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Drone-Based Real-Time Crowd Density Estimation Using Deep Learning Techniques

Prof.S.V. Jagzap, Pragatikatmore, Sanika Nimbalkar, Mayuri Chavan
Department of Electronic abd telecommunication Engineering SVERI's College of Engineering, Pandharpur Punyashlok Ahilyadevi Holkar Solapur University, India

Abstract: ***Crowd management is really important for preventing accidents and keeping people safe during events like religious gatherings, festivals and political rallies.Theoldwaysofwatchingpeoplelikewithsecurity cameras are not good enough because they do not cover everythingtheyarenotflexible.Theydonotrespondfast enough.***
This project is about a system that uses drones and Artificial Intelligence to watch crowds and figure out if there are many people in one place especially in areas that are open or might be dangerous. A drone with a camera takes pictures of the crowd from the air and then acomputerprogramlikeYOLOv8looksatthesepictures to find and count people calculate how crowded it is and see how people are moving.The system always checks this information against safety rules to see if there are many people. If it finds out that there are many people it sends out warnings and updates a special board that the people in charge can look at to take action right away.
This system is better than the ways because it can see more and it is more flexible. It also means that we donot need many people on the ground to watch the crowd, which helps us understand what is happening better and reduces the risk of people panicking or running intoeach other. Crowd management is really important. This system can help with that. The drone system can help keep people safe during events, like festivals and rallies.
Keywords: Drone Surveillance, Crowd Monitor-ing, YOLOv8, DeepSORT, Crowd Density Estimation, Anomaly Detection, Computer Vision, Public Safety.

I. INTRODUCTION

Managing public gatherings like festivals, protests and emergency situations is a big challengeforpeopleincharge.Theyhave to make sure everyone is safe control the movement of people and prevent accidents. Usually crowd management is done by security people watching and using fixed cameras. This can be very time-consuming and not always accurate. It is also easy to make mistakes.
This makes it hard to respond quickly when thingschangeinacrowdinareaswithalot of people. So this project is about making a crowd monitoring system that uses drones and advanced computer techniques. Drones have high-resolutioncamerasthatcanshowwhat is happening in an area in real-time, which is better than just using cameras on the ground.
The video from the drones is analyzed using computer models that can automatically find people look at how crowded it is and watch howpeoplearemoving.Thismeanspeople in charge can keep an eye on things without having to do it all themselves. The system can alsofindsituationsliketoomanypeopleinone place, big groups of people gathering suddenly or people moving in a strange way.
When the system finds something it sends an alert to security people right away so they can take action quickly. This helps prevent things fromhappeninglikestampedesandmakessure peoplearesafe.Italsohelpssecuritypeopleby reducing the amount of work they have to do and minimizing mistakes.
Thesystemcanbeusedindifferentsituations likeinsmartcitiesatbigeventsintransportation hubs and during disasters. Overall this projectis an efficient way to manage crowds by using drones and computer analysis, which makes peoplesaferandhelpsthingsrunmoresmoothly. The crowd management system is a solution, for modern crowd management. It combines surveillanceandcomputer-basedanalysistoen-hancepublicsafetyandmakethingsworkbetter.
Thecrowdmanagementsystemisreliable.Can be used to manage large public gatherings like festivals and emergency situations.

II. OBJECTIVES

The main goal of this project is to stop overcrowding, stampedes and accidents during public events. This is done by using time aerial surveillance to spot areas with high crowd den-sity. During festivals, protests or emergencies manypeopleinoneplacecanbevery dangerous. Oursystemusesdronestomonitorcrowdsfrom above giving a view of how people are spread out.

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This helps spot congestion so authorities can take action like redirecting people or is-suing warnings to prevent disasters.Another important goal is to use learning to accurately count people and track their movement. Our system uses models to detect individuals and follow them across multiple frames without counting them twice.This ensures we have an idea of crowd size and avoids counting people morethanonce.Oursystemisalsodesigned to be privacy-friendly by focusing on how people move and gather not on who they'reThe project also aims to create a cost and efficient drone-based system for monitoring crowds.Traditional surveillance systems can be expensiveandlimited.Dronesonthehandoffer more flexibility and can cover a wider area at a lowercost.Oursystemcaneasilybescaledupor down to suit events and environments makingit a practical solution for modern cities.The system also seeks to integrate crowd behavior analysistools.Thesetoolshelpauthoritiesmake decisionsbyanalyzingcrowdpatterns,such as density and movement flow.This provides insights, in real-time helping officials respond quickly to potential threats and manage crowds more effectively. Overall these goals work togethertobuildanreliablecrowdmanagement system that enhances safety and efficiency in large gatherings.The crowd management sys-tem helps to ensure public spaces.The system promotes innovation-driven approaches to in-frastructure.Thesystemenhancestheefficiency of crowd control mechanisms.

