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Object Fetching UAV using Autonomous Flight and Object Detection Algorithms

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Abstract: ***Autonomous UAVs (Unmanned Aerial Vehicles) are being used in various applications around the world like surveillance and aerial security, construction, agriculture, delivery, etc. These applications require heavy duty UAVs with high payload capacity and long battery life. The aim of this project is to use the principles of autonomous flight and object detection for indoor autonomous flight with the target to fetch and deliver lightweight objects with minimum energy and time consumption to create a viable prototype for indoor applications like delivering objects to bedridden patients, smart home applications, warehouse management and more.***

Keywords: UAV, PID, YOLO, Object detection, CPP, ROS, Autonomous Drone Operations, Whycon Detection, Darknet, OpenCV

I. INTRODUCTION

The realm of Unmanned Aerial Vehicles (UAVs) has witnessed remarkable advancements in outdoor applications, spanning surveillance to logistics. As the demand for UAVs expands to indoor settings, fresh challenges and prospects emerge, prompting innovative solutions. This research paper delves into indoor UAV operations, specifically focusing on the integration of autonomous flight and object detection algorithms to execute targeted actions within confined spaces. Indoor environments pose unique constraints on UAV operations, necessitating a delicate balance of maneuverability, perception, and navigation. Negotiating cluttered spaces, avoiding obstacles, and interacting with objects demand a sophisticated fusion of cutting-edge hardware and intelligent algorithms. This paper underscores the critical synergy of two pivotal components: autonomous flight and object detection. Autonomous flight empowers UAVs to navigate complex indoor spaces autonomously, optimizing routes for predetermined objectives. Meanwhile, object detection algorithms endow UAVs with the ability to discern and engage with specific objects, expanding possibilities to encompass tasks such as retrieval and delivery. As industries increasingly embrace robotics and automation, the potential applications of indoor UAVs grow apparent. From healthcare scenarios involving delivering essentials to the immobile, to enhancing smart homes and streamlining warehouse management, these UAVs present adaptable solutions. This research unravels the intricate amalgamation of autonomous flight and object detection[2], not only shedding light on technical nuances but also paving the way for a future where UAVs seamlessly coexist in indoor domains. The subsequent sections expound on methodologies, algorithms, and software driving the fusion of autonomous flight and object detection, offering insights into UAV capabilities within the intricate confines of indoor spaces. Also, the role of advanced tools required using ML and ESPs [11-80] are becoming important in recent applications, recognition and control.

II. PROPOSED WORK

A. Block Diagram

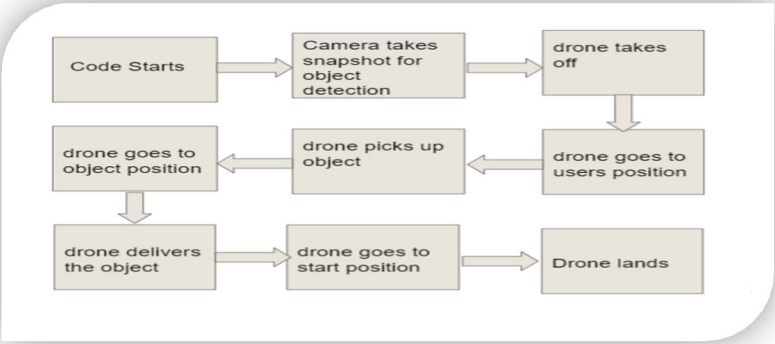

Fig. 1: Block Diagram of workflow

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The proposed flow starts with the fish eye camera taking top view live footage of the area. One snapshot is taken for detecting the object and the another shot is taken for creating the coordinate map of the area for creating target coordinates and to give the negative distance to the drone to cover to reach its various target destinations. Once we have the target coordinates for the detected target object, they are fed to the ROS file containing the PID algorithm. The drone then starts its movement from 0,0,0 and reaches its target object. Once the target object is picked up by the drone (in this case using magnets) target coordinates for users position are fed to the ROS file. When the drone reaches the target user, the user would have to remove the object from the drone manually. When the user confirms the object has been removed, the drone returns back to its original position, lands and disarms.

