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Shadow Detection and Removal Technique using CNN

Akanksha Bankhele[1], Neha Patil[2], Prajkta Waghmare[3], Sharada Patil[4]
[1, 2, 3, 4]*Dept. of Electronics and Telecommunication Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India 411044*

Abstract: ***The Shadow detection and removal Technique is used in many real-world applications, such as surveillance systems, computer vision applications and indoor outdoor system. The shape and orientation of an object, as well as the light source, can be revealed by shadows in an image. In a traffic surveillance system, the shadow can misclassify the actual target, lowering the system's accuracy. Numerous algorithms and techniques have been developed by researchers to aid in the detection and removal of shadows in images. This paper aims to provide an overview of different shadow detection and removal techniques, their advantages and drawbacks. Also implementation of Convolutional Neural Network for shadow detection and OpenCV features to remove shadows by re-designing the output and analysing different loss functions to train the network.***
Keywords: Shadow Detection and Removal Techniques, Shadow Image Processing.

I. INTRODUCTION

Image processing is a domain of study that has piqued the attention of a wide range of researchers. Camera processing entails the manipulation of images, photographs, videos, and other media. In Image processing which is type of signal processing has input and the output will be an image or their features and parameters detected. Image processing encompasses a wide range of functions, including image compression, segmentation, optimization, video and image encoding and transfer, computer vision, industrial applications and more. Shadow detection is important for object recognition and recovery of data in high spatial resolution remote sensing images [12]. Many fundamental computer vision functions can be complicated by shadows. Object detection, stereo, shape reconstruction, image segmentation, and scene interpretation performance will all be harmed. Knowledge about shadows and how to remove them will help increase the optical appearance of digital images.

II. OVERVIEW OF SHADOW

An Introduction to shadow Shadows are natural events. Shadow occurs when the light is blocked. If there is less light energy falling, that area is called a shadow field, and if there is more light energy released, that area is called a non-shadow zone

A. Types of Shadow

The clarity of images is often degraded by shadow. Self-shadow and cast shadows are the two forms of shadow[7]. Self-shadow casts its own shadow. This type of shadow has different brightness intensity level. The visibility of all shadows in an image is determined by the reflectivity of the object as well as the contrast of the image. Self-shadow receives more secondary lighting from surrounding illuminated objects hence has more brightness as compared cast shadow. Cast shadow again has two types [2]: umbra and penumbra. When the source of light is blocked by an object, then the shadow casted is called umbra. A Penumbra is the region around the umbra where the light source is partially or imperfectly blocked.

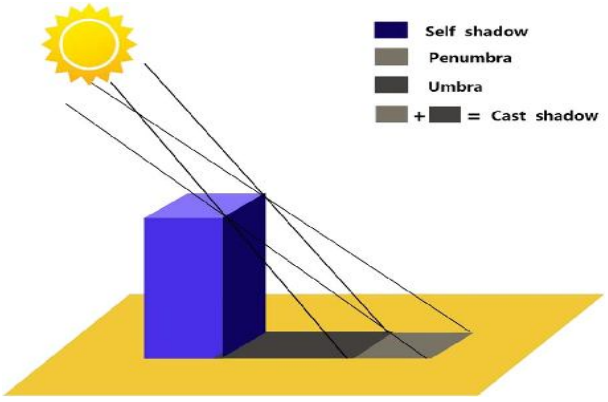

Fig.1. Illustration of types of shadows

B. Properties of Shadow

We can distinguish between shadow and background through some properties. Few of them are listed below.

1) A shadow region has less brightness or illumination than the background pixel. This change is smooth with the neighbor pixel.
2) The shadow RBG values are all smaller than the background RBG values.
3) The saturation and hue elements of shadow pixels are slightly smaller than the background in Hue-Saturation-Value colour space. [4]
4) Shadows have lower grey level value than the background and object.
5) Shadows have rich texture, while the shadows are texture-less. The texture of shadow and background is same.[11]
6) An indirect source of light illuminates the shadows, while direct light illuminates the background.
7) If compared with background a shadow has lower boundaries.
8) Even if the object and shadow has same motion, their location is different.