III. RELATED WORK

The proposed system uses an approach to achieve efficient real-time crowd monitoring and analysis. It uses drone-based surveillance andartificialintelligence.Theprocessstartswith data collection. Aerial crowd footage is cap-tured using drones. This data represents crowd scenarios. The system is trained on conditions. Datacollectionisdoneusingdronesorexisting datasets.The data includes gatherings, sparse populations and various movement patterns.

Next annotation is performed. Individualsand specific actions are labeled within images or video frames. Each person in the frame is markedusingboundingboxes.Relevantbehav-iorssuchaswalking,runningorlyingdownmay alsobelabeled.TheYOLOv8trainingphase is then carried out. The annotated dataset is usedtotrainthedeeplearningmodel.YOLOv8 learns to detect people in images. It classifies their presence accurately in time. The model adjusts its parameters through multiple training iterations. This improves detection accuracy. Reduces errors. Once trained the model can identify individuals in video footage.

The system then moves to drone integration. A camera is mounted on a drone to capture live video. The drone streams real-time footage to the processing system. This enables monitoring oflargepublicareas.Thenextstepisreal-time detection. The trained YOLOv8 model processes video frames. It identifies people present, in the scene. Bounding boxes are generated around each detected individual.This allows the system to locate and count people instantly.Crowdanalysisisthenperformedto extract insights. The system calculates the number of people. It estimates crowd density and analyzes movement patterns.The system performsanomalydetection.Itidentifiespoten-tially risky behaviors. These include running, falling or individuals lying on the ground.

The results are presented through dashboard alerts.Allanalyzeddataisvisualizedinato-understand format. The dashboard displays crowdstatisticsandmovementtrends.Ithigh-lightsanomalies.Generatesreal-timealerts.The system undergoes testing and validation. Its performance is evaluated using metrics. These includeaccuracy,precision,recallandresponse time. This ensures that the system works reli-ablyunderconditions.Overallthismethodology combinesdatapreparation,deeplearning,drone technology and real-time analytics. It createsan intelligent crowd monitoring system. This enhances safety and efficiency in managing public gatherings.

IV. PROPOSED METHODOLOGY

Thesystemweareusingismeanttohelp us watch crowds in time and understand whatis going on using advanced computer vision techniques. It starts with pictures and videos from two sources: drones and CCTV cameras. Dronesgiveusaview fromabove which'sgreat for seeing big areas and understanding how crowds are spread out while CCTV cameras showuswhatishappeningontheground with detailed pictures of people and what they aredoing.Byusingbothoftheseviewswe can see everything that is going on in spaces, which makes our surveillance more accurate and effective.

Once we have the video the next step is to collect and prepare the data. We take the video and break it down into pictures so we can look at each one. We then. Format these pictures so theyarereadyfortheAImodel.Wemightalso do some work to make the pictures clearer like reducing noise or improving the quality. This step is really important because if the data is good the model will work better and be more accurate.After we prepare the data we use the YOLOv8modeltolookateachpictureandfind people in it. YOLOv8 is a good deep learning algorithm for finding objects and it can do it in real time. It draws boxes around each person it finds.Givesusascorethattellsushowsure it is that it found someone. This step is crucial because it helps us know where people are and how many there are, which is important for the rest of our analysis.

NextweusetheDeepSORTalgorithmtotrack people as they move. While YOLOv8 finds people in pictures DeepSORT makes sure we can follow them as they move around. It gives each person an ID and tries to keep track of them even if they move, overlap with someone else or leave the picture for a moment. This helpsusunderstandhowpeopleareandhow crowds are flowing. It prevents us from counting someone twice.

Finally we show the results on a dashboard that'seasytouseandunderstand.Thedashboard shows us information like how crowded it is, where people are moving and if there are any potential problems like a big group of people gatheringorsomeoneactingstrangely.Thisreal-time view lets security people or authorities watch what is going on and respond quickly if there is a problem.

