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Finger Vein Authentication System using Convolutional Neural Network

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Abstract: ***The most vital requirement in today's world of spoofing attacks is high security. Thus, an embedded finger-vein recognition system for authentication is proposed. Finger-vein based recognition has gained attention in recent years due to its unique biometric technology.***
The vein based authentication system is a promising biometric pattern for personal identification in terms of its security and convenience.
The vein patterns are taken directly from live human body and hence, are totally natural as well as providing direct proof. To work effectively and efficiently, our finger vein recognition algorithm will make use of deep learning techniques. Deep learning has been successfully used in many technologies such as face recognition, image recognition and target detection, etc.
Keyword: Finger vein recognition, biometrics, deep learning, convolutional neural network, identification, feature extraction

I. INTRODUCTION

In this rapidly growing world of technology, the need to secure our systems from getting hacked into is crucial. One important part of security is making sure that no unauthorized personnel can access your system i.e. authentication system. Our paper will be focusing on biometric authentication.

Biometric authentication is the process of verification of user identity using a biological input, obtained by scanning or analyzing of some part of the human body.

One of the most commonly used forms of biometric authentication is fingerprint recognition. But it isn't fail-safe. Fingerprints are can be easily transferred onto the surfaces we touch, which can then be lifted and used to gain access. Hence, there is a need for something more robust.

Our proposed system is an embedded finger-vein recognition system that can be used for authentication. The patterns made by the veins present in our body are unique and do not change after the age of 18. This pattern can only be seen with the use of an near-infrared(NIR) light and hence, there is no risk of transferring and it is not easy to steal. Also, by making use of NIR LEDs, nothing else can be used in place of an actual finger.

Using biometric authentication in lieu of generic methods like ID/password, smart cards, key fobs, etc, which can be stolen or replicated, provides an even greater advantage.

Deep learning techniques will be used in the system for recognition and comparison.

Another advantage is that the system can be embedded with any other application in need of security as it is an authentication system, and hence it has widespread applications. It can be used on mobile and PC terminals to lock the device, which has become an increasingly standard feature.

Extending the same to technologies like Pay-by-finger, Finger Vein Authentication will make it safer and more robust. Furthermore, in-house verification by walk-through biometric authentication will also improve the security of the company drastically and can also be used for certification of time and attendance of the workforce.

It can also be used at airport security to verify passenger identity and make their journey seamless; which has been largely implemented by large international airports. Law enforcement agencies can also make use of the system, as vein patterns cannot be altered or destroyed easily.

Fusing our identity with this biometric data digitally makes it unambiguous, consistent and most importantly, permanent. These features ensure the highest level of security and safety.