B. Creating a Whycon Detector to Capture the Location of the Drone

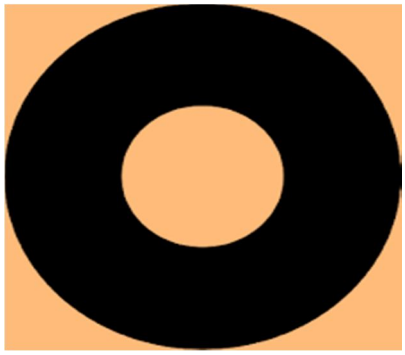

Fig. 2: Circular Whycon Marker

In the process of autonomously flying the drone[1] using its own coordinates and a set of target coordinates, the Whycon detection system uses the Whycon marker attached to the drone and the live camera feed to detect the drones coordinates with respect to the map of the room created by the algorithm[9]. With the drones coordinates, and target coordinates, the distance to be traveled in x, y and z directions can be calculated.

C. Writing a PID Algorithm and Tuning the Drone for Movement

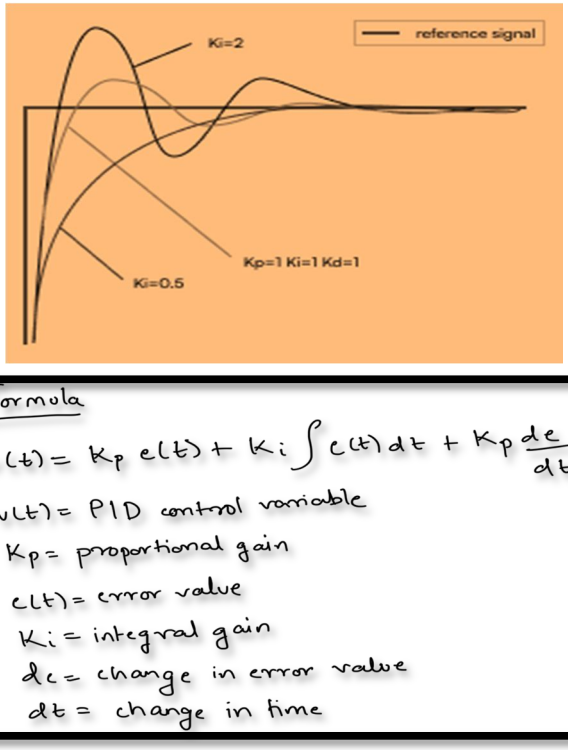

Fig. 3: PID algorithm and tuning

With the x and y distance calculated, the PID algorithm is used to feed the pitch, roll and throttle required to reach the destination. The pitch moves the drone in the y-axis, the roll moves the drone in the x-axis and the throttle moves the drone in the z-axis. The power should be maximum and the dampening minimum without causing turbulence to achieve maximum efficiency with which the drone travels to the destination coordinates. The integral value is determined by the offset of the drone with respect to its coordinates and adjusted accordingly to further refine the accuracy of the drone.

