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Blood Group Determination through Medical Image Processing

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Abstract: ***The determination of blood types is crucial during any emergency situation before blood transfusion. At present, these tests are performed manually by lab technicians in clinical laboratories, which can lead to slip-ups. In emergency situations, timely determination of the blood types is crucial for the treatment of the patient. A method based on image processing is developed. Image processing techniques, such as colour plane extraction, thresholding, morphological operations, and quantification, are used. The images of the slide test obtained from the pathological laboratory are processed, and the occurrence of agglutination is evaluated. The slide test used for processing consists of the mixture of one drop of blood with one drop of reagent, the results are interpreted according to the occurrence of agglutination. The combination of the occurrence and non-occurrence of the agglutination will determine the blood type of the patient.***
Keywords: Medical Image Processing, Thresholding, Quantification, Blood group determination.

I. INTRODUCTION

Blood grouping tells us what type of blood a person has. Traditionally, human interpretation of the agglutination reactions allow us to determine the antigens present in the red globules of the sample of blood, allowing the classification of the blood type. During emergencies, the determination of the blood group is critical to continue the treatment of the patient. It is laborious work and is prone to errors that can have fatal consequences. The project proposed, Blood Group Determination through Image Processing, is to make the method technology-dependent and reduce human intervention.

Blood groups are identified by antigens and antibodies in the blood. Antigens are any substance that stimulates the immune system to produce antibodies. Antigens can be bacteria, viruses, or fungi that cause infection and disease. Antibodies, also called immunoglobulin, are proteins manufactured by the body that help fight against foreign substances called antigens. When antigens enter the body, it stimulates the immune system to produce antibodies. The antibodies attach or bind themselves to antigens and inactivate them. The role of antibodies is to bind with antigens and inactivate them so other bodily processes can take over, destroy and remove the foreign substances from the body.

The major two types of blood groups are:

1) ABO blood system

2) Rhesus blood system

In human blood, the ABO blood group system involves two antigens and two antibodies. Two antigens are antigen A and antigen B. The two antibodies are antibody A and antibody B. The antibodies are present in the serum while the antigens are present on the red blood cells.

From the antigen property of the blood, all human beings can be classified into four groups, those with antigen A as group A, those with antigen B as group B, those with both antigen A and B as group AB, and those with neither antigen as group O. The antibodies present together with the antigens are found as follows:

a) Antigen A with antibody B

b) Antigen B with antibody A

c) Antigen AB has no antibodies

d) Antigen nil (group O) with antibody A and B.

There is an agglutination reaction between similar antigen and antibody (for example, antigen A agglutinates the antibody A and antigen B agglutinates the antibody B). Thus, transfusion can be considered safe as long as the serum of the recipient does not contain antibodies for the blood cell antigens of the donor.

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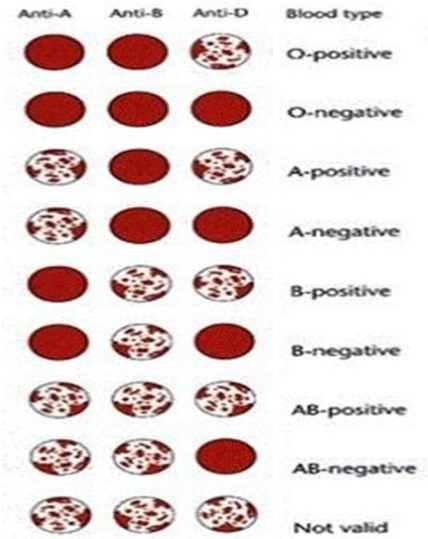

Fig 1 (*Pin on Medicine - Nursing school*, n.d.)

The aim of this system is to reduce human intervention and the time taken during the determination of the blood group that is trying to automate the process of determination of blood group using the technique image processing.

