iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** IV **Month of publication:** April 2021

DOI: https://doi.org/10.22214/ijraset.2021.33730

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IV Apr 2021- Available at www.ijraset.com

A Review on Automated Cricket Trainer

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Abstract: ***In today's world cricket is known to be one of the most popular sports. Also it is considered as a very competitive sport as there are various leagues, tournaments held for cricket between countries all over the world. So performance in such a popular sport is a very important aspect for an individual or even as a team. When an individual is playing for the team his/her performance contributes for the team. If a player's performance is not good then it might result for the team to end up on the losing side. So as a batsman, a player should play every inning with the responsibility of the team. But many times, even the best batsmen make mistakes while playing a particular shot. The study focuses on helping a batsman to correct his/her errors in miscued shots. So that when the same shot is played again chances of errors decrease. It tries to help the player to detect the error in a miscued shot as due to which part the shot was not executed properly. With the help of this, players can work on those errors and minimize them when played again. In this paper, an in- depth study is performed on various systems developed for shot detections, posture detection. Various approaches mentioned are studied with pros and cons identified.***
Keywords: Latent SVM, CNN, RNN, Fuzzy Logic, YOLO

I. INTRODUCTION

The game of cricket that is having its origin in England but in today's time, it is considered among the most popular sports in Indian- subcontinent, Australia, Africa, and Caribbean. And currently the game is getting famous all over the world. With the increasing craze for the game, various countries from all over the world are participating in cricket tournaments held every year. Due to increasing craze, many people come up for participation in cricket. All these players go for coaching in various cricket coaching academies and get trained by coaches. Players per coach count increases day by day so it becomes very difficult for coaches to train so many players at the same time.

This paper focuses for providing support to coaches in the coaching process. Batsman is trained to play various classical cricket strokes. A cricket shot is a combination of movements of body, bat and footwork. There are various classical cricket strokes namely straight drive, cover drive, cut, etc.

Players make silly mistakes while playing these shots. For example, a player may be in wrong position for the shot or has wrong footwork, etc.

For a coach to identify these mistakes in each player trained it becomes very difficult. So, this system describes the design and implementation of the system that will detect those errors and mistakes in a shot played by the batsman and provide feedback on how to play that shot more correctly with minimum error. And help every player to improve his/her performance in the game. Section 2 is about existing systems, methodologies, algorithms and their merits and demerits. Proposed system architecture is discussed in detail in Section 3. Section 4 is conclusion and paper ends with Section 5 as references.

II. LITERATURE SURVEY

A. *Literature Related to Existing Systems*

1) *Cricket Strokes:* This is a web application for coaching purposes. This system helps users to learn different shots of cricket and understand the game in a well-structured way and to become a master in the game. Sometimes it is difficult to get a good coach to help you get the shots right and then move on to become a master at it. This system achieves that purpose with the help of ex-cricketers and mentors. This system is divided into appropriate sections like batting, bowling, fitness, wicket keeping, fielding etc.
2) *Cricket NSW Coaching:* This platform provides hundreds of videos for learning various techniques. Also, it gives tactics and many exercises. Coaches can respond to these uploaded videos through feedback. This platform gives you tips for mental stability while playing cricket. A user can develop his game and the platform has an option through which he can interact with a coach. It also helps with understanding the game with ratings and with respect to trends.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IV Apr 2021- Available at www.ijraset.com

3) *Deep CNN based Data-driven Recognition of Cricket Batting Shots:* This system identifies and categorizes various cricket shots from videos of cricket with methods related on deep convolutional neural networks. The input to this system is in the form of video. The output that the system gets is the recognized shot played in the input video. The inputted video is converted to frames into specific size and then output is mapped with available frames of batting shots. This network performs convolution on frames for extracting features. On each convolution layer there are filters that produce feature maps and these are further used by the next convolution layers. Various layers used are convolution, max pooling, relu, and normalization layers [1].