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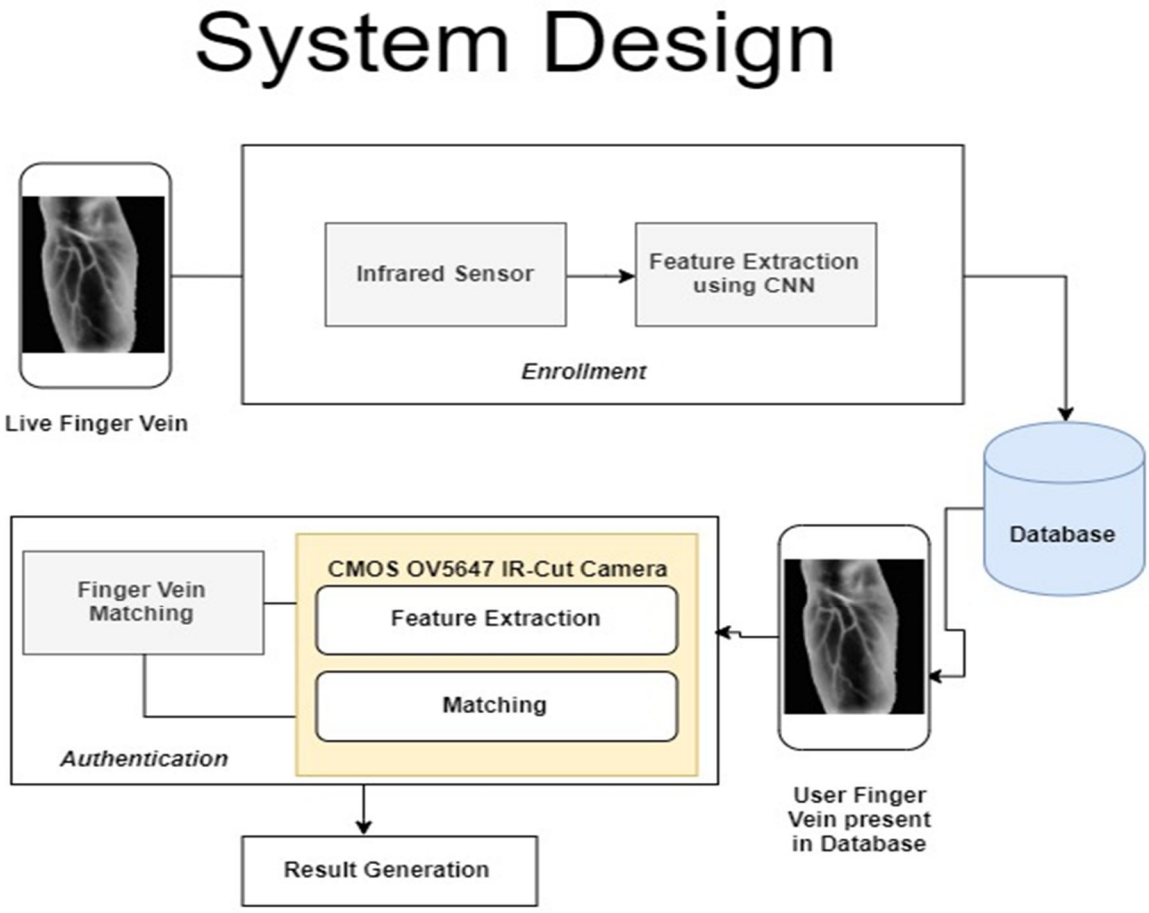

II. ALGORITHM

A. *What is Deep Learning?*

Deep learning is a collection of algorithms used in machine learning, used to model high-level abstractions in data through the use of model architectures, which are composed of multiple nonlinear transformations. It is part of a broad family of methods used for machine learning that are based on learning representations of data.

Deep learning is a specific approach used for building and training neural networks, which are considered highly promising decision-making nodes. An algorithm is considered to be deep if the input data is passed through a series of nonlinearities or nonlinear transformations before it becomes output.

Deep learning removes the manual identification of features in data and, instead, relies on whatever training process it has in order to discover useful patterns in the input examples. This makes training the neural network easier and faster, and it can yield better results.

Yamakun who is the Director of AI at FB got inspired by a paper written by 2 people on Mammalian Vision Cortex. This paper suggested that all mammals that see objects are seen through neurons in clusters which are hierarchical.

B. *Convolution Neural Network Is Used For Images Where Position Matters*

There are a series of clusters that get fired where each cluster is a feature, for example, when a dog is seen by a human eye, the first cluster detects the edges, the second shapes etc. and at the highest cluster it detects the entire dog.

Three important ideas of CNN

1) Local Connections (Connection between clusters of neurons)
2) Layering (Hierarchy of features)
3) Spatial Invariance (Facts that are recognized even under special conditions

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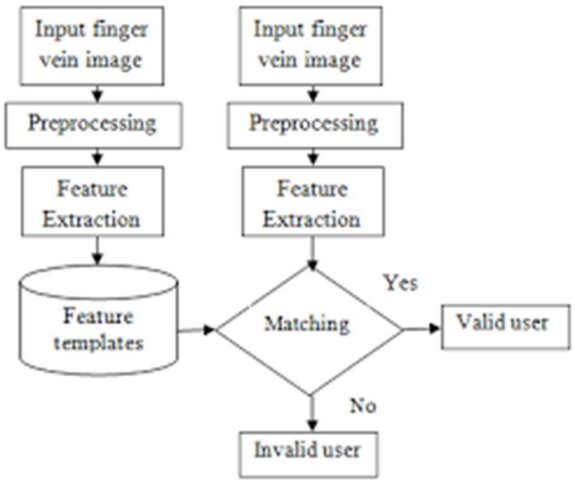
C. How Does it Work?