II. EXISTING SYSTEM OF BLOOD GROUP DETECTION

To find the blood group of a person, the red cells of that person are mixed with different antibody solutions. There are four major types of blood groups which are A, B, AB, and O. The A blood group contains B antibodies and A antigens, the B blood group contains A antibodies and B antigens, the AB blood group contains no antibodies but both B and A antigens and finally the O blood group contains both A and B antibodies and no antigens. There is agglutination between similar antibodies and antigen. For example, antigen A agglutinates the antibody A and antigen B agglutinates the antibody B. Hence, if the blood reacts to antibody A , it means it contains antigen A and we can conclude that the blood group is A. If the blood does not react to any of the anti-A or anti-B antibodies, it is blood group O. By adding anti-d we can determine if the blood group is negative or positive. If the sample of blood agglutinates when anti-d is added it means that the blood group is positive and if it does not agglutinate it means that the blood group is negative. If the person has a blood transfusion, the blood of the person will be tested against a sample of donor cells that contains ABO and RhD antigens. If there is no reaction, donor blood with the same ABO and RhD type can be used. It indicates that the blood has reacted with a certain antibody and is therefore not compatible with blood containing that kind of antibody If the blood doesn't agglutinate, it indicates that blood doesn't have antigens binding the special antibody in the reagent. In the existing system, the blood group is determined manually. In this system, adding solutions such as anti-a, anti-b, anti-d to the three samples of blood took place. After some time, agglutination may or may not occur.[3] Depending upon the agglutination, the blood group can be determined by the person manually. The disadvantages of this system are more chances of human errors are possible. Only experts can tell the blood type by seeing at the agglutination process.

III.LITERATURE REVIEW

In [1], the Methodology involves image processing techniques such as thresholding and morphological operations. The images of the slide test obtained from the pathological laboratory are processed and the occurrence of agglutination are evaluated. Thus the developed automated method determines the blood type using image processing techniques. The methodology used in the paper proves that it is an effective and efficient method to detect the agglutination and determines the blood type of the patient accurately.
In [2], The methodology involves collecting the digital images of blood samples obtained from the hospital/laboratory consisting of a colour image composed of three samples of blood. Then these images are processed using image processing techniques namely feature extraction, clustering, HSV luminance, etc. The final result is calculated on the basis of a combination of cluster and patch of the given three images. A fast, accurate and robust blood group judgment method is proposed for the rapid and accurate identification of blood types in the case of emergency transfusion.

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In [3] shows the methodology to find blood groups along with the counting of RBCs and WBCs in two phases. Phase 1 is the blood group determination. Phase 2 involves counting RBCs and WBCs. The green plane colour extraction, histogram thresholding and morphological operations are carried out on the image followed by object labelling. The blood group was accurately detected. The RBC and WBC count showed trivial errors within the permissible range (<-5%).The methodology is semi-automatic, only MATLAB software is used, it is cost-effective and simple. The system gives an overall accuracy above 90%. The system takes 4 to 6 seconds to execute the outcomes and hence is time-efficient.

In [4], the methodology using a data flow diagram, which focuses on how the image is captured, loaded in the system and copied to the workspace of the system. If in case image is not captured properly, the system is triggered to capture the image again.In the preprocessing steps, the image is resized with respect to height and width according to the necessity, the next step is green panel extraction i.e. conversation of RGB image to gray scale image and then Binarization is carried (Thresholding , morphology ,HSL luminance plane and quantification). This method gives rapid and exact recognition of regular blood type along with the special type i.e. Bombay blood. From more number of experiments, this technique shows quick and accurate identification, using serum and antibody agglutination.

In [5]. The obtained reactions were registered in real size, using a CCD camera. The analysis of the obtained images was performed using an image processing tool (IMAQ). When agglutination occurs, there are observed zones in the image analysis that present high levels of oscillation of pixel intensity. These preliminary results allow us to validate the methodology used, enabling a secure determination of the agglutination occurrence or not. Then, using statistical analysis it is possible to quantify mathematically the obtained. It was verified that for the image acquisition conditions used, the agglutination occurrence is translated by a standard deviation level superior than 20 pixels. The applied image processing techniques enable determining automatically, fast and accurately.

