the road traffic sign detection systems which help in informing the intelligent vehicle about the possible road conditions ahead and be cautious about it with the help of Image processing. A module which consists of a Raspberry Pi or USB camera with wide view and a simple processor is installed on the vehicle. The developed system works with three different stages: image pre-processing, detection, and recognition. The entire developed system is programmed using Python incorporated with OpenCV library and implemented using open source hardware platform and open source software environment.***

Keywords: ***Image Processing, Raspberry Pi, Vehicle control, Detection, Recognition***

I. INTRODUCTION

Each individual, regardless of whether a traveller, driver, walker would have seen along the side of the road different sign board that fill significant needs. These significant street signs help us as route guides, warnings and traffic controllers. As control devices for traffic, signs need complete consideration, regard and suitable driver's reaction. However, as indicated by the Ministry of Road Transport and Highways, Govt. of India, expresses that for the year 2017, the single greatest reason for street mishaps in India is Over-speeding, resulting in a staggering 70.4% of all the total road accidents for the entire year. Despite the fact that execution of traffic signals and different estimates like structure speed-breakers in streets close to packed spots are on an ascent, it appears to have little effect towards reducing the number of road accidents. Driver seems to neglect the road sign and tends to create a mishap. So, in this paper I have focused on eliminating human error by providing assistance while driving. This will ultimately help us to prevent road accidents and provide a less risky driving experience for the driver as well as the passengers. So as to comprehend the worries over street and transportation security, programmed traffic sign detection and acknowledgment framework has been introduced in this paper. A programmed traffic sign detection and recognition framework can distinguish and perceive traffic signs from inside and pictures are caught by camera introduced on the front of the vehicle. The programmed traffic sign detection and recognition frameworks when in doubt have made into two explicit stages. The first is typically identified with the discovery of traffic signs in picture utilizing image processing. The subsequent one is related to recognition of these detected road signs, which is based on shape or color segmentation and matching. The segmented potential areas are extracted to be contribution to recognition stage. The fundamental point of this examination is to build up an effective traffic sign detection and recognition framework which can recognize and characterize traffic signs into various classes progressively condition and lessens any odds of event of any street mishaps. Utilizing all the existing techniques and methods of the image processing and acquisition, I have also implemented and refined the ways and methods to make my system more efficient, accurate and foolproof. This will ensure the safety of the vehicle and passengers and will be a great solution to overcome this problem in the field of automation.

II. METHODOLOGY

In this paper, I have planned a traffic street sign identification and recognition framework which will manage the vehicle with respect to whether it should back off, stop quickly or proceed at its present speed. The entire process consists of two parts, firstly, image processing on a data set of roadside traffic signs and training the algorithm with it; and secondly, taking a real-time image capture, processing the image and testing for recognition. In the self-driving car, the parameter like Road sign detection and recognition is one of the primary concerns to be estimated. I have utilized OpenCV software with the Raspberry Pi to identify the road sign like stop sign, speed limit signs to make the vehicle as autonomous. The system will search for the sign, at whatever points it perceive the sign. It quits looking and limits the street sign and shows the message of the sign. The proposed system comprises of the accompanying two primary stages: detection and recognition. The total arrangement of street signs utilized in our project is perceived by the system. The framework utilizes the Raspberry Pi as the processing engine and OpenCV as the software engine.

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When the image has been captured and perceived, the Raspberry Pi orders the motor driver according to the code embedded in it. Thus, in turn the motor driver rotates the wheel and guides the vehicle to the appropriate path according to the sign the system had recognized. The structure of the proposed methodology is given in figure 1.

A. Image Processing

Image processing is a significant piece of the Traffic Sign Detection and recognition framework whose fundamental thought is to evacuate low-frequency noises occurring at the back, normalizing the force of the individual particles pictures, expelling reflections, and covering bits of pictures and disguising fragments of pictures. The input picture is isolated into channels Red, Green, and Blue independently. In the proposed approach, channels are applied on each channel cut-off to pick those zones of the image where the estimations of the pixels fall in the extent of our objective item. For example, for traffic signs with a red foundation, (for instance, stop signs), the breaking point for channel Red is pixels with values in the extent of 90–200 and for channels Green and Blue (for instance, move forward) the range is 0–80.