1) Feature Learning

a) Convolution

b) Relu

c) Pooling

2) Classification

Steps to achieve CNN

a) Prepare Dataset and Convolution

i) Every image is a 3D matrix of pixel values(1D-Heigt, 2D-Width and 3D- Depth (either R,G,B channels for coloured or B,W channels for grayscale i.e. amount of R or G or B from 0 to 255)

ii) Best Training Sets – CIFAR, CoCo.

iii) Convolution is the combination of input image to multiple matrices of abstract data through receptive field (a small part of the matrix e.g.: torch) to form a new output and this output is the input to the next layer and this is repeated.

iv) Taking a curve of a shape as an example, the curves weights are plotted on the matrix and then dot multiplied with the actual matrix. If the dot product is exceeding a particular value then it's a match! It's a feature! Else not.

b) Pooling

i) It takes the important part of the filter and makes a new matrix hence reducing the size and improving density.(Max pooling is the most used)

ii) In max pooling the pixels with max intensities is taken to make a new matrix.

c) RELU(Rectified Linear Unit)

i) It is an activation function as they make the models learn linear or nonlinear function.

ii) It turns all negative numbers as 0.

d) Drop Out: Every weight value in the matrices is randomly changed into a 0 at some point. This is to ensure that the network is forced to learn new data.

e) Softmax: Helps to make sense of the probabilities achieved.

f) Argmax: The max probability is chosen. This was Forward Propagation.

This system consists of the following steps:

i) Acquisition Of The Image: This step is the first and very important step in finger vein authentication system.The image of the finger vein is acquired with the help of a scanner which scans the veins of finger.This scanner comprise of infrared sensors. The finger vein scanner consists of an acryl which serves as a platform for placing the finger. The CMOS camera is used for capturing the image of finger veins.

ii) Finger Region Extraction: This step is performed after the required image of the finger vein is captured. The Finger region is extracted by using the principle of Region of Interest(ROI). The ROI is obtained by thresholding the image. The multidimensional filtering is done for thresholding.

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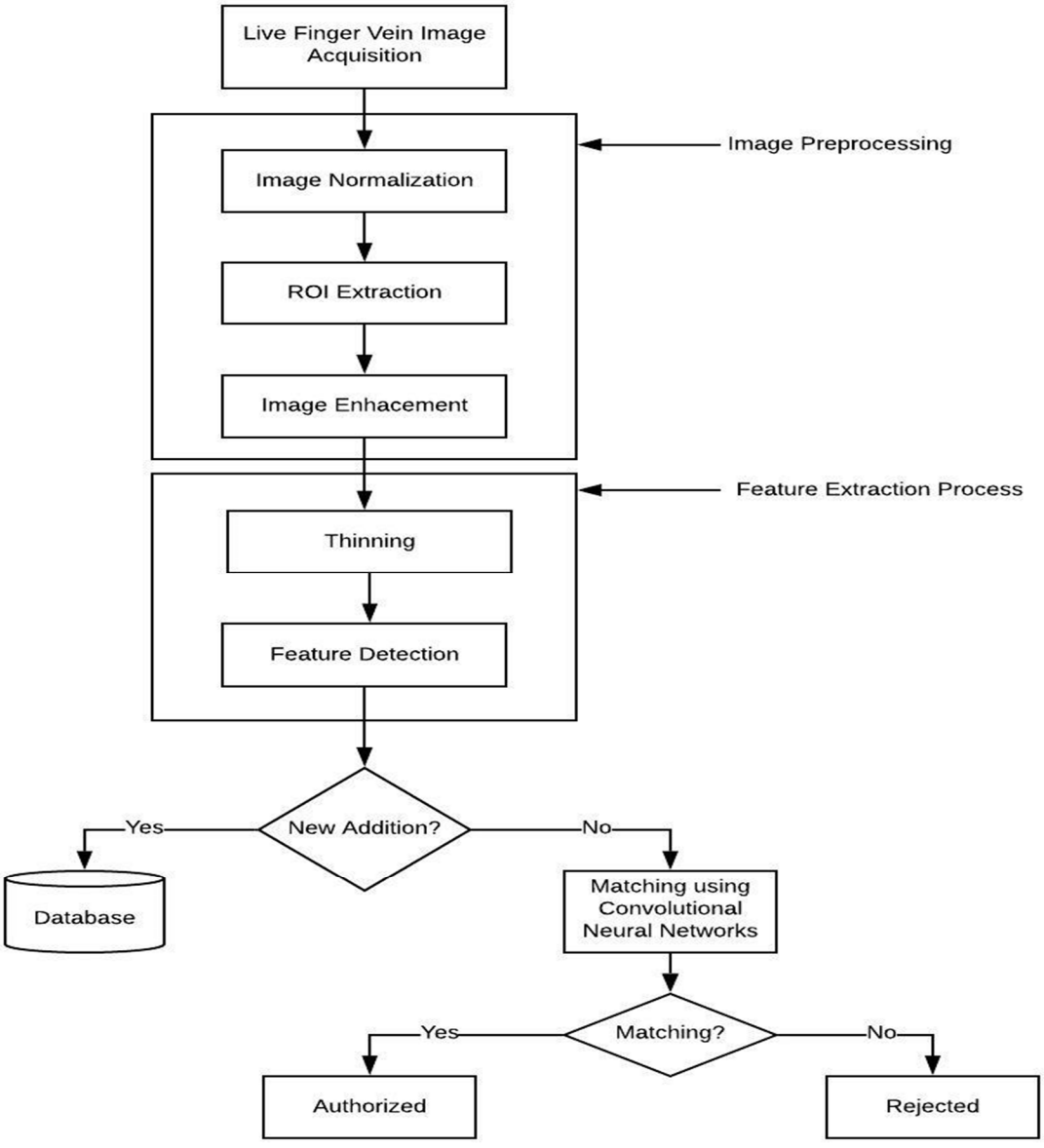
iii) *Preprocessing:* In the image preprocessing the image enhancement is done by certain image resizing rules in order to get the finger vein patterns to be visible properly. First, the original image is resized to 1/4th of its original size and again it is restored to original size. Again the restored image is resized to 1/3rd of its size. The histogram equalization and the contour of the 1/3rd image is obtained.