D. Fetching the Target Object Coordinates

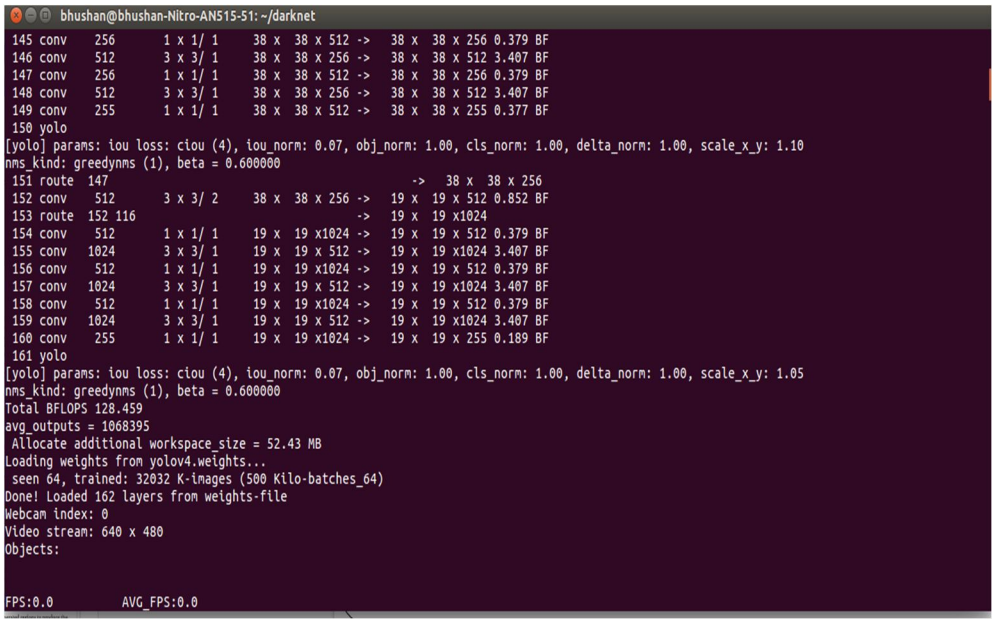

Fig. 4: Working of Darknet code

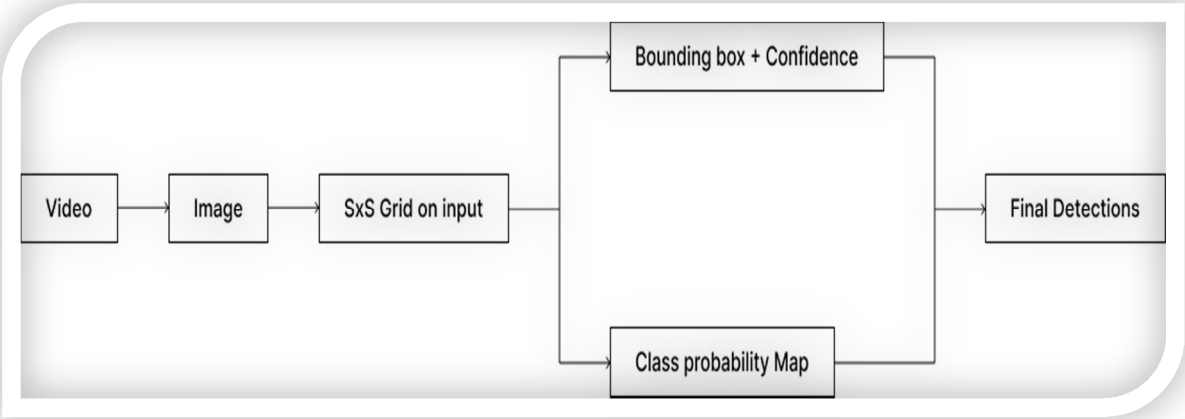

Fig. 5: Video data Processing stages

Using image captures from the live feed captured from the camera, the YOLO algorithm splits the image into a grid, creating m bounding boxes[10]. For each bounding box, the network outputs class probability and offset values. The target object is physically highlighted to further increase the accuracy of detection. The detected image is the run through the CPP algorithm used by the Whycon detector to fetch exact coordinates of the target object with respect to the coordinate map of the area.

E. Delivering the Target Coordinates to the Drone

The result target coordinates are then set as the value for the variable "target_coordinates" used in the PID algorithm to provide real-time dynamic target coordinates to the algorithm.

F. Collecting the Object

Using two simple magnetic strips and a light object as the payload, The drone can attract the object and carry it as a payload. To increase the max weight of the target object increase the payload capacity of the drone (by adding more powerful motors and larger body for stability) and increase the strength of the magnets to support the weight of the object. In the current setting, a 10mg target object was used with the available hardware (drone)

G. Delivering the Target Object to the Target Destination.

Using the same object detection algorithm, the target destination is detected for the object to be delivered, which in this case was a person with a white cap on his head for easy recognition. The same algorithm is run again with different target coordinates. This step requires human intervention to remove the object from the drone.

H. Returning the Drone Back to its Original Position

The target coordinates are once again sent to the drone as 0,0,0 to return the drone to its original position.