B. Shape Matching Based Detection

The procedure consists of two modules. The first module is associated with ROI (region of interest) extraction. I have opted for a circular Shape ROI as it transforms the colour images to gray images such that the characteristic colours for the traffic signs are more distinguishable in the gray images. Once the road sign image got converted into gray image, filtering is done on the image captured and its features are recognized, then the image of the traffic sign are chosen dependent on shape matching.

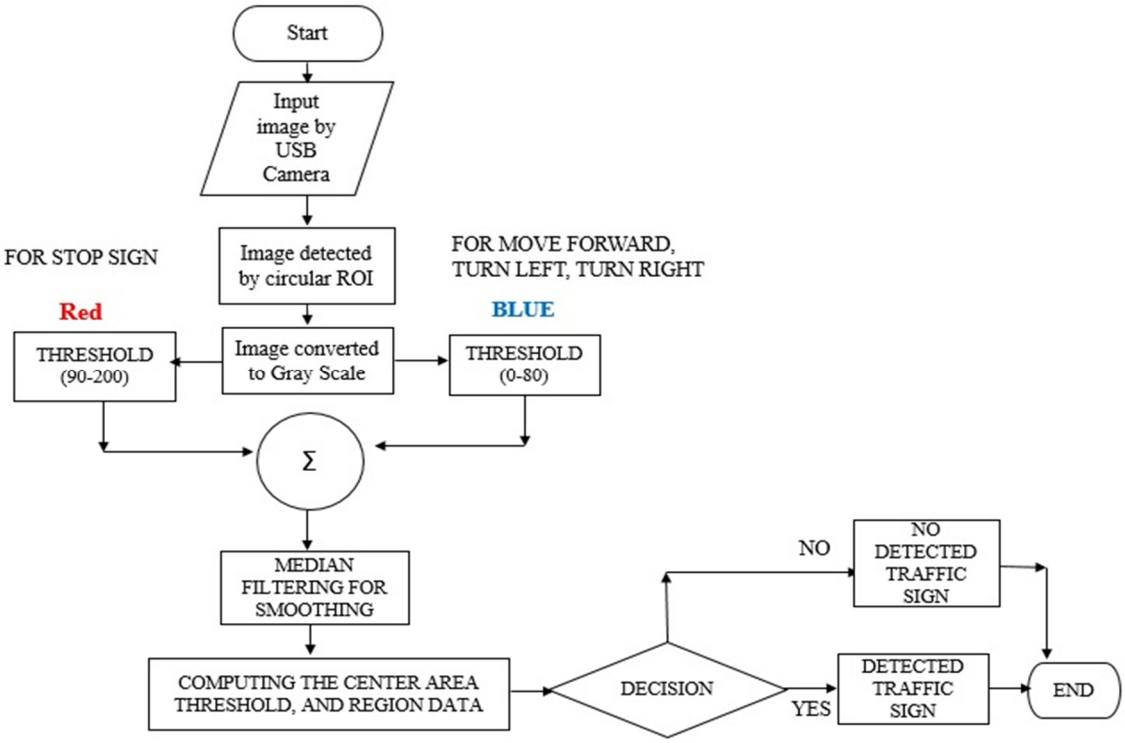

Fig. 1 Structure of Proposed Methodology

C. Baseline Algorithm

1) *The Viola-Jones Locator:* The identification approach by Viola and Jones presented in 2001 has become one of the most famous real-time object detection frame work. Unique outcomes were introduced on the face discovery issue yet the methodology can without much of a stretch be moved to different areas. The identifier is fundamentally a cascade of binary linear classifiers which are accordingly applied to the sliding window input. A model is gone through the course as long as it is emphatically ordered by the present stage. Each stage comprises of a specific number of weighted 1-dimensional edge classifiers that are taken care of with a solitary element. During the stage-wise preparing, at first chose identification and false positive rates are destined to be met by each cascade stage which is prepared utilizing AdaBoost. Consequently, one can evaluate the last execution given the quantity of stages. The preparation set for arrange n is given by every positive model and the bogus positives staying after stage n–1, where those for the principal organize are picked arbitrarily from the full pictures.

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The continuous capacity of the methodology is fundamentally empowered by two properties: Most sliding windows are just assessed by the primary stages which contain not many classifiers/highlights. The highlights offered during preparing are basic Haar-like channels which can be assessed economically utilizing a pre-determined essential picture of gray values.