In [6], the techniques used for Image processing for blood group detection are Pre-processing techniques, Thresholding, Morphological operations, HSL plane, Quantification. The system is developed in a robust manner so that it is unaffected by the exceptional conditions. The software developed in image processing effectively detects the occurrence of agglutination and the blood group of the patient in a short interval of time. The system would achieve a high percentage of sensitivity and specificity which will be useful in determining the blood group in emergency situations.

In [7], detection of blood group method is obtained from the use of image processing techniques enables automatic detection of agglutination and identifies the blood group of the individual in a short interval of time and accurately in the case of emergency transfusion. SVM is used for classification of blood groups and is capable of predicting an unknown sample with a good degree of accuracy. In future, the system contributes to undertake safe blood transfusion and to reduce the loss of human lives.

IV. PROPOSED SYSTEM

In our proposed system, reagents are mixed with three samples of blood. Agglutination may or may not occur after some time. After the formation of agglutination, the slide is captured as an image and allowed to process in the GNU Octave toolbox. By using this system, more chances of human errors can be reduced. Image processing techniques used for blood group identification are

1) Pre-processing techniques
2) Thresholding
3) Morphological operations
4) HSL Luminance plane
5) Quantification

In this proposed work, various pre-processing techniques such as colour plane extraction, gray conversion were used [2] . Image preprocessing can significantly increase the reliability of an optical inspection. The preprocessed image is then quantified to find the blood group.

A. Scope

We have been successful in reducing the time and effort required to determine the blood group of a patient during emergencies. The correct blood group is determined for the input images, provided the images are cropped in the right order during the final stage of analysis. The project makes it possible for even a novice to report the correct blood group easily. With the pandemic hovering, we were only available to collect a handful of image samples. However, accurate results were obtained for all the images of the blood samples tested. This is entirely a software-based project and the hardware implementation has not been explored.

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V. METHODOLOGY SOFTWARE IMPLEMENTATION

The following flowchart describes the general algorithm of the system. [2]

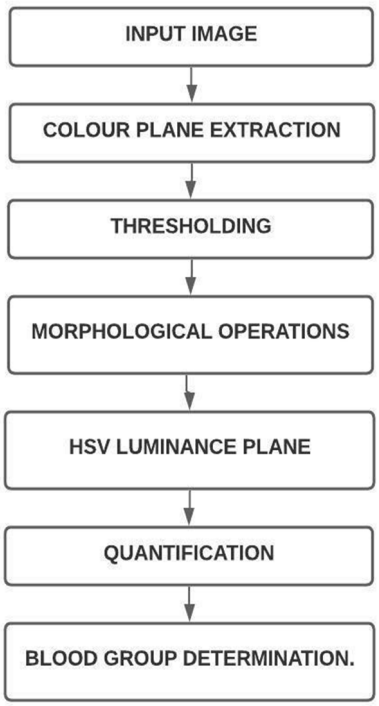

Fig 2: Flow of proposed methodology

For blood group detection images of blood samples are obtained from the laboratory consisting of a colour image composed of three samples of blood and a reagent. The image is captured with the help of a mobile phone camera of 12 MP. Simply a glass slide with a blood sample is placed on a white paper and the photo is taken by using a phone camera. The image is stored in the computer and read from it at the time of experimentation. Experiments were carried out on 8 dataset images. To obtain accuracy results of the system are compared with the results obtained by the manual method in the laboratory. . Figure 3 shows the database images collected.

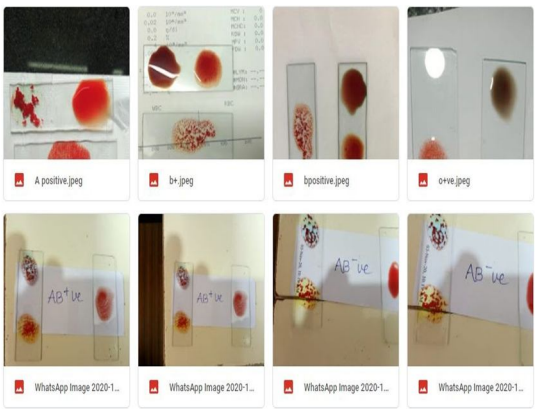

Fig. 3: Database images

The colour plane contains the colour information in images. The foreground and background colours of each image have different values. In this work, only the green colour component is extracted because it contains the maximum value in the RGB colour plane [5]. The green plane extraction is shown in figure 4 contains only the area of blood samples excluding the background and the slide,we used trial and error method. We varied thresholding values till area of interest was obtained.

