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Role of Fuzzy in Multimodal Biometrics System

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Abstract: Person identification is possible through the biometrics using their physiological and behavioral characteristics such as face, ear, thumb print, voice, signature and key stock. Unimodal biometric systems face a range of problems, including noisy data, intra-class versions, small liberty, non-university, spoof assaults, and unsustainable error rates. Some of these drawbacks can be overcome by multimodal biometric technologies, which incorporate data from various information sources. In this paper we work on multimodal biometric using three modalities face, ear and foot to find the optimal results using fuzzy fusion mechanism and produces final identification decision via a fuzzy rules that enhance the quality of multimodalities biometric system.

Index Terms: Biometric, Multimodal Biometrics, Fuzzy logic Foot, Iris.

I. INTRODUCTION

A biometric system is basically a device for object recognition which works by obtaining biometric data from a person, extracting a feature set from the data collected and comparing this with the template set in a database. A biometric device can work in authentication mode or identification mode, depending on the application context. [1].

Biometric authentication refers to the automatic identification of living individuals by using their physiological and behavioral characteristics. Face, fingerprint, palm printing, iris, eye, structure of hand, vein of the finger are physiological features where as tone, gate and signature behavioral features. Two kinds of biometric systems exist: unimodal and multimodal.

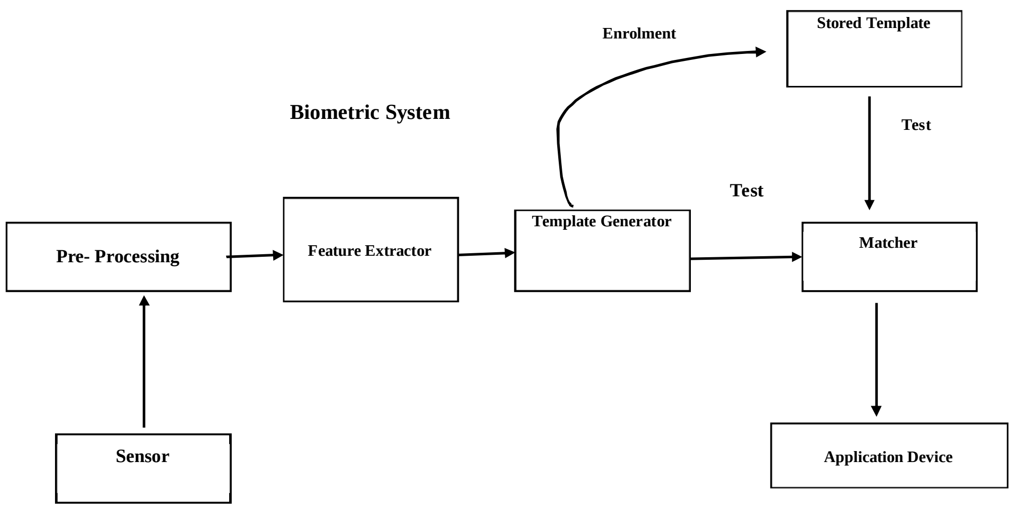

Fig.1. Biometric Authentication System

Biometric modality is a type of biometric system based on the different characteristics of the human body. For humans there are various types of specific characteristics, which are used as a biometric tool.

The biometric modes are of three forms −

1) Physiological aspect
2) Behavioral
3) Physiological and behavioral modality combined

Many physical characteristics remain unchangeable throughout the life of a person. They can be an excellent resource to identify a person. These physical characteristics allow for the development of a large number of recognition systems such as the fingerprint recognition system, hand geometry recognition, the iris recovery system and any other combination of the two methods. Some of these techniques are shown in Figure 2.

