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Mixture Based Superpixel Segmentation and Classification of SAR Images

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Abstract: The proposed approach suggests a mixture-based super pixel segmentation technique for synthetic aperture radar (SAR) images. SAR is a radar system used to generate 2D or 3D representations of objects like landscapes. This method utilizes SAR image amplitudes and pixel coordinates as features. Super pixels are large irregular-shaped regions obtained through over-segmentation of an image. While super pixel segmentation methods are commonly designed for colour images, this approach adapts a finite mixture model (FMM) for single-channel SAR images. By employing finite mixture models, the pixels are clustered into super pixels. Following the super pixel segmentation, the method employs a hierarchical decision tree clustering algorithm for classifying different land covers, such as climate monitoring and natural resources exploitation. The decision tree algorithm creates a dendrogram or tree structure to group feature vectors. The proposed super pixel method demonstrates improved classification accuracy compared to state-of-the-art methods like quick-shift, turbo pixels, simple linear iterative clustering, and pixel intensity and location similarity. The implementation of the proposed method is efficiently carried out using MATLAB software.
Keywords: Simple linear iterative clustering (SLIC), Mixture Based model super pixel segmentation (MISP), Image pre-processing, super pixels, Histogram, Satellite Aperture Radar Images (SAR) , Finite Mixture Model, Nakagami Distribution, Hierarchical Clustering ,Bi Clustering, Similarity, Proximity.

I. INTRODUCTION

This chapter deals with the SAR image and radars used to obtain Terra SAR-X images. Various applications of SAR images are listed along with their requirements. The Basic principles of radar imaging obtained through SAR radar are discussed. Climate monitoring, natural resources exploitation, coastal zone monitoring, army systems and earth map compiling requires a wide territory imaging at high resolutions. Radar imaging systems are useful in acquiring high resolution imaging for earth-surface monitoring. Radar systems make use of their own energy to capture an image as an optical system. SAR has entered directly into a brilliant age. More than 25 space borne SAR sensors are being worked these days and 20 new SAR frame works can be discharged within the following 5 years. SAR is interesting in its imaging capacity: it gives high-determination -dimensional images unbiased from sunlight hours, cloud coverageand climate conditions. Interpretation of Synthetic Aperture Radar (SAR) images is not always straight forward, in part because of the non-intuitive, side-looking geometry. Layover is highlighted by bright pixel values. The backscattering of a signal is significantly influenced by the different combinations of polarizations between the transmitted and received signals. The right choice of polarization can help emphasize topographic features. The buildings in the urban areas are exactly perpendicular to the flight direction and they are shown as bright spots. The trend for destiny systems shows the need for an accelerated data content material in SAR images that may be performed through multichannel operation (polarimetry, multi-frequency), stepped forward. For the existing methods in segmentation of SAR images the noise is quite influencing the consequences of the algorithmic strategies. Instead, There is a constrained range of Super pixel segmentation methods proposed for SAR images. Direct application of current super pixel techniques to SAR images may be performed by way of changing the color components with 3 polarized components of SAR Images.

II. RELATED WORK

1) Normalised cuts and images segmentation Authors Jianbo shi and J. Malik, IEEE Organisation. As part of this version, a technique extracts global impressions and provides hierarchical descriptions of scenes. By treating the grouping problem as a graph partitioning challenge, design a normalized cut criterion for the usage of segmenting graphs. The normalized cut criterion assesses both the overall dissimilarity among different groups and the internal similarity within each group.