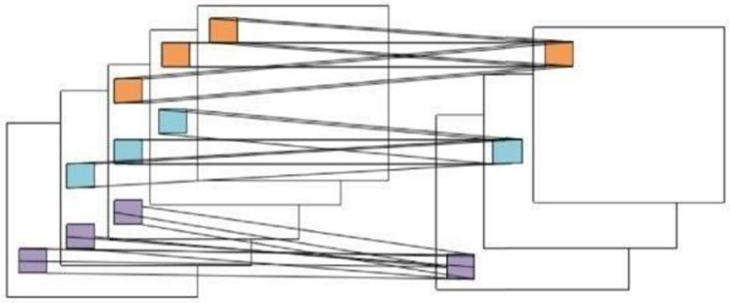

Fig 1: Convolution 3D Structure

4) *Wireless Electronic training system for Cricket:* This system proposes a method for coaches to train players by using sensors while practicing. This system uses a built-in watch which comprises of an accelerometer using which real-time acceleration data is transmitted. Coaches acquire real-time feedback from the system using which they train batsmen and help improve their techniques. Real time analysis is provided to the player by analyzing the data with the help of machine learning techniques. Data is created based on player's performance which is recorded by the system and used by the coaches for analysis and view of their performance. This system is known as Learning Management System [2].
5) *Cricket Shot Classification using Motion Vector:* This system uses the Motion Vector technique for recognition of a shot played from a video sample. Extraction of salient features and optical flow directly from cricket shot videos is still a difficult task as there are several different direction optical flows of body parts are created while playing a shot. So classification of different shots is done using spatio-temporal 3D MACH filter which also uses motion estimation approach [3].

Fig. 2: 3D Model of Skeleton

6) *Cricket Shot Detection from Videos:* This system recognizes and classifies various types of cricket strokes. The classification model depends on techniques like optical flow and saliency to bring out dynamic and static cues. It also depends on Deep Convolutional Neural Networks (DCNN) for extracting representations. Here, input videos are first converted to frames and which serves as an input to the CNN to determine the configurations of the shot [4].

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7) *Modelling and Control Design of Straight Drive:* The main aim of this system is to build a model of a straight drive using MATLAB. Every basic feature of the shot, extraction, and Analysis the shot is achieved using a software. Which is commonly known as Biomechanics video analysis software. This model consists of different body parts such as shoulder, elbow, and wrists joints. Comparison of movements of arm and bat of actual shot in the model output. In MATLAB SimMechanics, the Straight drive model is composed of Fixed components, Connectors, Foot movement, Force applied, Ball impact [5].

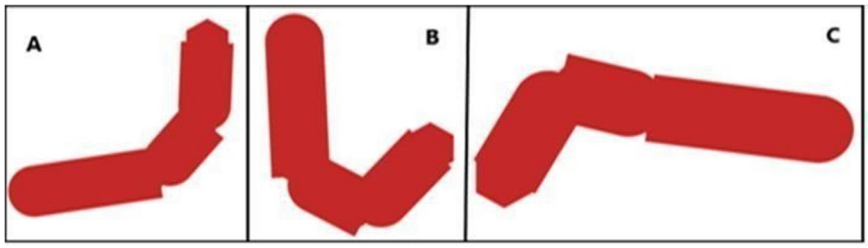

Fig. 3: Simulation result of straight drive showing intermediate stages.

8) *Bat detection and tracking toward batsman stroke recognition:* This model is used for recognition of stroke from pre-recorded footage. This system ensures detection of bat techniques like Otsu's Thresholding and Optical Flow, thereafter, using the result of Kalman filtering to train datasets, further matching process is done using the cross-correlation function. Otsu's thresholding is mandatory in finding a threshold level for separation of foreground from background. The Shot matching is done in Shot recognition unit that displays the stroke played as part of the frame which determines the shot played. This output is then fed to Shot Recognition Unit, that further compares signals to data about shots, which is obtained after training and then data for that shot is displayed [6].
9) *Cricket batting technique/analyzer using Fuzzy Logic:* This system captures the movements of a cricket batsman while playing a shot and classifies them using fuzzy logic. Here the movements of head, feet and the bat are investigated for fuzzy set classification, there are various positions available for each part in motion in different shots. This system consists of various components such as sensors, a motion capture interface, and a computer system. Based on the foot positions, head position, elbow, knee and the flow of bat swing, different shots are identified [7].