Indeed, once the pre-figuring is done on the full picture, reactions of every essential sort of Haar-like highlights is figured by 5–8 increases/subtractions and a solitary division, free of position and size. During discovery, the sliding window was scaled to cover all conceivable sign sizes. So as to accomplish strength towards middle measured models, positive examples were haphazardly scaled inside the chosen go. The equivalent was accomplished for interpretation, which is acquainted during preparing with take into consideration bigger advance sizes of the sliding window. Given in the figure 2 are some essential kinds of Haar wavelet highlights utilized for Voila-Jones detector.

Fig. 2 Some essential kinds of Haar wavelet highlights utilized for Voila-Jones Detector.

III. WORKING

A. *Central Principal*

In autonomous driving vehicle, the detection and recognition of any available Road sign is one of the primary concerns. I am utilizing OpenCV Technology with the Raspberry Pi to recognize the Road sign like Stop sign, Move Forward, Turn Right and Turn Left signs to make the vehicle as self-sufficient. The framework will search for the sign, at whatever point it perceives the sign. It quits looking and limits the street sign and shows the message of the sign. The schematic of the proposed system is represented in figure 3.

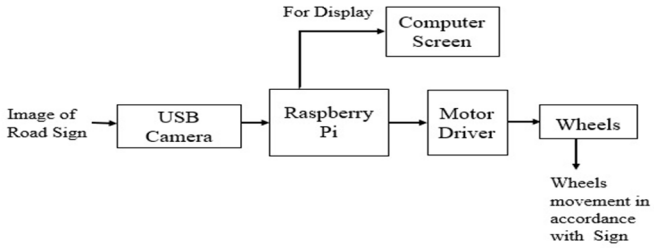

Fig. 3 Proposed Block Diagram

B. *Hardware Component used for Implementation of System*

1) *Raspberry Pi-3:* It is an extremely little size PC that connects to a screen or TV, and uses any standard mouse and console. It is an affordable and capable device that can be used to explore computing, and powerful languages like Python can be implemented in it for computing complex tasks and functionalities. It is the brain of our system which has the code embedded in it to controls the wheels of the car through motor driver and it is also a crucial part in image processing.
2) *USB Camera:* USB Cameras are imaging cameras that utilization USB 2.0 or USB 3.0 innovation to move picture information. USB Cameras are intended to effectively interface with committed PC frameworks by utilizing the equivalent USB innovation that is found on most PCs. The main function of the USB camera is to capture the roadside images and once it captures a frame, it sends them for further processing.
3) *Motor Driver (L293-D):* To control a motor using a Microcontroller or processors I need something called a Motor Driver or Motor Controller. It takes the instruction from the Raspberry Pi module and rotates the wheel accordingly.
4) *Ultrasonic Sensor:* As the name demonstrates ultrasonic sensors measure separation by utilizing ultrasonic waves. The sensor head transmits an ultrasonic wave and gets the wave reflected back from the objective. Ultrasonic Sensors measure the separation between the source and the target by estimating the time between the signal send and the signal received. In our system it is used to avoid the obstacles and prevent collision from any other vehicles in its path.
5) *Battery (Sealed rechargeable 12 V Lead acid battery):* A 12 V Lead acid battery is used to provide the power to the motor driver to rotate the vehicle's wheels, as per the commands.
6) *Power bank:* The Raspberry Pi requires +5.1 V micro USB supply which is provided by an external power bank.
7) *Chassis:* A vehicle outline, otherwise called its body, is the primary supporting structure of an engine vehicle, to which every single other part is connected, equivalent to the skeleton of a life form.

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C. Software used for implementation of system