2) Super pixel segmentation using multiple SAR image products. Authors Mary M. Moya Mark W. Koch, David N. Perkins, R. Derek West. An automated terrain recognition model is presented in this paper. Structures and features should be visible in SAR imagery. It is important to apply these SPS Image algorithms to enhance statistical characterization, reduce image complexity, and improve image quality Scene object segmentation and categorization. Speckle-reduced images can be processed using widely used SPS algorithms, developed for optical imagery Products based on SAR images.
3) Mixture-Based Super pixel Segmentation and classification of SAR Images. In this paper, authors Sertac arisoy and Koray Kayabol Proposed a model in a combination-based totally super pixel segmentation Method. It makes us of hierarchical clustering algorithm for synthetic aperture radar (SAR) images. The Approach uses SAR photograph amplitudes and pixel coordinates as Capabilities. The feature vectors are modelled statistically by way of taking Under consideration the SAR photo data. This paper performs a super pixel segmentation on splendid pixels. After super pixel segmentation, classify different land covers such as city, land, and lake using the features extracted from every super pixel. A super pixel approach is like-minded to SAR picture records. A mixture primarily based model that includes the theoretical information of the SAR pixels.
4) Understanding Synthetic Aperture Radar Images. In this research, the author oliver discusses about the received SAR pixels that they are affected by a strong multiplicative noise referred to as speckle. Speckle is a noise-like version of assessment. Speckle noise happens as a granular pattern fashioned the interference of a randomly scattered strength which occurs when the object is illuminated by coherent radiation that has a tough floor. Speckle noise reasons difficulties in image interpretation and similar processing of the image.
5) SLIC Super pixels Compared to State-of-the-art Super pixel Methods. Author's Radha Krishna Achanta, A. Shaaji, K. Smith, P. Fau IEEE Super pixel algorithms group pixels into perceptually meaningful atomic regions, which can be used to replace the rigid structure of the pixel grid. They detect redundant image information, offer a useful foundation for computing image features, and significantly simplify subsequent image processing tasks.
6) Super pixel Segmentation for polarimetric SAR Imagery Using Local Iterative Clustering. Author's F. Qin, J. Guo, and F. Lang IEEE Published. While the simple linear iterative clustering (SLIC) algorithm is generally effective in generating super pixels for optical imagery, it may exhibit subpar performance in the presence of high levels of image noise.
7) "Turbo Pixels: Fast super pixel using geometric flows". A. Levinshtein, A. Stere, K. Kutulakos, D. J. Fleet, S. J.Dickinson, and K. Siddiqi. Super pixels serve as a constrained type of region segmentation, striking a balance between reducing image complexity.

III. EXISTING METHODS

Super pixel generation algorithms can be broadly divided into gradient ascending techniques and graph-based techniques. For each of these categories, the review popular super pixel techniques shown below, some of which were not initially intended to produce super pixels. Summary of the methodologies under assessment, including their relative success, in both qualitative and quantitative terms. The present system is possible to apply widely used SPS algorithms, developed for optical imagery, to speckle reduced SAR image products. Taking the logarithm of SA-ML and MRCS before applying SLIC with a difference-based distance measure reduces SPS sensitivity to multiplicative contamination. The SLIC algorithm produces higher quality super pixels than does the Quick-shift algorithm for SAR product images.

Furthermore, SLIC is computationally faster than the Quick-shift algorithm. SA-ML-derived super pixels have straighter edges and produce slightly better segmentations than other products. We can use super pixels derived from one product to process data from any other co registered product, which could include an individual RCS magnitude. Thus, this approach does not depend on having temporal multi look data available. The SLIC algorithm parameters directly control the number and average size of resulting super pixels to allow an operator control of trade-offs between super pixel fidelity, computational cost and statistical representation. Combining multiple products as multi-channel inputs to SLIC does not reduce global super pixel errors, but it could provide more flexible segmentations for specific objects, such as including height information to create super pixel segments for the drainage ditch. They have applied SA-ML-derived super pixels to develop a terrain/structure classifier for SAR imagery. These super pixels provide small local self-similar regions for estimating back scatter statistics and can significantly reduce computational requirements for a classification algorithm. Several approaches exist for generating super pixels, each with its own strengths and weaknesses that make them suitable for specific applications. For instance, when preserving image boundaries is crucial, the graph-based method may be the preferred option. On the other hand, if the goal is to construct a graph using super pixels, a method that generates a more regular lattice, such as, would likely be a better choice. While it is difficult to define what constitutes an ideal approach for all applications, we believe the following properties are generally desirable:

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IV. PROBLEM STATEMENT

Further advancements are required in the development of synthetic-aperture imaging techniques, specifically for scenarios where only a limited number of transmitters and receivers are available, and where their positions may be widely dispersed. In this multistate situation, synthetic apertures and real apertures are combined. One specific area that requires attention is the development of methods to align and synchronize the diverse signals from different sources to a shared time reference. Develop fast imaging and target image systems classification/identification of algorithms. The latter deals with the problem of identifying an unknown target from a SAR or ISAR image. For example, from radar images of a scene, we can identify not only the vehicles, but also the vehicle type and even individual vehicles. This challenge exhibits a close relationship to the field of computer vision. Target classification and identification algorithms ideally should run in real time. When the target motion is complex (pitching, rolling and yawning, it may be possible to form a three-dimensional image; fast, accurate methods for doing this are needed. Typical radar frequencies are scattered by forest canopies and foliage. Lower frequencies penetrate better but result in lower resolution images. We cannot extract most information from foliage- penetrating (FOPEN) SAR. In forested regions, multiple scattering phenomena can play a significant role, which is often overlooked in existing imaging methods. These methods typically rely on certain simplified assumptions, such as considering the target or scene as a rigid body, which may not accurately capture the complexities of the scattering process in such environments. as a rigid body. This assumption is obviously inadequate for scenes that include multiple moving objects.

(ii) They also assume a linear relationship between the data and scene. In many situations, this is also inadequate.

V. PROPOSED METHOD

The type of land covers in artificial aperture radar (SAR) images is one of the maximum flourishing research subjects in remote sensing. In conventional pixel-primarily based type methods, the pixels are clustered using best their depth values. A good way to include the spatial dependence of adjacent pixels, a segmentation approach may be used. Unlike the pixel-based totally classification, in super pixel-based totally type, the picture is first divided into big image segments referred to as super pixels. Then, a type of technique is achieved on the first-rate pixels. Notable pixels can be seen as abnormal-formed big image regions received after the over-segmentation of an image. Super pixels are beneficial in reducing the complexity and processing time of images. In image knowledge applications, super pixel segmentation is used as a pre-processing step to obtain a midlevel illustration of an image. Super pixel segmentation strategies are commonly proposed for optical colour pictures. One of the first proposed super pixel strategies is a graph-primarily based segmentation method that uses normalized cuts. In different techniques, some other graph-based approach is proposed. Further to the graph-based totally strategies, clustering based methods have been recently proposed for great pixel segmentation. All the methods can be used for super pixel segmentation of the coloured images. Most of the techniques use the Euclidean distance or Gaussian kernels to degree the similarity among the pixel intensities. The Gaussian distribution may also be a good approximation to model the colour image facts, but this isn't always the case in SAR images. For example, theoretical depth and amplitude statistics of a multi look. SAR images follow gamma and Nakagami distributions. Because theoretical statistical models for SAR images are received under the multiplicative noise assumption, they may be consequently greater convenient fashions to deal with speckles in SAR images. There are a constrained number of super pixel segmentation approaches and methodologies have been put forward SAR images. Direct software of current incredible pixel techniques to SAR images can be accomplished by means of replacing the shade components with 3 polarized The elements comprising of SAR images. In this method, Super pixel segmentation techniques are proposed for polarimetric SAR images using a Wishart distance instead of the Euclidean one. A modified version of SLIC super pixels is proposed for SAR images. Instead of the Euclidean distance, amplitude ratio distance, which became proposed for SAR image speckling is utilized. In this, a new super pixel segmentation technique based totally on a finite aggregate model (FMM) for single-channel SAR images. It makes use of the theoretical statistical model of the SAR Images, which is strong for speckle noise. An interpretation technique is used to think about gestalt-based totally perceptual grouping methods. The most effective use of the two regulations is called similarity and proximity. For similarity, the Nakagami distribution is used as a statistical measure, i.e., two pixels inside the same cluster are assumed to be generated from the same Nakagami distribution. For proximity, the bivariate Gaussian distribution uses a model of the spatial distances between the pixels. Each similarity and proximity statistic are blended into an FMM. FMMs have been already utilized in SAR picture intensity and amplitude type. The use of these statistical measures inside an FMM, the pixels are clustered around the top-super pixels' centroids. Super pixel segmentation itself won't suffice to represent a whole image. To attain an extremely good pixel representation of the image, super pixels are classified in line with their features, which can be extracted from super pixels. A histogram is used for the pixel intensities as capabilities. On this letter, re-sorting to a hierarchical clustering algorithm for the class of the splendid pixels. Super pixel Segmentation with the combination version.