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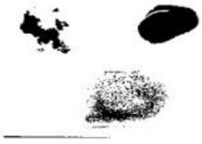
Table 1: Finding optimal threshold value for a particular image.

Images	Threshold Values
	0.6
	0.35
	0.2

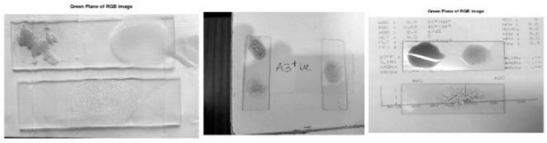


Fig 4 : Green plane image

In digital image processing, thresholding is the simplest method of segmenting images. Thresholding is a type of image segmentation, where we change the pixels of an image to make the image easier to analyze. In thresholding, we convert an image from colour or grayscale into a binary image, i.e., one that is simply black and white [9]. From a grayscale image, thresholding can be used to create binary images. We have done the thresholding using the graythresh function. The thresholding value for each image is different because of varying illumination and background. To obtain the area of interest that For the above image the optimal threshold value is 0.35.We calculated the threshold value for all the images in our database, the threshold value varies from 0.3 to 0.7. The binary images are shown in figure 5.

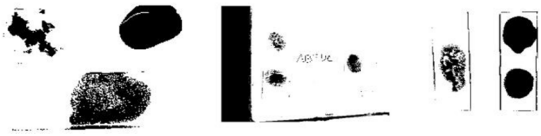


Fig 5 : Binary Images

Morphological Operations process objects in the input image based on characteristics of its shape, which are encoded in the structuring element. In morphological operation, there are two fundamental operations such as dilation and erosion, in terms of the union of an image with a translated shape called a structuring element. This is a fundamental step in extracting objects from an image for subsequent analysis. The fundamental operations in morphological operations can be listed as

Erosion is one of the two basic operators in the area of mathematical morphology. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels shrink in size, and holes within those areas become larger [4]. Dilation is the process that grows or thickens the objects in an image and is known as a structuring element. Graphically, structuring elements can be represented either by a matrix of 0s and 1s or as a set of foreground pixels.

The opening operation erodes an image and then dilates the eroded image, using the same structuring element for both operations. It removes small objects from the foreground (usually taken as the bright pixels) of an image, placing them in the background.

The closing operation dilates an image and then erodes the dilated image, using the same structuring element for both operations. It removes small holes in the foreground, changing small islands of background into the foreground.

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The structuring element used in our project is diamond, after trying it out with several other structuring elements we found that structuring element diamond suited the best for the images we analyzed to obtain accurate results.Figure 6 shows the results obtained from morphological analysis.

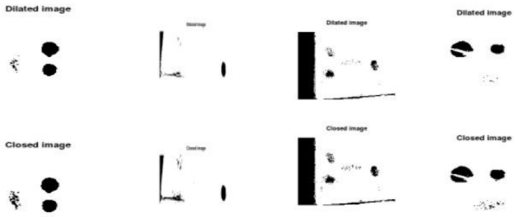

Fig 6 :Result from Morphological Operations

HSV (Hue, Saturation, and Value) are alternative representations of the RGB colour model, designed in the 1970s by computer graphics researchers to more closely align with the way human vision perceives colour-making attributes [4]. [3] In these models, colours of each hue are arranged in a radial slice, around a central axis of neutral colours which ranges from black at the bottom to white at the top. The HSV representation models the way paints of different colours mix together, with the saturation dimension resembling various shades of brightly coloured paint. The HSV luminance plane images are shown in figure 7