1) *Python IDLE:* IDLE (short for Integrated Development Environment Integrated Development and Learning Environment) is a coordinated advancement condition for Python, which has been packaged with the default usage of the language. The code is written in this environment and Raspberry Pi is programmed though it.
2) *OpenCV:* OpenCV is the gigantic open-source library for the PC vision, AI, and image processing. By utilizing it, one can process pictures and recordings to recognize items, faces etc. At the point when it coordinated with different libraries, for example, NumPy, python is equipped for handling the OpenCV exhibit structure for examination.
3) *SciKit (library):* SciKit is a library in Python that gives numerous solo and administered learning calculations. It's based upon innovation like NumPy, pandas, and Matplotlib. The functionality that Scikit offers include: Regression, Classification, Bunching, Model determination and Pre-processing.
4) *SciPy (library):* SciPy is a library that utilizes NumPy for progressively scientific capacities. SciPy utilizes NumPy exhibits as the essential information structure, and accompanies modules for different normally utilized errands in logical programming, including straight polynomial math, combination (analytics), customary differential condition comprehending, and signal preparing.
5) *NumPy (library):* NumPy is a low level library written in C (and FORTRAN) for elevated level scientific capacities. NumPy keenly beats the issue of running more slow calculations on Python by utilizing multidimensional exhibits and capacities that work on clusters. Any calculation would then be able to be communicated as a capacity on exhibits, permitting the calculations to be run rapidly.
6) *Advanced IP scanner:* Advanced IP scanner is a free, speedy and fantastic framework scanner with a straight-forward interface. In almost no time, advanced IP scanner can find all the PCs on your wired or remote neighbourhood system and direct a sweep of their ports. The application filters all system gadgets, and gives you access to shared organizers and FTP servers. When Raspberry Pi is turned on, it generates a particular IP. Advanced IP scanner helps us to obtain the IP when the Raspberry Pi is in proximity. The IP is essential to open desktop of Raspberry Pi in our PC and helps us control the microprocessor.
7) *VNC Viewer:* VNC represents virtual network computing. This is a work territory sharing system that licenses you to remotely control another PC. With the assistance of Advance IP scanner, the IP of the utilized Raspberry Pi is obtained and through the help of IP can obtain the desktop of Raspberry Pi and open it inside our personal computer.

IV. HARDWARE IMPLEMENTATION

The USB camera is associated with the Raspberry Pi-3 through USB port by utilizing a link. The USB camera is placed in front of the system such that it can easily detect the sign in front of the vehicle. The motor driver is connected to Raspberry Pi 3 through 4 GPIO pins. GPIO are called as General Purpose Input/ Output pins. The pins can be configured as both general purpose input or general purpose output. Pin number 12, 16, 20 and 21 of Raspberry PI 3 are taken as GPIO pins with pin number 26 and 19 as enable pins. Through Motor driver L294-D, 2 motors are connected. A motor driver has Dual H- bridge configuration. This configuration is used to run motor in either forward or reverse direction. It contains 2 H-Bridges, where each H-Bridge is used to move a single motor. Thus 2 motors are connected to the Motor driver. The motor driver is powered though a 12 V battery and a power bank is used as a USB supply to power up the Raspberry Pi-3. The entire components are placed on a 4-wheel Chassis. The 2 motors are connected at the rear wheels of Chassis which gives it ability to move in any direction. Once any traffic sign is placed in front of USB camera and power is given to each component the camera start detecting the sign through the help of OpenCV library which is equipped with the Python code which has been burned inside the Raspberry Pi-3. Circular ROI (Region of Interest) is used as an Image processing technique to obtain the features of an image. The image is obtained in the form of pixels and these group of pixels are grouped together to form a frame as it can't process picture as a whole. Once this is done, the image is converted on gray scale. On the basis of gray scale readings different signs are distinguished. If the reading on gray scale lies in the range of 80-200, it belongs to the colour red. The sign containing red colour is Stop sign. So stop is displayed on the screen and Raspberry Pi 3 sends the signal to motor driver. The motor driver which is connected to the GPIO pins changes the value to 'low' on each of the pins and motors stops and the wheels do not move. Thus the system attains the rest state when stop sign is detected and recognized. But if the readings on gray scale lie in the range of 0-80, it belongs to the colour blue, the sign containing blue colour are Move Forward, Turn Right or Turn left. So to differentiate between these signs, zones are created which helps us to distinguish between the signs. If the sign Move Forward is detected, the motor driver connected to the GPIO pins of Raspberry Pi 3 changes the value to 'High' on each of the pins. Thus each motor rotates forward and the system moves in the front. In the case of Turn Right, the motor driver keeps initial pins to the 'High' states and the rest to the 'low' state.

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Thus turn right is displayed on the screen and the systems takes a right turn. For Turn left, the polarity of the pins is interchanged and the systems takes the left turn. So in this way the system works and gives promising results.