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It can easily produce a significant classification map through classifying the exceptional pixels into a finite number of instructions. This letter makes use of a hierarchical choice tree clustering set of rules for the class of super pixels.

VI. FLOW CHART

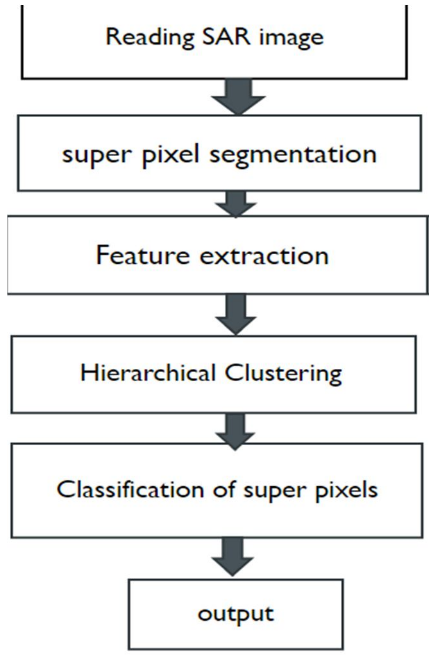

Fig 1: Flowchart of MISP

Additionally, there are clustering methods like two-way clustering, bi and co-clustering, or biclustering, which not only cluster the objects but also consider the features of the objects, typically represented in a data matrix, the initial rows and columns are clustered simultaneously.

VII. RESULTS

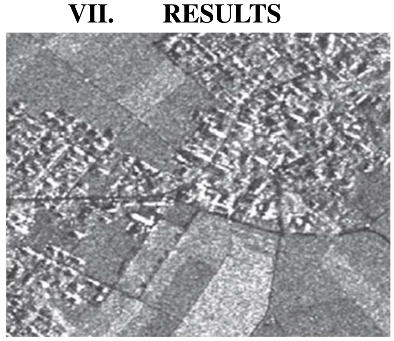

Fig 2: Input SAR Image

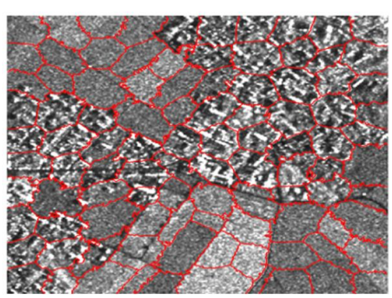

Fig 3: MISP Segmenatation

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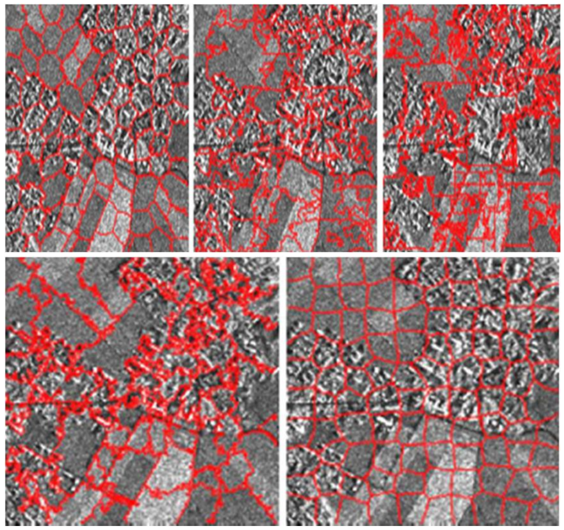