III. RESULTS

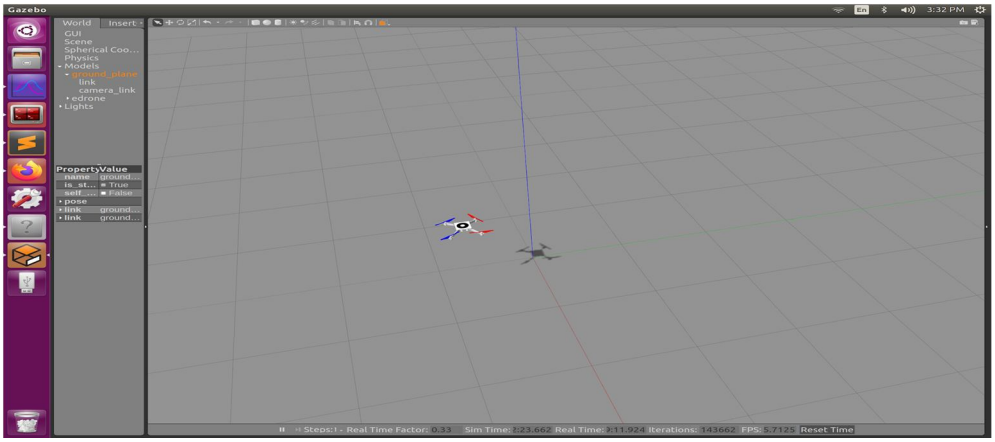

Fig. 7: Flight Simulation in Gazebo

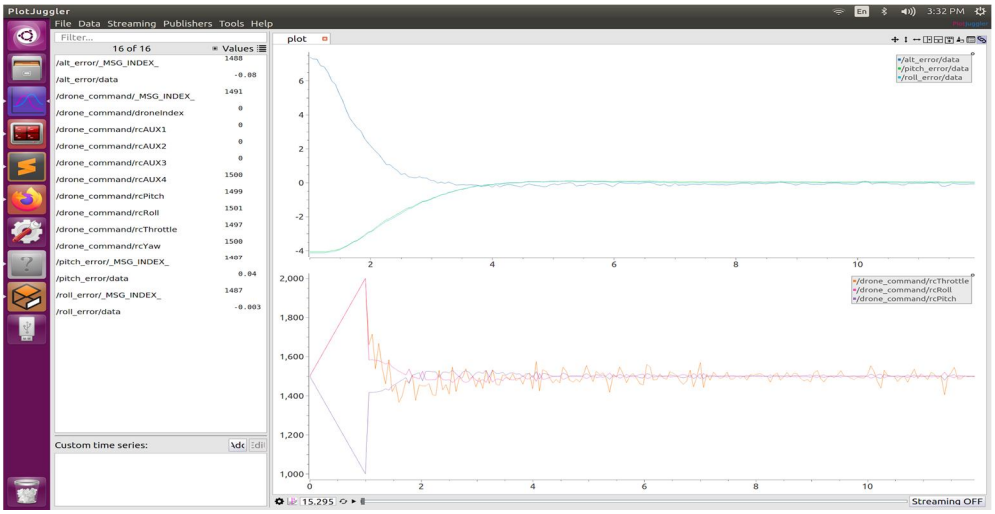

Fig. 8: PID Results of flight on PlotJuggler

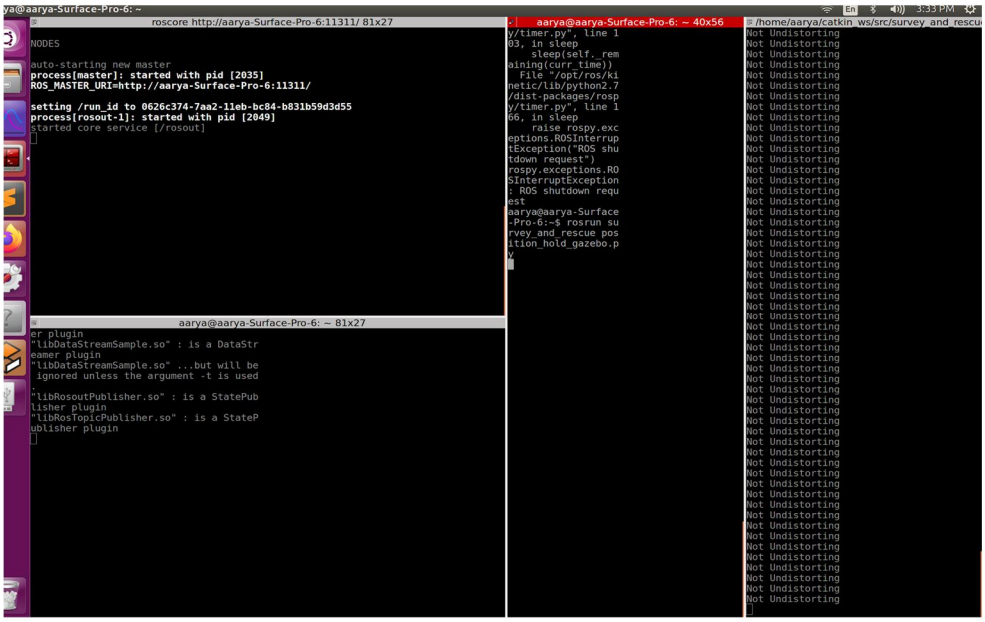

Fig. 9: Flight and Object detection script working

Simulation tests were conducted using Gazebo Simulation Software. The simulation settings provided an environment to conduct PID tuning and testing autonomous flight using dynamic target coordinates. The total displacement of the drone for each mission (flying to the target object, delivering the target object and returning to its original position) was 10.6m with total time spent being 8.34 seconds in flight time. Since the time to remove the object from the drone requires human intervention, the time required for that process was excluded from calculations.