III. LITERATURE REVIEW

In ref. [1], they have tried to detect shadow for the moving objects. For this the observations have been taken as the street which is recorded by a fixed camera. They have approached with 2 different models and have compared with their Accuracy, criticality and Computation complexity. The first model is, SAKBOT and the second model is ATON. Further they concluded that the first model can identify the shadows of the moving objects better. While, second is better in detecting shadows of still objects.

In ref. [2], the shadow edge is detected by a method called clustering. This method is an extension of Finlayson's method which is again, based on Canny, which is process of edge detection. This basically aims to in increasing the processing time and efficiency. The whole algorithm divided in three steps.

A. Distinguish the binary background image.
B. Recognize object region by HSV color space.
C. Removing shadow and restoring the input image.

In ref. [3] in this method the shadow is detected by using Discrete Wavelet Transform (DWT). DWT along with HSV is used to find relative standard deviation over standard deviation as it is more accurate to determine threshold. This method is used to examine video snippets sequences. This method also works well at places with poor lightning.

In ref. [4], this algorithm uses NIR information. This algorithm works on raw images. The method is comparatively fast and accurate (when it comes to computation) than segmentation method and pixel based method. Along with advantages there are a few disadvantages also. A material which has very less reflectance such that it is almost transparent it may be detected as shadow. Similarly, a material with high reflectance the shadows may be avoided. For further more work in future it can be outstretched to moving background images also.

In ref. [5], method is based on presumption about complexity and grouping of shadow image. Basic goal of method is: 1. it gives review on difficulties in shadow removal of single image. 2. It provides solutions in shadow removal like illumination and reflection. If shadow edge of image is correctly detected, then only this method gives good results. A new method is suggested for shadow removal without shadow detection. In this method original image converted into YCbCr color space and after that Y channel is divided into base layer and detail layer[5].

In ref. [6], different types of ostu algorithm are discussed. Ostu algorithm is a core of histogram. In this method, two-dimensional Ostu algorithm has better segmentation performance than one-dimensional Ostu algorithm for both strong and weak noise case, but there are some mis-sorted points in two-dimensional Ostu algorithm[6]. Two-dimensional Ostu algorithm and its fast algorithm having computational complexity strong but applications are limited. One-dimensional average decomposition of two-dimensional Ostu algorithm keep better anti-noise nature as well as enhance the processing speed and storage space and segmentation outcome can be better than the previous Ostu algorithm[6].

Ref [7], in this method RGB image converts into HSV color model. Element of shadow in the image is filtered by homomorphic filter and it gives the image without shadow. By using subsequent image processing the quality of image is improved. This method removed shadow in outer region but shadow inside the region is not completely removed.

In ref. [8], this paper proposed actual edge features for shadow detection of remote sensing images. Feature edge gradient is used to display edge intensity of region; texton texture analysis is used to resolve the number of pixels of each region as in ref. [11]. Accuracy of this method is good as compared to method of ref. [12] and ref. [13]

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IV. THE PROPOSED METHODOLOGY AND IMPLEMENTATION

Fig.2 is the proposed block diagram of the shadow detection and removal method. In this architecture, the shadow detection network is adopted with CNN (Convolutional Neural Network) whereas for shadow removal we are using OpenCV.

A. Input is provided in the form of an image which contains shadow, this can be in formats like jpeg., png., etc.
B. Second block consists of processing of image. Image processing is basically eliminating the noises and distortions. It also includes analysing and manipulating image according to the application (which in our case is shadow detection).
C. Third block consists of feature extraction. It is a special type of dimensionality reduction and initiates from an initial set of measured data and builds derived values (features) intended to be informative and non-redundant, facilitating the subsequent study and generalization steps, and in some cases leading to better human interpretations[4].
D. Further for detection the whole algorithm has to be trained using CNN. For this training we have used SBU dataset which has almost 6000 images. Once the algorithm gets trained then we are able to detect weather the images contain shadows or not.
E. For shadow removal mechanism, as mentioned earlier, we are going to use OpenCV. OpenCV is basically a library of python which is many times used in image processing applications.
F. First, the image is read and is converted into numpy array. Further Bilateral filtering is applied to remove the shadows present in the images.