B. Literature Related to Methodologies

1) *Shot Detection Using CNN and LSTM Models:* This approach is based on CNNs comprising of both 3D and 2D convolutions. In 2D convolution neural networks, the convolution on images is performed by the 2D kernels which helps in extraction of features maps. There are distinct numbers of kernels in each convolution layer that gives feature maps which are passed to succeeding layer. Since the task requires the understanding of both visual as well as change in motion over time, the system uses VGG16Net followed by LSTM (Long short-term memory). The features at fully connected layers are the input to the LSTM (Long short-term memory) which is a type of recurrent neural network and capable of capturing long-term dependencies in sequential data. The 3D convolution is done by convoluting a 3D kernel on consecutive frames from the video and feature maps are generated that depends on the count of 3D kernels present in the layer, and then these maps are then fed to next layer [1].
2) *Detection of Shots using DCNN and SVM:* In this approach, initially videos are converted to frames and then these frames are used as input to the Convolutional Neural Network. The categorization of shot as right-handed or left-handed is done first, and then individual frames are applied as input to the CNN layers. The pretrained Alex-Net model is used. There are 5 convolution layers and 3 pooling layers in Alex-net architecture after which the output is followed by two Fully Connected Layers. To get a better accuracy, the system has 3 CNNs that are F1, F2, F3 which represent the different vectors extracted by each of the three CNNs. Then, the vector F is supplied as an input to the SVM (Support vector machine). Multi-class SVM classifier is used as it yields better accuracy in comparison with other state-of-art classifiers [2].
3) *Classification of Shots using Motion Vector:* In this approach, spatio-temporal MACH is used for action recognition. Optical flow for each of the frames is evaluated. Then motion vectors for each of the pixels of each of the frames are obtained. Angle of each motion vector is calculated by the system. Basic tan inverse method is used in case of complex values. The shots are classified by computing the Laplacian of Gaussian (LoG) of each frame. Laplacian of Gaussian (LoG) is used as there are large number of motion vectors [3].

4) *Shot classification using DTW and Minimum Distance Classifier:* In this hardware-based approach, Sensors are used. In this system a body worn sensor (watch) with built-in accelerometer is used. It transmits real-time acceleration (3 axis). DTW (Dynamic Time Warping) is a technique which is used to make comparison between two signals or waveforms. A score is allocated to every input signal using this algorithm. These scores are based on the difficulty in matching the new signal to the saved signal. The main purpose here is to find the closest match for which another technique is used for shot classification. This Technique is Minimum Absolute Distance Classifier (MADC). Here, feature vector is created from statistical properties of the signal such as standard deviation, mean, entropy, skewness [4].
5) *Stroke Recognition using Cross-Correlation:* Batting strokes are recognized using bat tracking and correlation. Otsu's thresholding technique used for getting a threshold which helps in separating the foreground from background. Optical flow is used for recognizing patterns of bat. Initially, in the static background, optical flow should generate only the bat and motion of the player. To yield a point representation of the bat, blob analysis, centroid location method is used. Kalman's filtering is the method to deal with noisy measurements. Using this, bat position is predicted using its previous positions. The Shot Recognition Unit gives data signals about shots, which the system got from training and displays shot information. The output of the past algorithms is in the form of coordinates for the centroid of the bat detected [5].
6) *Control Design of Straight Drive using LQR*: In this approach a model is developed exclusively for straight drive shot using MATLAB which fulfils every detail of the drive. This model is represented using the sequential stages as Fixed components, Connectors, Front foot motion, Force applied, Output Sensing and Bat with ball's impact. The system uses two techniques for control design which are LQR Controller with feedforward compensator and LQR Controller with Integral Action (LQI). The combination of LQR controller and feedforward compensator is used. In State-Space model, calculations of weight matrices for inputs and states are done. The LQI controller optimal gain matrix are obtained using Matrices in MATLAB. Stable steady-state response and reference tracking is obtained after applying the state- space model to the controller [6].