The crowd monitoring system we are using combines all these steps. Taking videos prepar-ing data finding objects tracking people and showing the results. Into one system. It helpsus watch crowds in time which makes it easier to keep people safe manage crowds and make good decisions in critical situations. The crowd monitoring system is very helpful for crowd monitoring it helps with crowd monitoring. Itis good, at crowd monitoring.

V. SYSTEM ARCHITECTURE

Thecrowddensityanalysissystemismadeup ofpartsthatworktogether.Itstartswithgetting the data, which is done by drones with quality camerasthattakevideosofpublicplacesinreal time. Sometimes CCTV cameras are also used to get views from the ground. These videos are sent to the part of the system that processesthe data using communication.Next the videois broken down into pictures. These picturesare made smaller made to be the same and formatted so that the deep learning model can use them. This makes sure the data is good and ready to be used.Then the pictures are sent to thepartofthesystemthatdetectsthings,where the YOLOv8 model is used.This model finds peopleineachpicture. Drawsboxesaround
them. It also gives each person a score to make sure it is correct. This part is very important because it helps the system find people quickly and reliably.

After that the system uses the DeepSORTalgorithmtotrackthepeopleitfound.Thisgives each person a number and tracks where they move in each picture. It can even keep track of people when they are blocked by something or someoneelsewhichhelpsthesystemunderstand how people are moving.

Thenextpartiswherethesystemlooksatthe dataandfiguresoutthingsaboutthecrowd.This includes how many people are there how they are. If there is anything unusual going on like people running or a big group of people.Then theresultsaresentto thepartofthesystemthat shows the information in a user way. This is like a dashboard that shows how crowded it is, where people are moving and if there are any problems. It also sends warnings to security people if it finds something that might be a problem so they can respond quickly.

Finally the system stores all the data and results so that it can be used later to make the system better. This part also tests the system to make sure it is working well and quickly.The crowddensityanalysissystemisacombination of drones, deep learning and real time analysis that works together to make a good crowd monitoringsystem.Thecrowddensityanalysis system uses crowd density analysis to make sure everything works well. The crowd density analysis system is very good, at crowd density analysis.

1) Data Acquisition: Data acquisition is the initial stage where input is collected for the system. It involves capturing real-time video footage using drones and CCTV cameras. Drones provide an aerial view, which is useful for monitoring large crowds and open areas, while CCTV cameras offer a ground-level perspective for detailed observation.

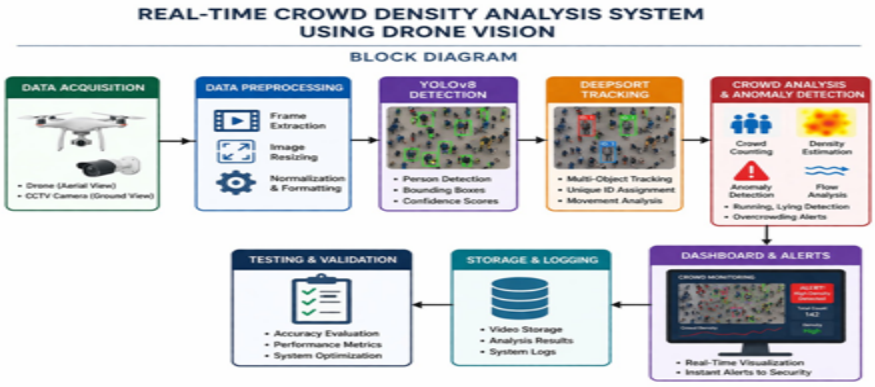

Fig.1.

This combination ensures complete coverage of the environmentandimprovestheaccuracyof crowdmonitoring.

2) Data Preprocessing:

Data preprocessing is performed to convert raw video data into a suitable format for analysis. First, the video stream is divided into individual frames through frame extraction. These frames are then resized to match theinput dimensions required by the AI model. Additionally, normalization and formatting are applied to maintain consistency in data quality. This step enhances the efficiency and accuracy of the detection process.