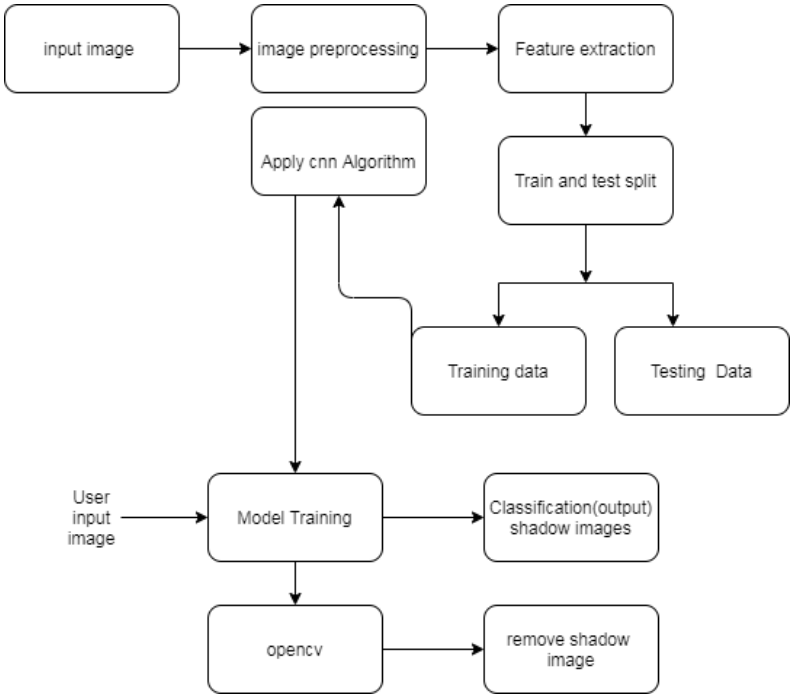


Fig.2. Block Diagram of Proposed Method

V. FLOW CHART

The flowchart shown below (in fig. 3) explains the working of whole process of system to detect and remove shadow from an image. The image will be taken as input. Cropping and resizing of image will take place in pre-processing block. This process is done to minimize the memory usage by the image. It is a method that changes the pixel intensity values range. Further normalization of image is done. The purpose of normalization is usually to bring the image into a range that is more familiar for the algorithm to achieve consistency in dynamic range for a dataset, (images) to avoid mental distraction or fatigue.
Shadow detection is done by training the model. At model training stage, the model weights are sequentially adjusted accordingly with the target of minimizing the Cross-Entropy loss. The process of adjusting the weights is what defines model training and as the model keeps training and the loss is getting minimized; we say that the model is learning. Hence, for detection of the shadow Convolutional Neural Network will be used.

When OpenCV is integrated with various libraries, such as Numpy, python is capable of processing the OpenCV array data structure. This property will further help in image detection, hence for shadow removal. At first, we split the image (which is taken as input) into different image channels that is, Red Green and blue. For this there is a dedicated split function in cv2 module (OpenCV module) called as split().This function splits the images of the source matrix into the channels the image and saves them in the destination matrix.

Further we apply the filter algorithm (Binary Filter) which again, is present in OpenCV module as bilateralFilter().Through this process the shadow is removed. Even though shadow gets removes the image is still in the form of numpy array, whch is basically a 2-D array. So, to convert a numpy array into the general formats like JPEG or PNG .We have another step called Normalization. We normalized images using OpenCV's *"cv2.normalize()"* function in Python.