iv) *Extraction of Features:* The feature extraction is the most important step in the recognition process. In the finger vein recognition system the important features are texture and edges. The algorithms used for texture extraction is Fractal Dimension and Lacunae and for extracting edges the Gabor filter is used.

v) Matching: The matching is same as classification. The matching is done using the distance classifier which is the difference between features of different or same images of finger vein and the difference is compared with the threshold value. If the difference is less than or equal to threshold then the images are likely to be matched and if it is greater than threshold then it is not the image of the same personality. The features fractal dimensions, lacunae and Gabor features are used for matching.

III. PROPOSED METHODOLOGY/IMPLEMENTATION

Our implemented method uses the following System Architecture:



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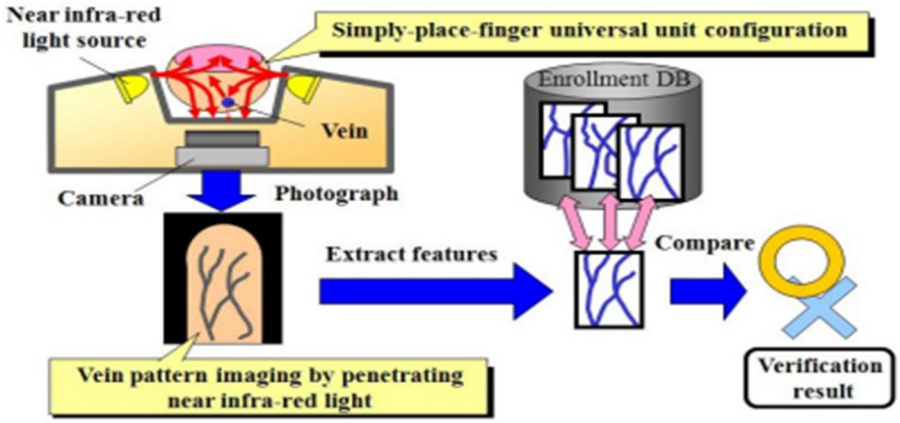
This architecture explains the following steps

A. Customer registers as a new user with the help of administrator. The vein of the user is scanned and the credentials are entered. The database is then updated with the new user.
B. The customer will scan his finger through the system.
C. The image will be then processed into the convolutional neural network and will extract the features.
D. After the features are extracted, testing based on the previous training set is performed.
E. The user is then predicted and gets checked if authorized or not.
F. If the user is authenticated then the user is given access.
G. If the user is not authenticated then the access is revoked and the admin is notified about the unauthorized personality.