3) YOLOv8Detection:

In this stage, the YOLOv8 deep learning model is used to detect people in each frame. The model processes the input images and identifies human objects by drawing bounding boxes around them. It also assigns confidence scores to indicate the reliability of each detection. YOLOv8 is designed for real-time performance, making it suitable for continuous surveillance applications where quick and accurate detection is required.

4) DeepSORTTracking:

DeepSORT is used to track detected individuals across multiple frames. It assigns a uniqueidentity(ID)toeachpersonandfollows their movement throughout the video. Even whenpeopleoverlaportemporarilydisappear from view, the algorithm attempts to maintain consistent tracking. This helps in analyzing movement patterns and prevents counting the same person multiple times.

5) CrowdAnalysis:

Crowd analysis focuses on extracting meaningful insights from detected and tracked data. The system counts the total number of individuals present in the frame and calculates crowd density based on the number of people per unit area. It also analyzes the movement flowofthecrowd,identifyinghowpeople are moving within the monitored space. This information is useful for understanding crowd behavior and managing congestion.

6) AnomalyDetection:

This stage identifies unusual or abnormal activities within the crowd. The system detects behaviors such as sudden running, people lying ontheground,orunexpectedcrowdgatherings. These anomalies may indicate emergencies, panic situations, or security threats. Early detection of such events allows authorities to respond quickly and prevent accidents.

7) DashboardAlerts:

Theprocessedinformationisdisplayedona monitoring dashboard in a user-friendly format. The dashboard shows crowd count, densitylevels,movementpatterns,anddetected anomalies. In case of any abnormal situation, the system generates real-time alerts to notify securitypersonnel.Thishelpsinquickdecision-making and effective crowd management.

8) TestingStorage:

In the final stage, the system is tested and evaluated to ensure reliable performance. Met-rics such as accuracy, precision, and response time are used to measure effectiveness. At the same time, video data, analysis results, and system logs are stored for future reference and improvement. This step helps in optimizing the system and maintaining long-term efficiency.

VI. LIMITATIONS AND CHALLENGES

The drone crowd monitoring system faces challenges. One big challenge is detecting peoplefromup.Whenpeoplearepackedclosely together it is hard to count and track them accurately. The drones movement and shaky camera footage make it even harder. Weather conditionslikelighting,rainandfogaffect the video quality.The system needs a lot of computer power to process high-quality video in time. This can make the system expensive and slow. Also drones can only fly for a time, which limits how long they can monitor a crowd.There are also some limitations to the system. It does not work well in crowded areas. The camera quality and video resolution are important for detection. At night the system may need cameras.

The project has to follow drone flight rules and laws in areas. Some people may worry about their privacy with surveillance. The AI modelmayneedtobeupdatedifitisused in a place or with a different crowd. Withthese limitations the system is a good solution for monitoring crowds and keeping people safe.The drone crowd monitoring system faces challenges.

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VII. SECURITY AND PRIVACY CONSIDERATIONS

Theproposedsystemusesdronesandartificial intelligencetokeepaneyeonareasallthetime. So it is really important that we keep the data safeandprivate.Thevideosthatthedronestake might have information that we do not want to share. Therefore we need to make sure that the dataisencryptedwhenitisbeingsentandwhen it is being stored. This way nobody can get toit without permission.Only the people who are allowed to see the videos and the monitoring dashboardshouldbeabletogetin.Weneed to have security so that only these people can see or manage the data. The system should not keep any information that it does not need. It might be an idea to blur faces in the videos so that we cannot see who people are.

We have to make sure that we are following all the rules about using drones to watch people and that we are protecting peoples privacy. When the drones are talking to the servers and the dashboards they need to use channels. This way the bad people cannot get to the videos. Change them or steal them.We need to have rulesabouthowweusethesystemandweneed to be honest, about how it works. This way we can make sure that we are using the system ina way when we are watching people in public. The proposed system should do all these things to keep peoples data safe and private.

VIII. CONCLUSION

This project is about using drones to watch crowds in time. It is an efficient way to dothis. The system uses models to find objects and track them. This means it can tell who is there how many people are in the crowd and what they are doing. Drones can see a lot of people at once which’s hard to do with regular cameras.

The system can also find problems like many peopleinoneplaceorpeoplemovingquickly.