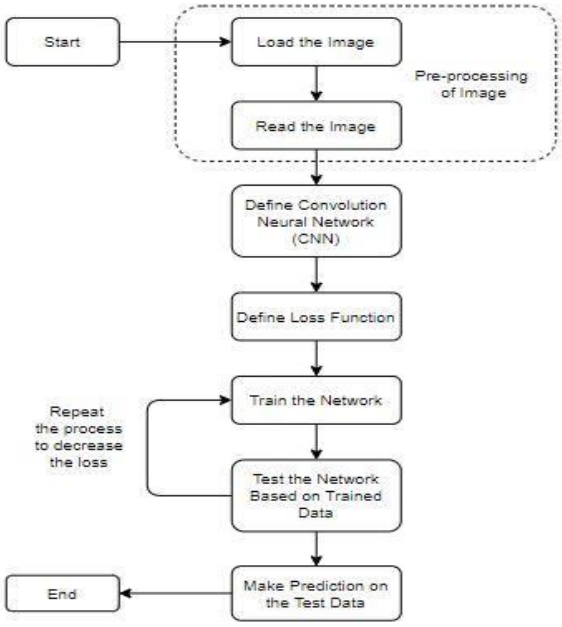


Fig.3. Flow Chart of Proposed Method

VI. OUTCOMES

We have examined our algorithm on various kinds of images of different quality, size and images having different light sources. Based on the results we have concluded the following:

A. Our algorithm is able to identify shadow of indoor and outdoor images properly.
B. It detects images of all quality properly with an accuracy of 93%.
C. As we have used CNN its computational capacity is more than many other present algorithms.
D. In the cases of high contrast colors the colors are not retained properly

Our algorithm performs very well as of shadow detection part. But for the shadow removal part it has many limitations. We have used OpenCV (which is a python library) the resultant images are of reduced quality, this is because of the fact that their tricolor attenuation model, which forms the basis for their shadow removal. This can be further improved by:

1) If we use a GPU based (Graphical processing unit) device instead of CPU which we have used for our current experiments.
2) If we have a large data set along with their shadow masks. Presence of shadow masks the process of shadow removal more easy.
3) The more we train our algorithm with diverse dataset the results will be more satisfying and we will be able to achieve more accuracy.

Hence our future scope is to get better outcome for the shadow removal by improving the shadow removal algorithm.
Shadow detection result:

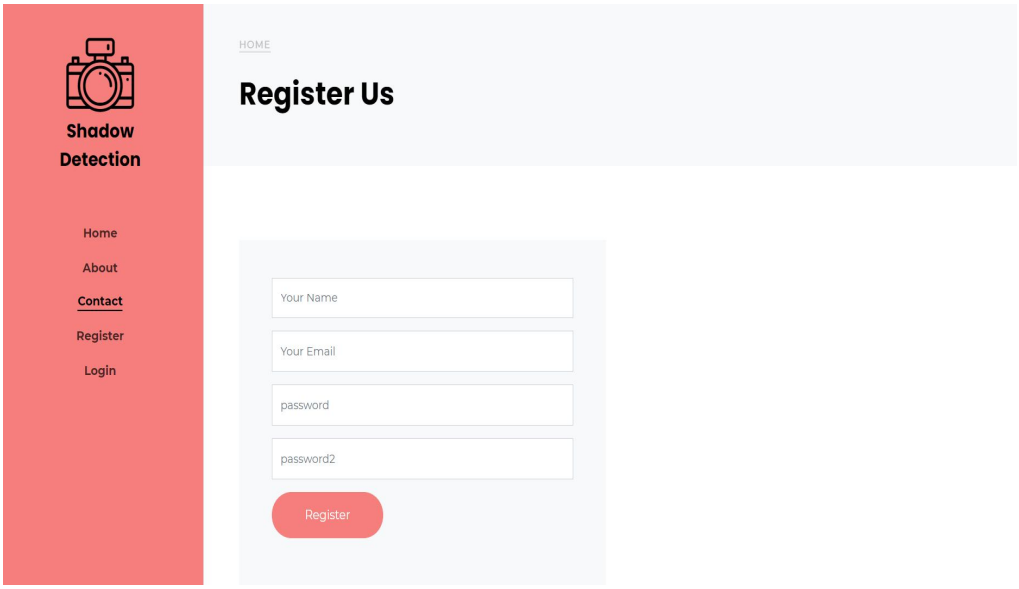
Fig.4. Shadow Detection

A. Shadow Removal Result

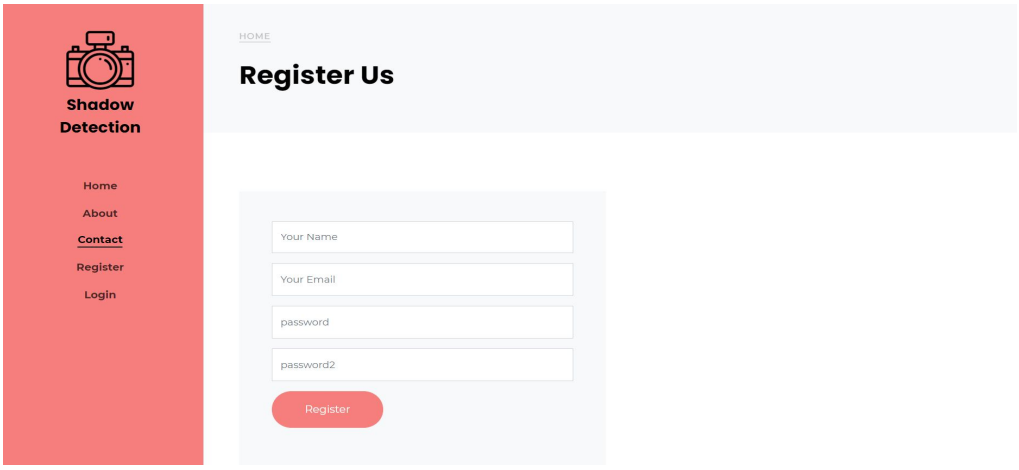
(5.1) Image with shadow (5.2) Shadow removed from image

Fig.5. Shadow Removal

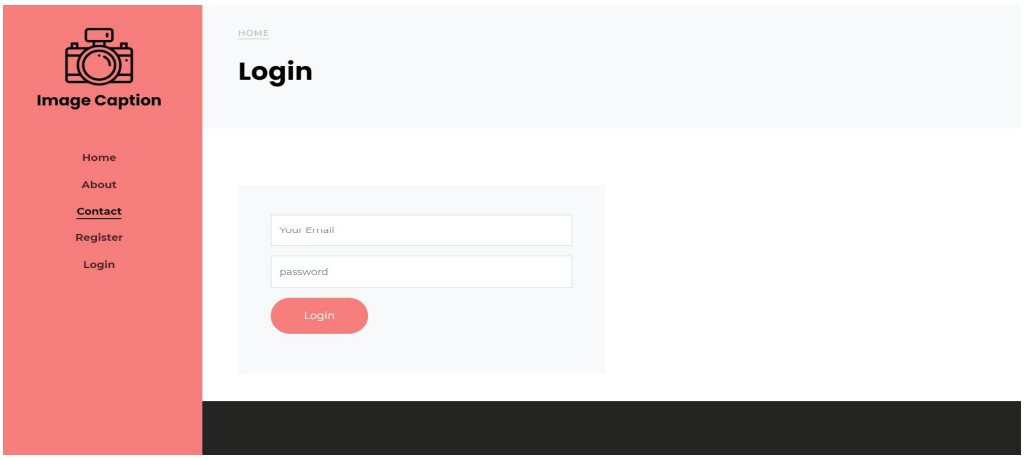
B. Website View For Image Upload And Checking