V. RESULT

This research talked about Traffic Sign detection and Recognition system utilizing OpenCV application. The hardware design implemented as shown in figure 4, effectively served the purpose of detection and recognition of traffic signs. The pictures were pre-prepared in stages with image processing techniques, for example, threshold technique, Shape based detection, Color Matching and Voila Jonas baseline Algorithm and uses the concepts discussed. At that point, these stages were performed to perceive the traffic sign examples. The fundamental motivation to select this technique is to lessen the computational expense in request to encourage the constant usage. When any traffic sign is placed in front of USB camera attached to Raspberry Pi, it captures the roadside images and once it captures a frame, it sends them for further processing. Raspberry Pi has the code embedded in it, once the image is detected; it is recognized by image processing algorithms. The microprocessor then sends the signal to motor driver which in turn rotates the wheel in accordance with the sign recognized. The system also contains Ultrasonic sensor which helps the system to avoid any obstacle and prevents system from collision with any hindrances. Results of the detection system are shown in figures 5a, 5b, 5c and 5d, which depicts the Traffic signs detection and recognition on Python IDLE using OpenCV for circumstances stop, forward, forward right and forward left respectively.

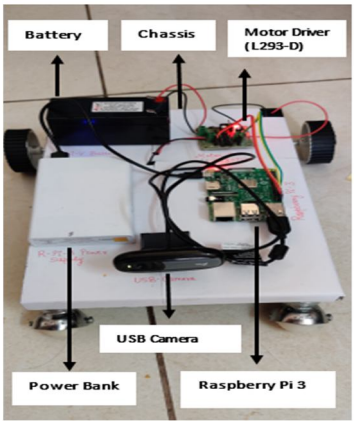

Fig. 4 Hardware system to detect and recognize traffic signs

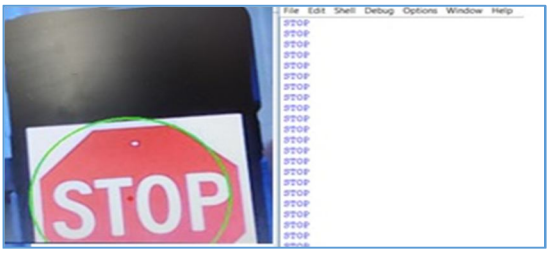

Fig. 5 A)

Fig. 5 B)

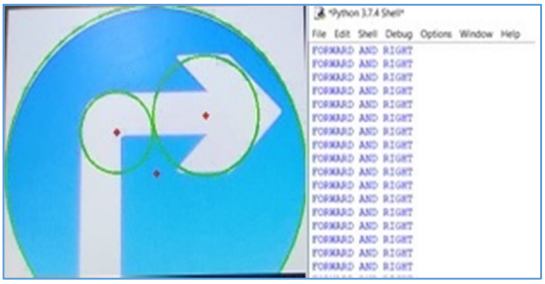

Fig. 5 C)

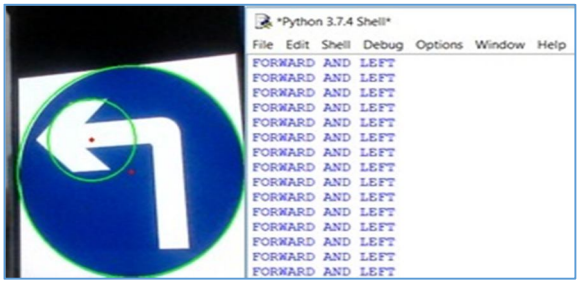

Fig. 5 D)

Fig. 5A, 5B, 5C and 5D Traffic Signs Detection and Recognition on Python IDLE using OpenCV for circumstances stop, forward, forward right and forward left respectively.

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VI. CONCLUSION

This research was focused on finding a unique solution for the problem of over-speeding of vehicles by drivers on roads which led to road accidents. Every year, road accidents due to over-speeding of vehicles are on the rise. The solution to this issue, from a technical viewpoint, turned out to be a Raspberry Pi enabled road traffic sign detection model which detected road traffic signs and based on the inference of those detected signals (which the smart system is able to recognize), the system makes decisions as to whether the vehicle should be stopped immediately, slowed down to a safe-limit where the driver would be able to manoeuvre it safely ahead. The system designed is extremely helpful as it will assist the driver in following road traffic rules properly. Also, it will help to eliminate human-error which is the main reason as to why drivers forget to act according to the road traffic signal shown ahead. The paper focuses on implementing few particular road signs, namely the stop, move forward, turn right and the turn left signals. Notwithstanding, this can be reached out to incorporate other important signals too. This is sure to help the drivers towards helping them achieve a safer ride and improve safety for people walking on the roadside footpaths as well.