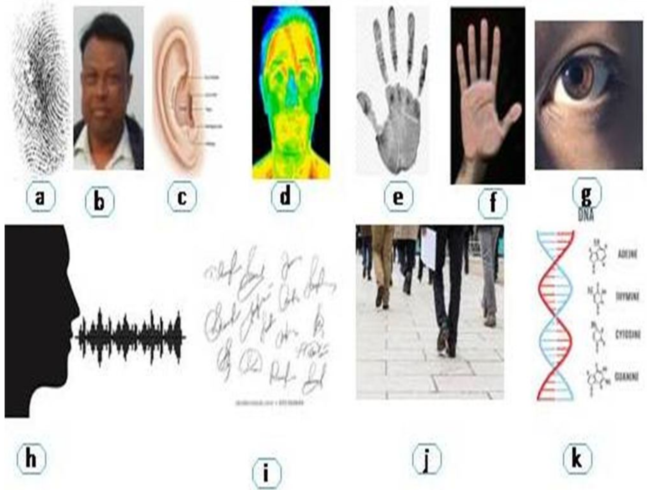

Fig. 2. Types of biometric properties: (a) fingerprint (b) face (c) Ear (d) facial thermo gram, (e) palm print (f) hand vein, (g) iris (h) voice (i) signature (j) Gait (k) DNA.

On the basis of these biometric traits there are various types of biometric system are developed using single traits and combine two or more traits i.e. DNA matching, eyes- iris recognition system, Eye- retina recognition system, face recognition, fingerprint recognition, gait to determine identity, odor to determine identity, typing recognition and signature recognition etc.
In spite of that, Multimodal Biometric is at a state of proliferation and this is an interesting time for biometric modality, innovation and adaption.
The major problem with the unimodal biometric system is that no technology can be suited to all uses. The multimodal biometric system is therefore compliant with the constraints of the unimodal biometric system.[3].
Unimodal systems face various challenges such as lack of privacy, non-universal samples, user comfort and autonomy, spoofing assault against stored data etc.

A. Multimodal Biometric Systems

All the biometric systems we've got mentioned to this point are unimodal, taking one supply of data for authentication because the name suggests, multimodal biometric systems work on accepting data from two or a lot of biometric inputs.
Multimodal biometric device incorporates two or more biometric technologies including facial identification, fingerprint, scanning of iris, morphology of hands, voice recognition, etc. Single and multiple sensors are used to calculate two and more specific biometrical characteristics in these devices. A system that incorporates facial and iris features for biometric identification is known as a multimodal system, regardless of whether the images of face and iris are captured by one or other imaging tools. In other words, the measures do not have to be combined mathematically. This system enables users to check using either of these modalities. A multimodal biometric system enhances the scope and diversity of the system inputs that users can authenticate.

B. Multimodal Biometric Techniques

All the modern modules of the multimodal biometric application have a unimodal configuration −

1) Capture unit
2) Feature extraction unit
3) Evaluation unit
4) Decision making unit

Typically, the data can be integrated at senor level, feature extraction, match score level, rank level and decision level within a multimodal biometric system. The fusion can be carried out at any of the next stages −

a) During feature extraction.
b) During evaluation of live samples with stored biometric templates.
c) During decision making.

In the initial phase, the multimodal biometric systems that integrate or merge information are more efficient than those integrated by information at later phases. The apparent reason for this is that the early stage provides more precise information than the comparative module scores.