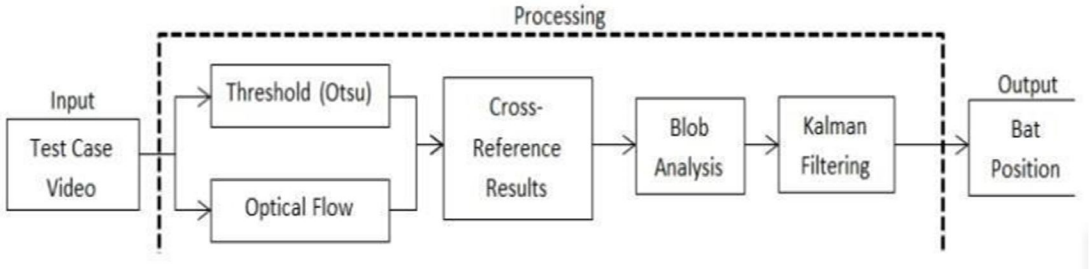

Fig. 4: Bat Detection Block Diagram

7) *Cricket Technique Analyzer using Fuzzy Logic:* The approach uses fuzzy logic for the classification of cricket batting shots. The hitting motion of the bat can be separated into different stages like Bat swing phase, follow through phase and impact. The cricket shot is described using fuzzy sets. These sets are Head Vertical, Head Horizontal, Front foot, Back foot, Bat. The sensors are positioned to extract the positions of various parts such as bat, feet, elbow, and head of the player. The sensors are fitted on different parts as one in the middle of back of the bat, feet, and the head of the batsmen. Thereafter created fuzzy set is compared with the sets in the dataset. The difference between the values is calculated and the accuracy is calculated which tells how well the shot was played [7].

C. *Literature Related to Algorithms*

1) *Artificial Neural Network:* An artificial neural network (ANN) is a computational model based on the functions of biological neural networks. An ANN is collection of connected units called artificial neurons just like neurons in the human brain. Artificial neural networks are quite considered as data modeling tools where relationships between inputs and outputs are modeled and patterns are found. In the given system, a neural network with three hidden layers is trained using batch training and using the sigmoid activation functions.
2) *Fuzzy Logic:* Fuzzy Logic is an approach to variable processing that allows for multiple values to be processed through the same variable, these values have range from 0 to 1. Fuzzy logic is used to handle the concept of half-truth or partial truth, where the truth value may fall between completely true and false. Similarly, in Boolean logic, the truth values of variables may be the integer values 0 that is False or 1 that is True. Fuzzy logic is based on the observation that people make decisions based on indefinite information.