IV. EXPECTED RESULTS



In the proposed system of finger vein authentication, finger vein pattern is generated using CMOS Camera and Near-Infrared sensors. Vein pattern generated is converted into grayscale for feature extraction. Extracted features are stored into the database and this procedure is used for registration of the new user.

In order to authenticate, the user needs to place his/her finger in the system. The features extracted from the vein pattern are compared with the previously extracted features stored in the database. If feature set matches with the feature set stored in the database, authentication is successful. If the authentication is not successful then the user will get another 5 chances to place the finger properly in order to be authenticated. Else, even after the number of chances provided if the authentication fails, the admin will be notified for suspicious activity.

A. Functional Requirements
1) Addition of new user
2) Recognition of existing user
3) If pattern matches, system should authorize
4) If there is failure to match pattern, system should reject
5) Failsafe in case of too many failed attempts(admin will be notified about the suspicious user)

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B. Non Functional Requirements

1) System should be fast and accurate
2) Database should be secure
3) Comparison should not be time consuming
4) Process should be easy to understand

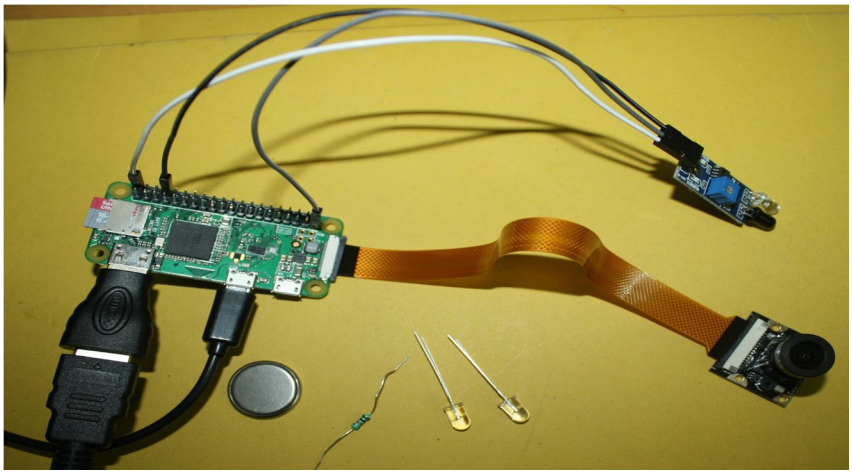
C. Advantages

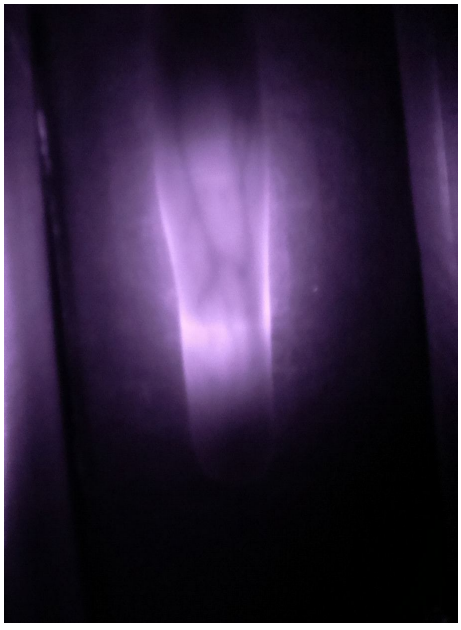
1) Internal Structure
2) Hygiene readers
3) Usability
4) Uniqueness

D. Disadvantages

1) It may have some hygiene issue in that fingers needs to placed into confined spaces.
2) Problems can be experienced if the users suffer from Raynaud's syndrome.

E. Hardware Implementation





Finger Vein through our Syste

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V. CONCLUSION

By using the Convolutional Neural Networks algorithm, the system is able to find the differences between the images and the exact originality can be found out. The system is hence equipped with detecting the user effectively and furthermore, will help reduce and in turn, boost the security of the system.