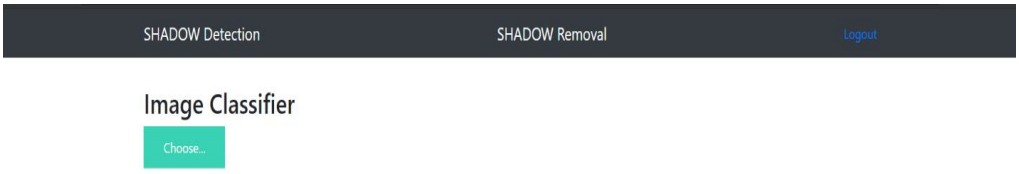
(a) Main Page



(b) Register Page



(c) Login page



(d) After Login

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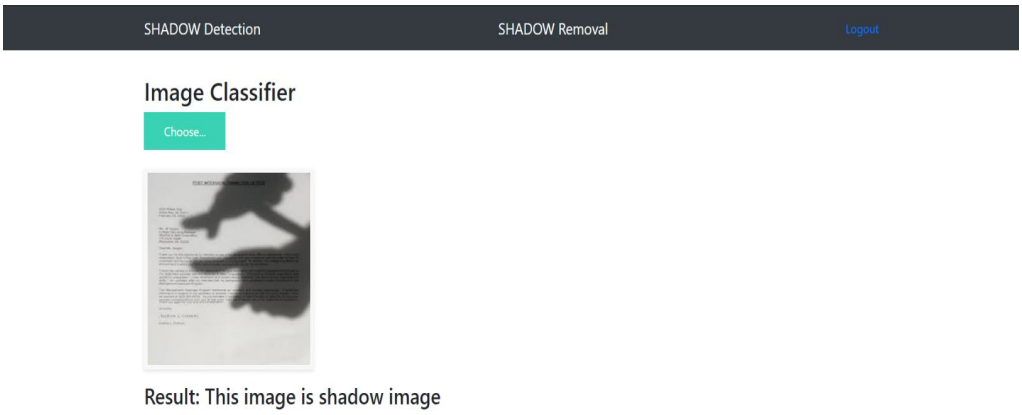
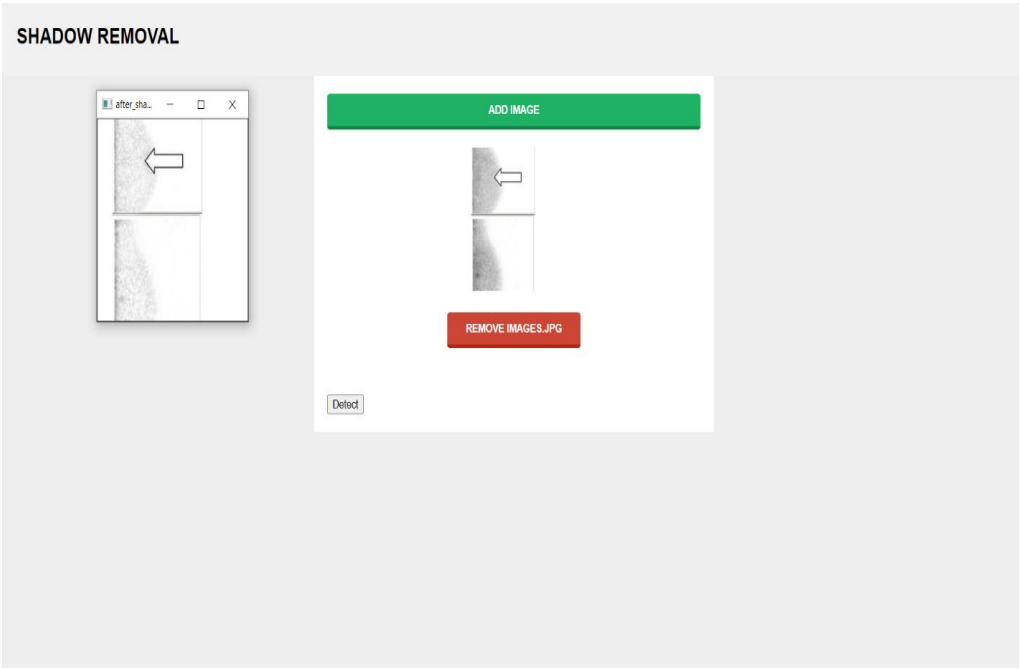


(e) Shadow detection



(f) Shadow Removal

Fig.6 Website screenshots

VII. CONCLUSION

Shadows are un-detachable part of nature. Due to this it causes problems in many space applications where presence of shadow may cause many confusion, hence shadow detection and removal comes in picture. In our paper we have used Convolution Neural Network for the shadow detection. Further with the help direction aware spatial context, which an integral part of CNN we have tried to detect the shadows using shadow masks. We have used OpenCV along with bilateral filters (to minimise the effect of noise) for the purpose of shadow removal. As for shadow detection results are quite impressive. It detects images of all quality properly with an accuracy of 93% whereas for shadow removal there are areas of improvement. Future scope is to increase the accuracy and maintaining the quality of image in shadow detection and removal process respectively.