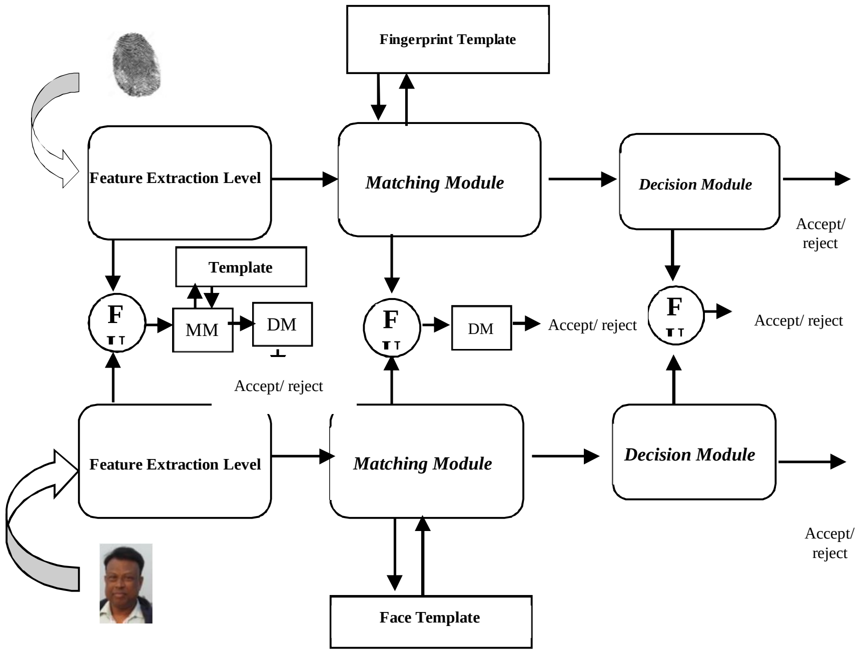

Fig. 3. A Multimodal biometric system showing the three levels of fusion; FU: Fusion Module, MM: Matching Module, DM: Decision Module

Fusion is acquired by two or more biometric features in multimodal biometric systems, which are then used to take decisions with two or more separate algorithms. For circumstances like a mass scale public identification case, the existence of thousands of people must at once be authenticated, such a methodology proves extremely useful.

II. RELATED WORKS

Many researchers have given their contribution in this field like Jain et al. (2005) reported that the biometrics is becoming more commonly used in several places through different biometric device such as bank, institute, airports.

Multimodal biometrics is preferred in authentication based image processing applications. Barde S. et al. (2014) introduced a multi modal systems working on physiological and demography information for identification of person.

Ross et al. (2004) introduced a multimodal biometric system for person recognition that shown the improvement accuracy of the recognition system.

Abate et al. (2007) worked on face and ear based hybrid system. This system is used Iterated Function concept in which images are compression and indexed.

Barde S. et al. (2015) designed a multimodal biometric system that combines face modalities and foot modalities using PCA classifier for face and wavelet transformer for foot and concatenated after normalization process to obtain a matching score and take a decision.

Barde S. et al. (2015) proposed a system for multimodalities biometric that combines face, ear and iris using PCA, Eigen image and hamming distance classifier for feature extraction, sum rule method is used for fusion to calculate matching score.

Bigun et al. (2005) introduced recognizing person utilizing multiple biometric traits and their advantages such as high accuracy and robustness, that increased recognition performance.

Barde, S. (2015) developed a multimodal biometric system, which combined face and foot modalities at decision level using PCA classifier for face and wavelet transformer for foot and concatenated after normalization process to obtain matching score.

Eid M. (2017) proposed fuzzy logic fusion strategy in Multimodal Biometrics to secure the template which allow an efficient and accurate identification procedure for high-security critical applications.

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III. METHODOLOGY

1) *Face Biometrics:* Face recognition technique is a process of recognizing a person based on features extracted from the face of the person. This is an application of computer for automatic identification or verification of a person using digital image or a video frame captured. Face recognition methods are various types using facial metrics and Eigen faces. Facial metric method relies on the specific facial features such as positioning of eyes, nose and mouth and distance between these features; whereas the Eigen face method is based on differentiating faces according to the degree of it with a fixed set of 100 to 150 Eigen faces.
2) *Ear Biometrics:* Ear biometrics uses ear as a modality where features or characteristics of ear are used as the basis of matching. This is a stable biometric system and does not vary with age. The ear is also visible part of the human body that can be used for a non invasive biometric technique. The ears undergo very slight changes from infancy to adulthood. The ears also do not suffer the change in appearance by hair growth like the face does. We used eigen image methods for ear recognition.
3) *Footprint Biometrics:* Person identification through the footprint image is very popular now a day. Measurement of features of footprint is not a complicated process some transformation such as furrier, haar are available. Each parson has completely different footprint and it is easy to capturing without any special requirement both leg images can be used for recognition. Captured foot image needs some additional approach such as cropping and resizing. Figure 2 displays the picture captured by high quality camera than the RGB image converted into gray scale after that resize them for preparing the database.