This helps the police know what is happening so they can stop accidents like people getting hurt in a crowd. The system is automatic so peopledonothavetowatcheverythingall thetime.Thismeanstherearemistakesand it works better. The project is a way to manage crowds because it is big enough to work for manypeopleitdoesnotcosttoomuchandit is smart. It is useful for things, like concerts,big gatherings and emergencies. The crowd monitoring system using drones is an idea because it helps keep people safe. The drones and the system work together to make sure everything is okay. The project is an exampleofhowcrowdmonitoringcanbedoneinasmart way.

IX. FUTURE SCOPE

This project is about using drones to watch crowds in time. It is an efficient way to dothis. The system uses models to find objects and track them. This means it can tell who is there how many people are in the crowd and what they are doing. Drones can see a lot of people at once which’s hard to do with regular cameras.

The system can also find problems like many people in one place or people moving quickly. This helps the police know what is happening so they can stop accidents like people getting hurt in a crowd. The system is automatic so peopledonothavetowatcheverythingall the time. This means there are mistakes and it works better. The project is a way to manage crowds because it is big enough to work for manypeopleitdoesnotcosttoomuchandit is smart. It is useful for things, like concerts,big gatherings and emergencies. The crowd monitoring system using drones is an idea because it helps keep people safe. The drones and the system work together to make sure everything is okay. The project is an exampleof how crowd monitoring can be done in a smart way.

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REFERENCES

[1] K. Verma et al., "Strip-based rural food testing kit with GSM/IoT improvement," International Journal of Embedded Systems, vol. 12, no. 2, pp. 109–116, 2020.
[2] A. Verma and R. Deshmukh, "Drone-Based Crowd Monitoring Systems," International Journal of Robotics and Automation, vol. 35, no. 2, pp. 101–108, 2023.
[3] S. Chakraborty and K. Nair, "Real-Time Crowd Density Estimation Using Deep Learning," IEEE Transactions on Intelligent Transportation Systems, vol. 24, no. 1, pp. 45–53, 2022.
[4] D. Sharma and N. Yadav, "Anomaly Detection in Public Surveillance Systems," Journal of Artificial Intelligence Research, vol. 64, pp. 233–247, 2022.
[5] T. Singh and P. Bansal, "Image Processing Techniques for Drone Surveillance," Procedia Computer Science, vol. 199, pp. 1100–1107,
[6] 2022.
[7] R. Kumar and M. Ali, "Smart City Surveillance with AI and IoT," Sensors, vol. 21, no. 12, pp. 1–15, 2021.
[8] H. Patel and R. Sinha, "Deep Learning for Human Detection in Aerial Imagery," IEEE Access, vol. 9, pp. 56034–56045, 2021.
[9] K. Nakamura and A. Das, "Crowd Behavior Analysis in Real-Time Surveillance Systems," Journal of Real-Time Image Processing, vol. 18, pp. 889–902, 2022.
[10] B.PtakandM.Kraft,"ImprovingTrajectory Continuity in Drone-Based Crowd Monitoring UsingDeepDiscriminativeCorrelationFilters," arXiv preprint arXiv:2504.20234, Apr. 2025.
[11] B. Ptak and M. Kraft, "Enhancing People Localisation in Drone Imagery for Better Crowd Management by Utilising Every Pixel in High-Resolution Images," arXiv preprint arXiv:2502.04014, Feb. 2025.
[12] A. Sharma, R. Gupta, and S. Mehta, "IoT Based Crowd Monitoring System," E3S Web of Conferences, vol. XX, pp. XX–XX, 2026
[13] J. Liu, M. Chen, and Y. Zhang, "LiDAR for Crowd Management: Applications and
[14] FutureDirections,"arXivpreprint arXiv:2603.27663, 2026.
[15] 13.P.K.SinghandR.Verma,"Advancementin Crowd Monitoring Using Machine Learning," in Proceedings of Springer Conference on Smart Systems, 2026, pp. XX–XX.
[16] S. Patel, K. Joshi, and M. Shah, "Real-time Crowd Monitoring and Management," ResearchGate Preprint, 2025.
[17] R. Desai and P. Kulkarni, "Real-time Crowd Monitoring System," International Research Journal of Advanced Engineeringand Technology (IRJAET), vol. XX, no. X, pp. XX–XX, 2025.
[18] V.KumarandA.Tiwari,"AIandIoT-Based Crowd Capacity Prediction System," International Journal for Research in Applied ScienceEngineering Technology (IJRASET), vol. XX, no. X, pp. XX–XX, 2025.
[19] L. Wang, H. Zhao, and X. Li, "Enhancing Crowd Management through Behavioural Analysis," Journal of Smart Cities and Society, 2025.
[20] N. Patil and S. Jadhav, "Smart Eye:Real-Time Crowd Monitoring and Anomaly Detection System," International Journal of Progressive Research in Engineering Management and Science (IJPREMS), 2025.