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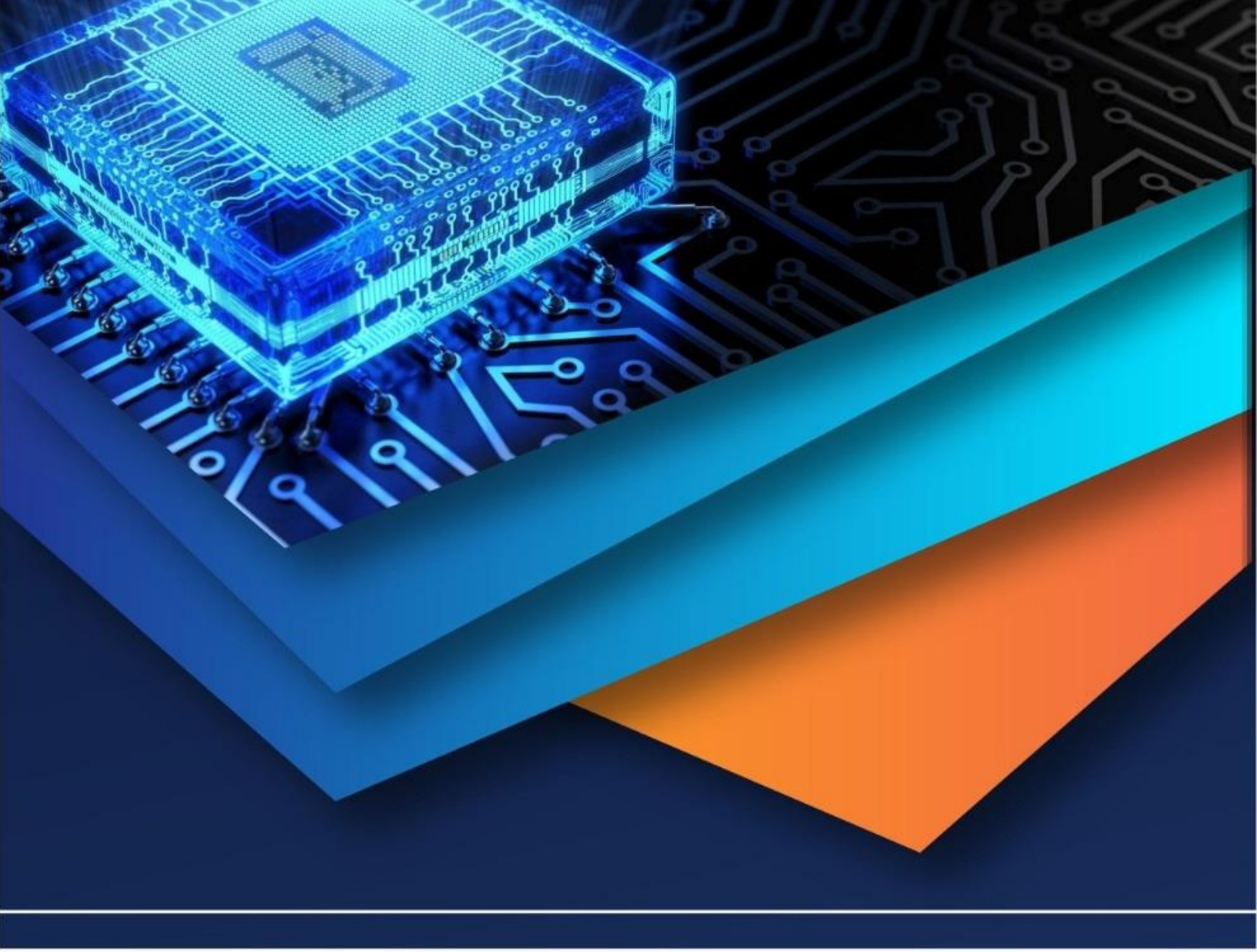

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