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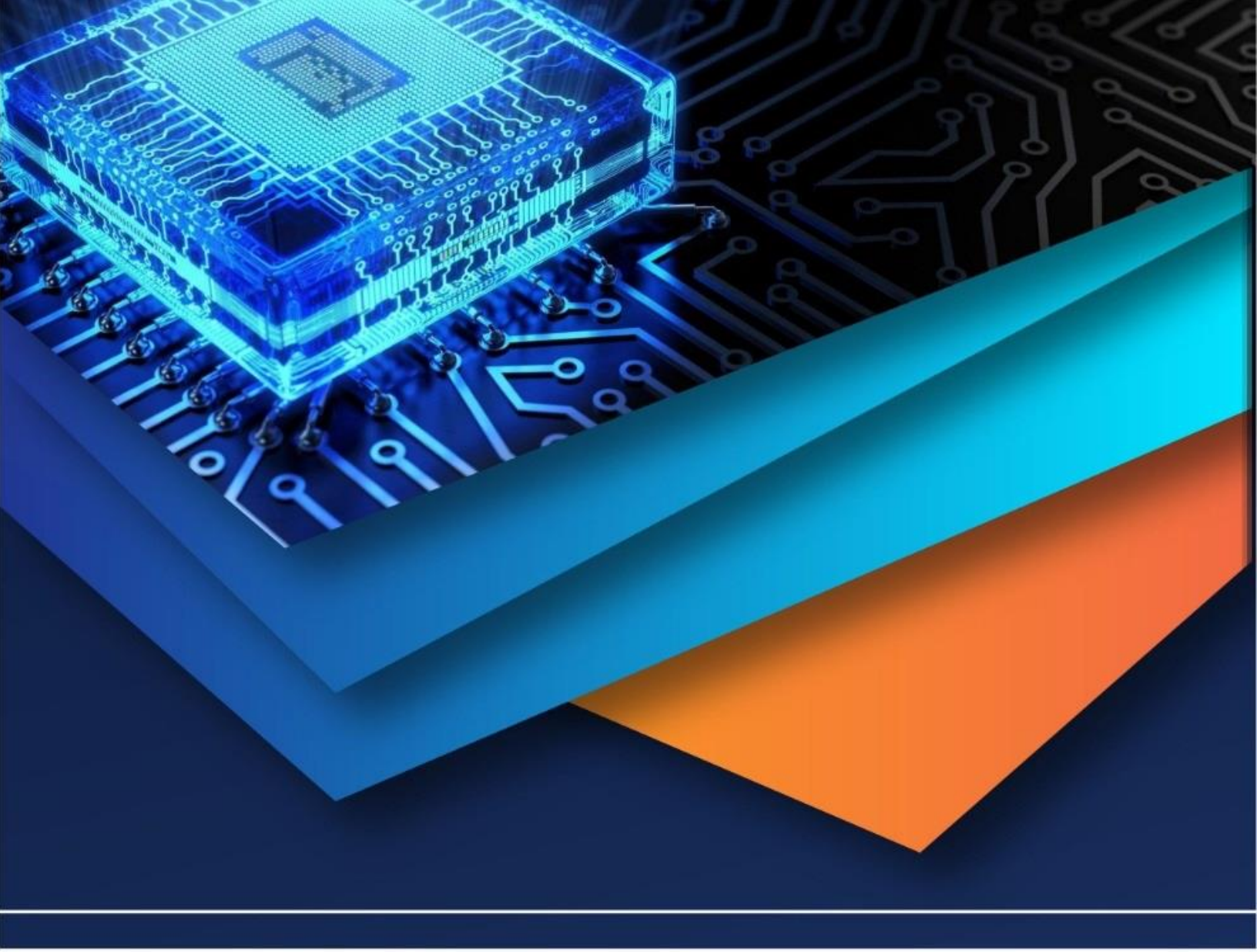

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