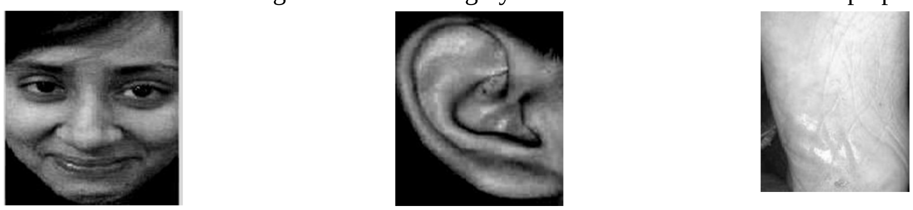

Fig. 2: Resize and gray converted images

A. *Fuzzy Logic Framework*

The verification performance based on Multimodal systems is affected by external conditions. The fuzzy inference system adjusts the weighting for each biometric as affected by the external conditions. Hence we attempt to incorporate these conditions by the use of a fuzzy logic framework for multi-biometric fusion. Fuzzy logic enables us to process imprecise information in a way that resembles human thinking, e.g. big versus small, high versus low, etc., and allows intermediate values to be defined between true and false by partial set memberships. A fuzzy logic method is used for fusion which is given better performance and accuracy. Fuzzy logic is used for comparing and deciding to verification. Fuzzy logic decision fusion is used which gives reasonable results.

IV. ANALYSIS AND RESULT

A. *Eigen Image*

The face and ear images are projected onto the image space, and their weights are stored. Once the Eigen space is defined, the test image is projected into the Eigen space. The images with a low correlation can be rejected. Acceptance or rejection is determined by applying a threshold; the distance below the threshold is a match. Fig. 3.9 shows results as Eigen images for face and ear images.

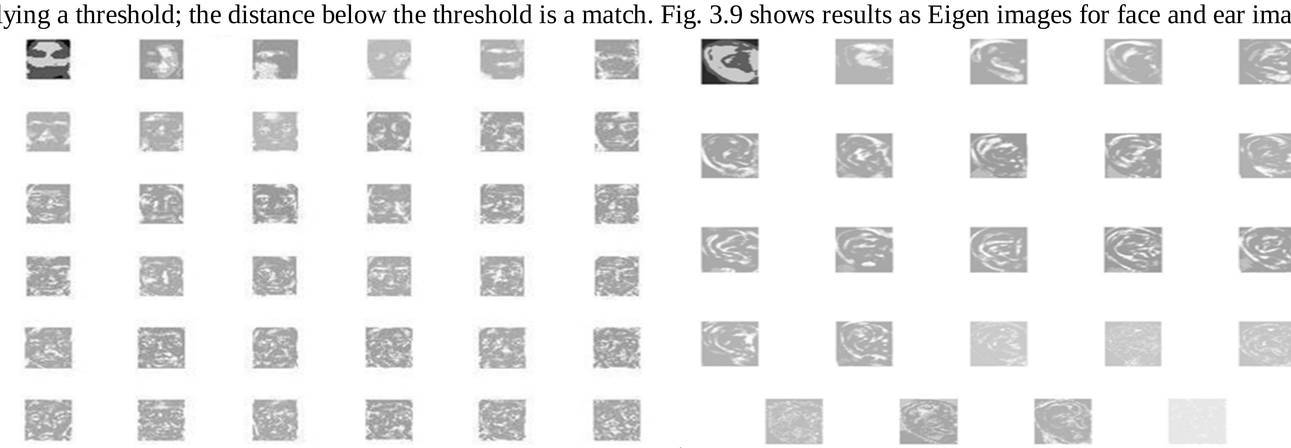

Fig: 3: Face and Ear Eigen images

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B. Sequential Modified Haar transform Technique

The middle portion of the foot image is taken for the process because it has more intensity and this captured area is partition into 4x4 rows and columns and applied sequential modified Harr transform the result is shown in figure 4.

The sequential modified haar wavelet is based on the mapping technique in which integer-valued signals are mapped using the reconstruction of image technique. The MHE is compared at different stage of decomposition to calculate the accuracy. After that combined them the minimum MHE is calculated and saved in the database. Finally, MHE of test image is matched with stored database template indicate the genuine and imposter.