Fig4: Super pixel segmentation results obtained by MISP, SLIC, PILS, QS, and TP methods for the First input image. (a) MISP. (b) SLIC. (c)PILS. (d) QS. (e) TP.

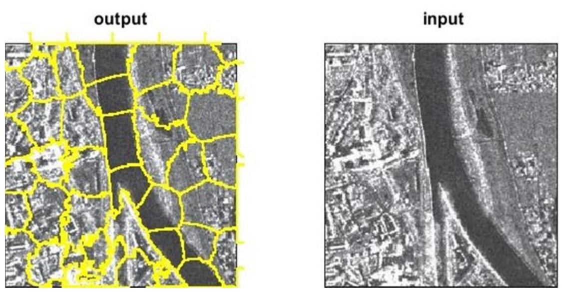

Fig 5: MISP Segmentation for Second Image

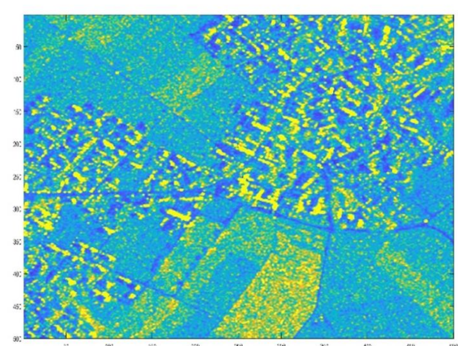

Fig 6: Classification of input image

OA OF THE CLUSTERED APPROXIMATE 100 SUPERPIXELS ACCORDING TO THE HIERARCHIAL CLUSTERING OF FIVE DIFFERENT ALGORITHMS.

Algorithms	MISP	SLIC	PILS	QS	TP
SAR 1	76.30	61.30	53.30	41.30	29.3
SAR 2	71.30	58.30	50.30	38.30	19.3
SAR 3	70.30	55.30	49.30	34.30	17.3

Hence, it can be observed that the MISP is comparatively better than the other algorithms. For the first input image, MISP has an OA value of 88.05 while the SLIC has 53.96 and PILS with 39.87. The same trend continues for the rest of the images. The second image produces a classification with OA value of 87.35 with PILS at 37.76. To conclude, MISP is far better than the existing algorithms by huge margin.

VIII. CONCLUSION

The MISP (Mixture-based Super Pixel) model proposed in this study is a well-suited method for super pixel segmentation in SAR image classification. The classification results obtained using super pixels demonstrate that MISPs outperform other methods in accurately classifying land covers in the best SAR images. Although this letter focuses on using histograms extracted from super pixels as features, further exploration of different feature extraction methods is warranted. The proposed method has undergone successful design and testing. Given that super pixel methods developed for optical images do not yield satisfactory performance for classifying land covers in SAR images, this approach aims to address this limitation by developing a super pixel method specifically tailored to SAR image statistics. By employing a mixture-based model incorporating the theoretical statistics of SAR images and utilizing elliptic contours of Gaussian density for spatial clustering, the resulting super pixels exhibit more regular shapes with smooth boundaries. Comparative analysis of the classification results confirms that MISPs outperform other methods in accurately classifying land covers in SAR images.

IX. FUTURE SCOPE

Synthetic Aperture Radar (SAR) images is one of the most flourishing research topics in remote sensing. By using clever signal processing, SAR creates Radar images of higher resolution than otherwise be possible. SAR imagery provides information about what’s on the ground, but distortions and speckles make these images very different from optical images. Furthermore, FMM is computationally faster than the Quick shift algorithms.