3) *Linear SVM:* A support vector machine (SVM) is a supervised machine learning model that uses classification algorithms for two-group classification problems. The SVM algorithm separates the data into classes by creating a line or a hyperplane. The algorithm searches points that are the closer to the plane from both the classes. And are termed support vectors. The space between these vectors and the plane is known as margin. The main aim of the SVM algorithm is to maximize this distance. When this maximum is selected as an optimal hyperplane. SVM tries to make decision boundaries between classes in such a way such that they are as wide as possible.
4) *Dynamic Time Warping (DTW):* DTW is a common method which is used for comparison two signals or waveforms. It has its applications in handwriting analysis, speech recognition, gesture recognition and motion detection. A score is allocated to every input signal using this algorithm based on the difficulty in matching the new signal to the saved signal. In general, DTW is a method that calculates an optimal match between two given waveforms and sequences.
5) *Otsu's Thresholding:* Otsu's thresholding method is a technique in which the algorithm iterates and searches through all values and calculates measure of spread for the pixel levels at all sides of the threshold, i.e., the pixels that lie in foreground or background. Finding the threshold value where the sum of background and foreground spreads is minimum., is the major aim of the algorithm.
6) *Kalman's Filtering:* Kalman's filtering is a method that which deals with measurements related to noise as, statistical noise and other outliers and inaccuracies, and it gives estimations of those variables that are more accurate than known variables based on a single measurement alone. It is done by estimating a joint probability distribution over these variables for each timeframe.
7) *LSTM Network:* Long Short-Term Memory networks (LSTM) are a type of recurrent neural network. They are capable of learning long-term dependencies. They work very well on a large variety of problems and the algorithm is now widely used. LSTMs are developed specially to steer clear from the long-term dependency problem. RNNs are in the form of a series of modules of Neural networks repeatedly which are like neurons in brain.
8) *YOLO:* You only look once (YOLO) is a single shot detection algorithm. The algorithm is one of the most effective object detection algorithms. YOLO is a convolutional neural network for doing object detection in real-time. The algorithm applies only one neural network to the whole image. Thereafter, the algorithm divides the image into sections and predicts bounding boxes and probabilities for each section. The predicted probabilities are used for getting the bounding boxes. YOLO is a popular object detection algorithm because of its high accuracy and its speed. It can process up to 45 frames in a second. The other advantage is YOLO does not struggle in detecting small objects [8][9].
9) *LQR:* Optimally controlled feedback gains to enable high performance design of systems are obtained using the Linear Quadratic Regulator (LQR) algorithm. The theory of optimal control is related with operating a dynamic system at minimum cost. The LQ problem is defines as the case where system dynamics which are described by various set of linear differential equations and the cost function is shown as a cost function. The solution is provided by LQR. The control engineer's work gets minimized by the LQR algorithm as it optimizes the controller efficiently [10].
10) *Laplacian of Gaussian (LoG):* Laplacian filters are also termed as derivative filters. Using these filters, areas of sudden change are extracted which are edges in images. It is necessary to smooth the image as these filters are very sensitive to noise. That is done with the help of a Gaussian filter before applying the Laplacian. This two-step process is called the Laplacian of Gaussian (LoG) operation.

D. Merits and Demerits of Systems

1) *Cricket NSW Coaching:* This application provides videos for training and also interaction with trainers. Players can interact with the coach to improve their playing technique. But it becomes very difficult for trainers to reach out to every player on a personal basis.
2) *Deep CNN based Data-driven Recognition of Cricket Batting Shots:* This system is based on Convolutional Neural Network (CNN) for categorizing various batting shots played by a batsman. It gives good accuracy in identifying shots but does not help in correct execution of the shot.
3) *Wireless Electronic training system for Cricket:* This system uses sensors for recording various stats of a shot played by the batsman. But this system is not cost effective as batsmen wear those sensors while training which may result in wear and tear of these sensors that will make trainers keep more sensors for backup and this may result in decreasing cost efficiency.
4) *Cricket Shot Classification using Motion Vector:* This approach does feature extraction and also points optical flow from videos of cricket shots played by a batsman. This method uses motion vectors for measuring angle of the optical flow for shot identification. Does not work for providing feedback for played shots as shots are played correctly or not.

5) *Cricket Shot Detection from Videos:* The system uses videos as the input to the Convolutional Neural Network for shot identification. But the processing of video is time consuming that includes converting to frame and then extracting features.
6) *Modelling and Control Design of Straight Drive:* This system is created for straight drive only. Here, the model is created using virtual reality that consists of different stages of straight drive. And compares the features of input video with a model for training of straight drive.
7) *Bat Detection and Tracking Toward Batsman stroke Recognition:* In this approach, stroke recognition is done by bat detection from optical flow from consecutive frames extracted from videos. Output of the system provides efficient data about the shot recognized from the input video.
8) *Cricket batting technique/analyzer using Fuzzy Logic:* This method consists of body-worn sensors for recording data required for creating fuzzy sets categorizing various cricket strokes. Data inserted in fuzzy sets is recorded by sensors based on various parts as foot positions, head position, bat position, etc. At the end, this data is analyzed for shot recognition. This data can be used further for implementing a shot more efficiently.