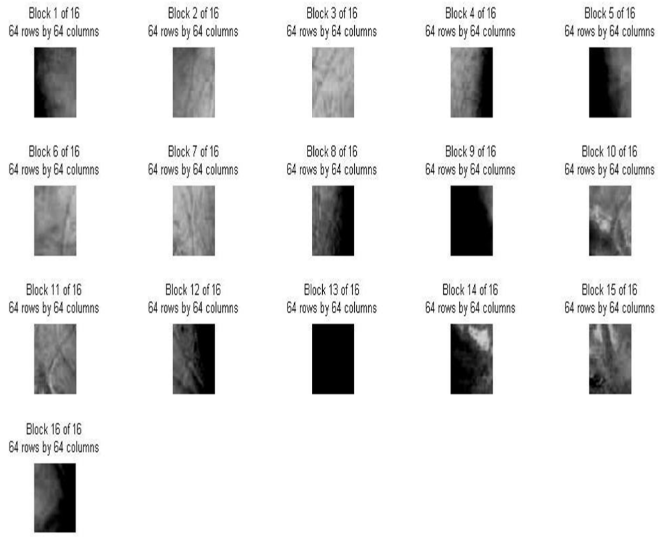

Fig: 4: Foot image divided into 4x4 blocks

Table 1 shows genuine score, imposter score and threshold value for iris and foot images.

Table 1: Genuine score, Imposter score and Threshold value for face, ear and foot images

Traits	Genuine Score	Imposter Score	Threshold Value
Face	1.5470E+04	1.8119E+04	1.5510E+04
Ear	1.5282E+04	1.6488E+04	1.5370E+04
Foot	2.2277E+04	2.6613E+04	2.2325E+04

Face, ear and foot biometrics were tested individually and Table 2 show False accept rate (FAR) and False reject rate (FRR)

Table 2:FAR and FRR for face, ear and foot images

Traits	FAR	FRR
Faces	1.1682E+00	9.9742E-01
Ear	1.0727E+00	9.9427E-01
Foot	1.1921E+00	9.9785E-01

The weight of all individual face, ear and foot modalities was calculated, shown in table 3.

Table 3: Weight for all Modalities

Traits	Weight
Faces	0.85
Ear	0.92
Foot	0.83

C. Fuzzy Fusion Process

We selected eigen image and modified haar wavelet transformation as a classifier for face, ear and foot independently. To get a combine result we work on multimodal database using fuzzy logic between the results of modalities

1) Step-1: Min-max normalization technique used for score normalization.

Face, ear and foot recognition algorithms produced dissimilarity scores. The Min-Max normalization technique was used to convert all dissimilar data into similar data shown in table 4.

Table 4: Normalized Score

Traits	Normalized Score
Face	0.35
Ear	0.15
Foot	0.07

2) Step-2: the mean match scores calculated as

$S = 1/M \ \Sigma \ W_i S_j$

Matching score was calculated for when we combine two modalities using their weight table 6 shows the matching score

Table 5: Matching Score for each Trait after fusion

Traits	Score
Face + Ear	0.248
Face + Foot	0.178
Ear + Foot	0.113

3) Step-3: Define the fuzzy linguistic variable as:

H $S >= 0.20$

M $0.20 < S > 0.15$

L $S =< 0.15$

Where, H represented high, M to medium, and L as low.

4) Step-4: Make the fuzzy rules represented by

If the value of S in 'H' category, then the conclusion is 'Strongly Identified'

If the value of S is 'M' category, then the conclusion is need some improvement to 'Strongly Identified'

If the value of S is 'L', then the conclusion is 'Weakly Identified'

V. CONCLUSION

Multimodal biometric system used face, ear and foot biometric traits. The weight of each biometric trait was calculated applied to Eigen images and modified haar transformation classifier approaches. The information was combined after normalization. Fuzzy logic is used for result calculation. Fuzzy rules is defined apply to all possible combinations of modalities and the highest matching was found as 0.248 when two modalities face and ear were combined and lowest matching was found as 0.113 when two modalities ear and foot ware combined.