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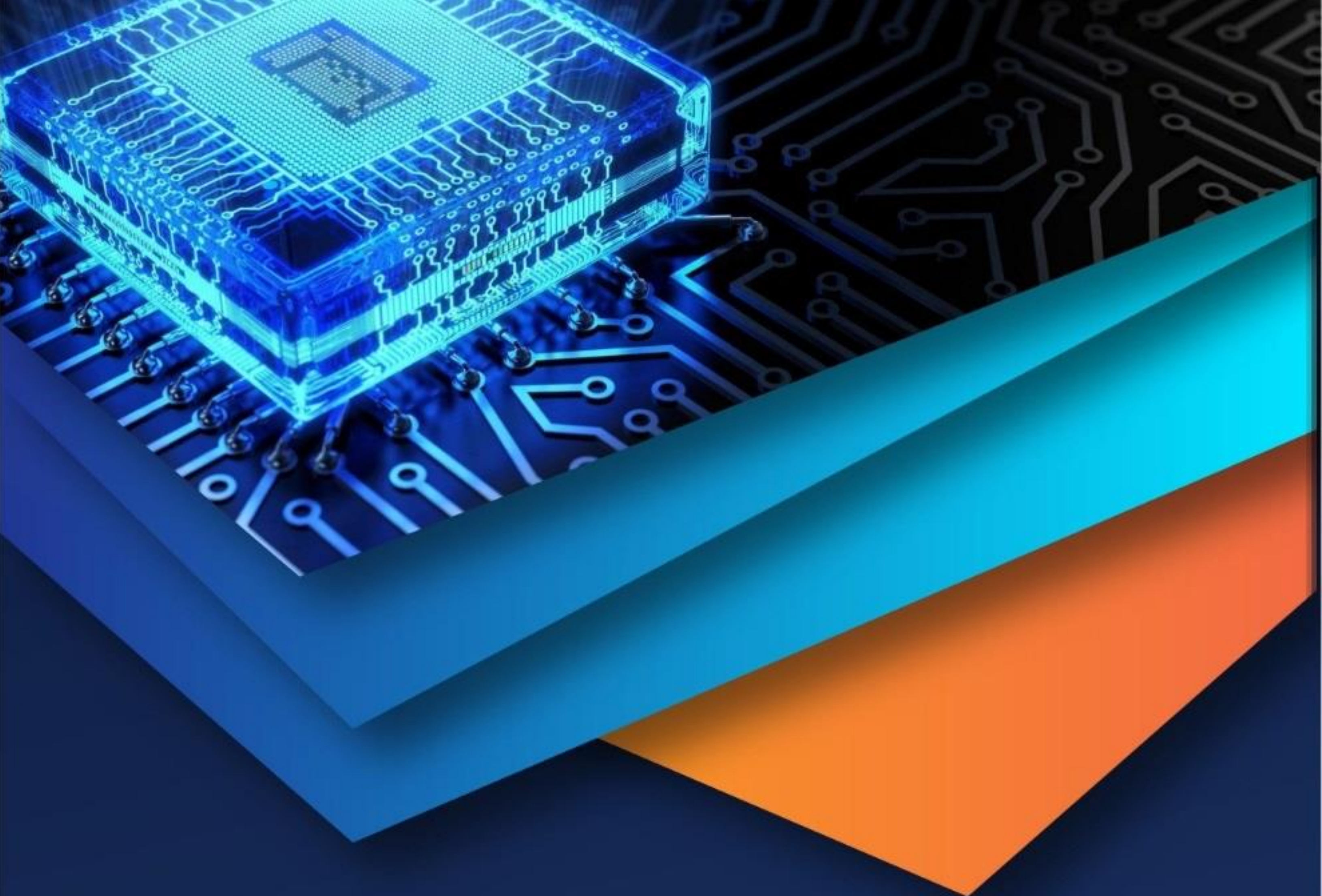

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