A. Future Scope

1) Biometric technology combined with mobiles devices can provide wide range of security facilities.
2) It can be used in the areas to give biometric security growth.
3) The next step would be integrating the mobile biometric technology with the cloud based biometric solutions to effectively handle the huge amount of data.
4) This technique can be used in commercial fields like ATM/credit cards, e- commerce etc. and in government field for passports, nation ID to make things easy.

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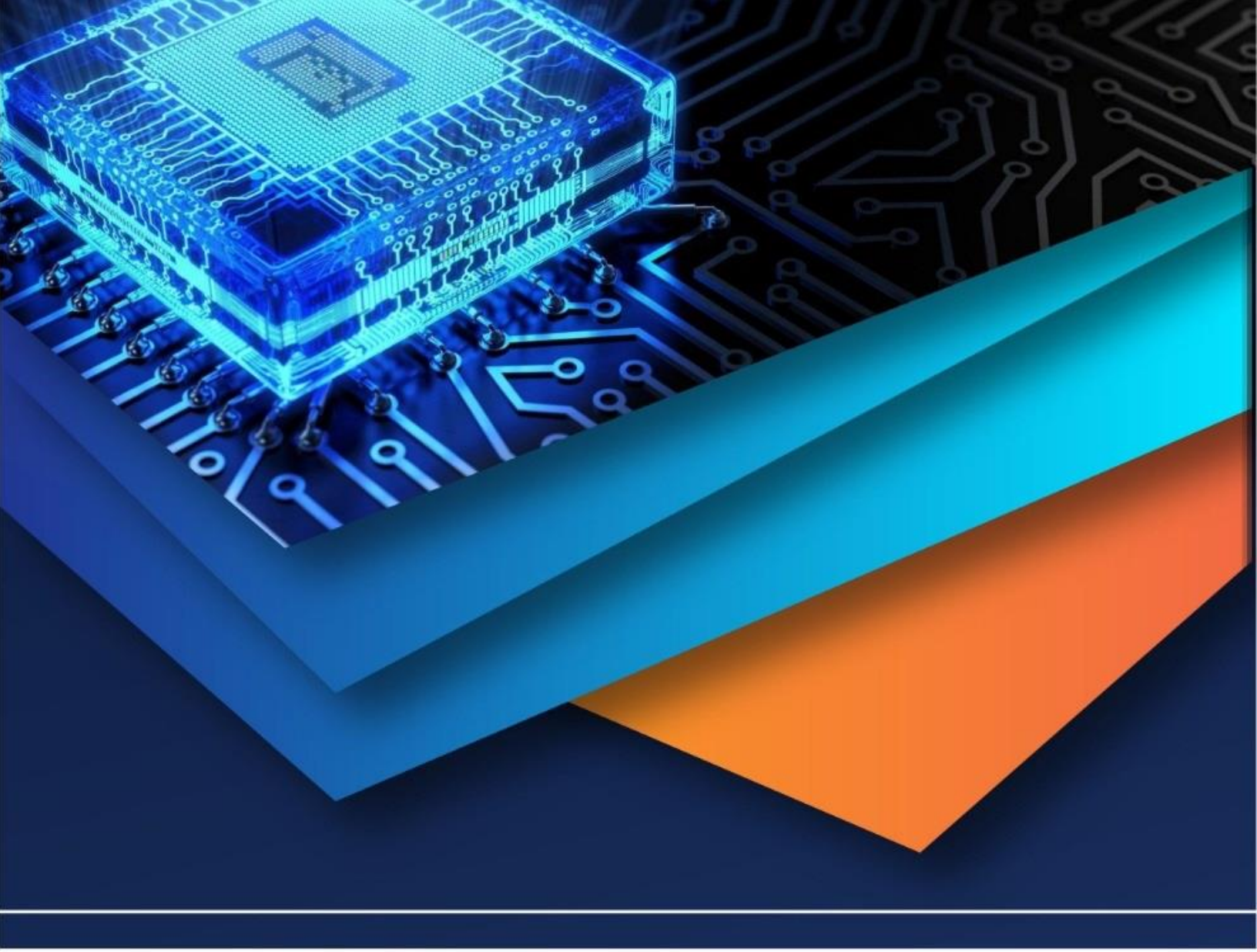

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