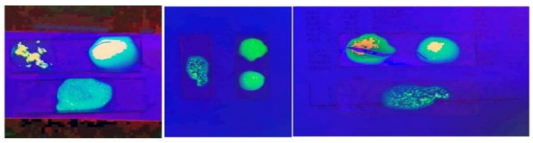

Fig 7 : HSV luminance plane

Quantification is expressed as a number or measure of quantity [7] [8]. It measures intensity only in the region of interest. Area (percentage of surface examined for full image), mean (average value of the pixel), standard deviation, minimum and maximum values of pixel intensity are determined. Also, region properties are extracted. Using the value of standard deviation, the occurrence of agglutination is identified, and accordingly, the blood group is determined.
The Standard Deviation is a measure of how spread out numbers are [8]

$$\sigma = \sqrt{\frac{\Sigma(x_i-\mu)^2}{N}}$$

σ =population standard deviation N=the size of the population
x_i =each value from the population

μ =the population mean
Equation 1: Standard Deviation formula

VI. RESULTS AND DISCUSSIONS

The methodology described above was applied to a set of blood samples obtained from the laboratory, which consisted of slides with three different antigens of the test. We have calculated the standard deviation for the region of interest cropped during analysis. From experimentation we found agglutination to have occurred if the standard deviation exceeded 0.16. The region of interest includes the three blobs of blood mixed with different antigens to check for the blood group. For instance, If blob1 was found to have clumped with anti-A and no clumping with anti-B and anti-D it was found that the blood group was A negative. Likewise, several combinations are analyzed to find A positive, B positive, B negative, O positive, O negative, AB positive, and AB negative. Fig 1 shows how the different blood groups are identified from the slides. Image processing is a technique that requires a lot of images for sampling and finding the results to improve the efficiency and accuracy of the system.100% accuracy was obtained for the dataset analyzed. The more the images analyzed, the better the software and the algorithm developed is.Given the time and situation constraints, only a handful of images of blood samples were analyzed. Images were obtained from different hospitals and laboratories and differed greatly in the quality and illumination of the blobs of blood.

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However, the algorithms and the values that were found during the experimentation process to find the right threshold value and standard deviation work uniformly for all the images in our database. This method requires manual cropping of the blobs of blood for the analysis of the region of interest during quantification. Using contour extraction or blob and patch detection would make this project more efficient and more dependable.

Cropping methods would require a person to carefully choose the blobs in the right order to make the program work accurately.

With some technical background about the areas to be analyzed and the different antigen reagents, the blood samples have to be tested with an algorithm that is found reliable. The project can be improved upon by using noise filters, automatic analysis of the blobs of blood that prevents human intervention. However, during the practical application of this project the images clicked will differ in quality and illumination, care must be taken to prevent external factors hampering the determination of the right blood group.

Table 2:Ground truth as obtained from lab technician

Image	Laboratory Result	Result Obtained
	A+	A+
	B+	B+
	B+	B+
	O+	O+
	AB+	AB+
	AB-	AB-
	AB-	AB-
	AB+	AB+

VII. CONCLUSION

In this project, detection of blood group method is obtained from the use of image processing techniques enables semi-automatic detection of agglutination and identifies the blood group of the individual in a short interval of time and accurately, in case of an emergency transfusion. This is done using OCTAVE, an open source tool. It is an effective and efficient method to detect agglutination and determines the blood type of the patient accurately. Distinct zones in the pixel intensity of the images are identified, allowing classification of regions showing no change and agglutinated regions. As a reference, it was the plate method, adjusted conveniently to the methodology of detection of blood type using image processing, presenting safe results in a time inferior to 2 minutes, thus, the use of the approach described in this work allows eliminating the errors committed by the technicians in the blood type classification.

VIII. SCOPE FOR FUTURE WORK

The future scope is to improve on the proposed algorithm, to adjust the illumination, and resize the image under any given circumstances for accurate detection of the right blood group. A hardware device that captures the image with the given program embedded would make the project efficient and can be easily implemented in a real-life scenario. It can be made small and portable. Although ambitious, the algorithm can be worked upon to determine the blood group without the use of different reagents(anti-A, anti-B, and anti-D). The project is constrained by the varying threshold values for different images.The process of finding the optimum threshold value for every picture is tedious. The region of interest has to be cropped manually in order to find the standard deviation.