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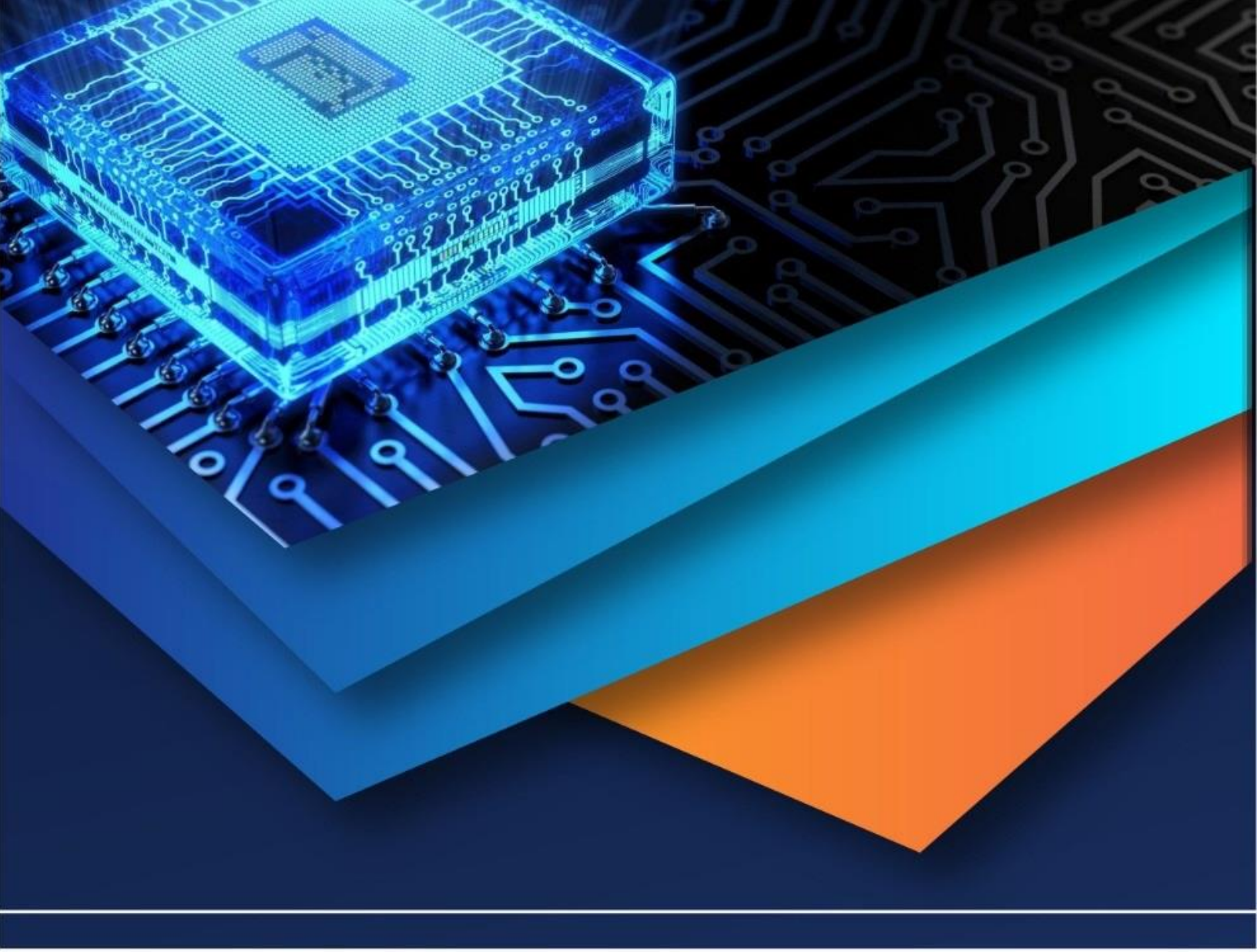

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