IV. CONCLUSION

This project uses a combination of ROS and PID algorithm, Object Detection using Darknet, OpenCV and YOLO algorithms; to give a final product that is capable of:

1) Detect the object in a room and send the coordinates forward to the ROS of the drone
2) The drone further decides a path to traverse and executes the movement using specified PID algorithm
3) A further elongation of this project is to use magnets to attach target objects to the drone for delivery to target recipients.

The concepts in this project can be applied to generic smart homes, medical centers for bedridden patients, construction, warehouse management, etc. Depending on the application, the payload changes, thus the hardware requirements like the drone, quantity and quality of the camera and the system running the software would need to change.

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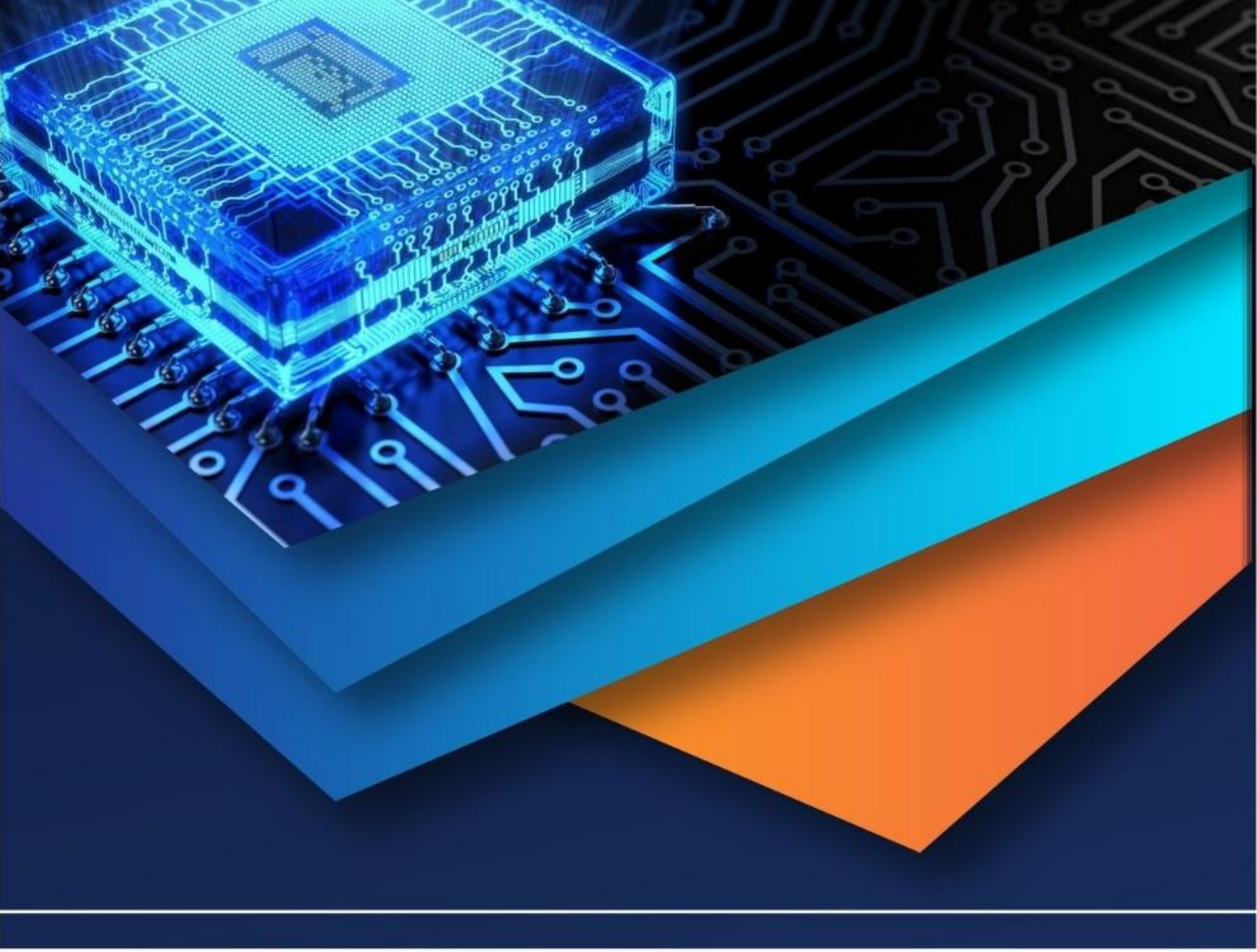

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