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AUTHOR PROFILE

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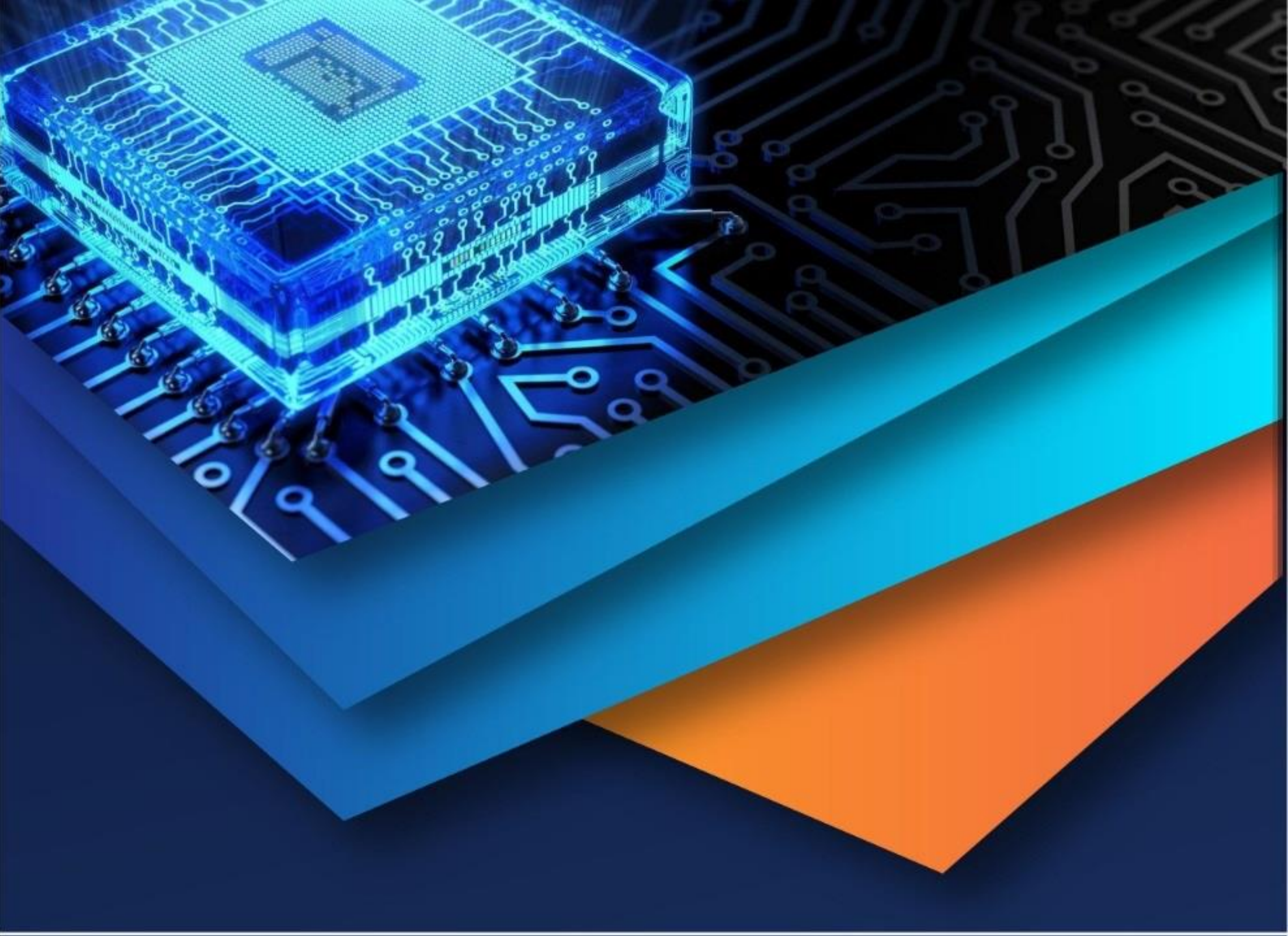

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