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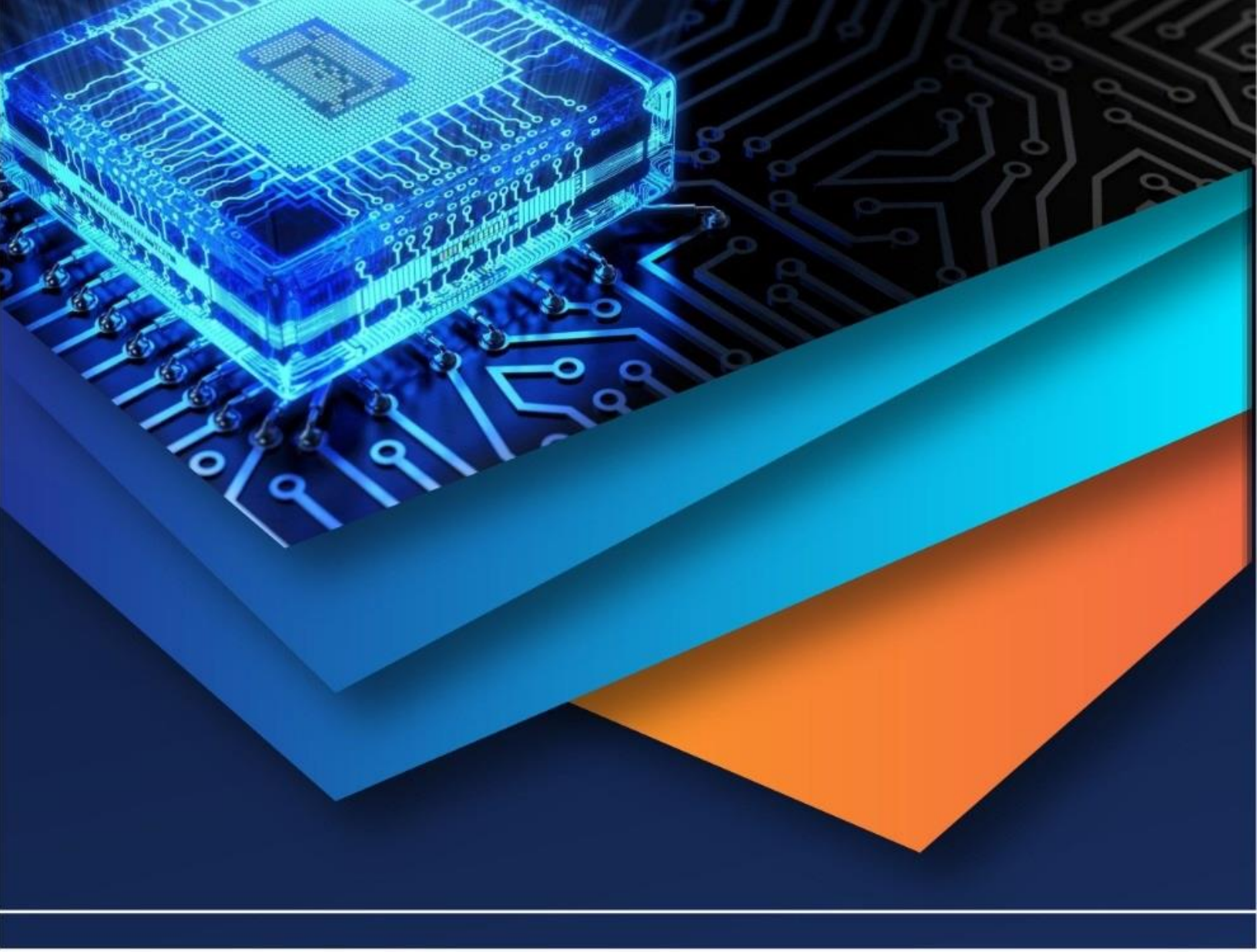

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