III. PROPOSED ARCHITECTURE

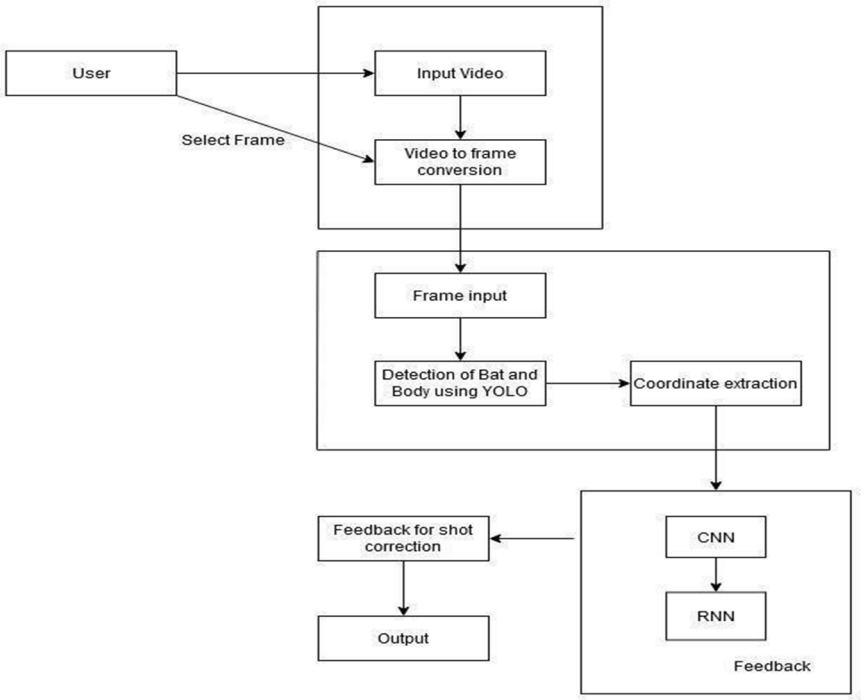

Fig. 5: Proposed System Architecture

Fig. 5 depicts the Proposed System Architecture which comprises different modules. The user will be the one to interact with the interface to access the system. The User will upload a video of a batsman playing the shot as an input to the system. The first module of the system is selecting the appropriate frame for analysis. The system will convert the video into frames and return it back to the user. The user must select the frame from the collection of frames. User must select the frame in which the ball is in contact with the bat. The selected frame will be input to the module 2 of the system. Module 2 of the system is detection of bat and body parts. Bat and body parts will be detected using the yolo algorithm. Yolo algorithm is an effective real-time object detection. The main advantage of the yolo algorithm is its speed. It can process up to 45 frames per second. Bat and body parts will be detected, and the coordinates of bounding boxes will be used for further analysis. The Deep learning model will be trained using a dataset comprising coordinates of bat and body parts of a player playing a perfect shot. Some outliers will be added to achieve better accuracy. The coordinates received from module 2 as an output will be input to the deep learning CNN and RNN based model. If the result is above threshold, the shot would be considered as an ideal shot. If not, feedback would be provided on how the shot could be improved. This would be achieved using a RNN model. RNN is used because at each step the context of previous steps has to be remembered to compare with the ideal shot. After the process, feedback to the user is provided as an output.

IV. CONCLUSION

The paper gives a thorough analysis of various existing systems, their methodologies, algorithms and technologies that have been used as well as their merits and demerits. This review paper shows a comparative study between the existing systems, understanding their algorithms and accuracy of methods being used, their merits and demerits. After studying the detailed analysis of existing systems, the paper also proposes a system that integrates the various approaches discussed. The paper also helps us in understanding the basic modules of the system that we would be developing in the near future, using our own algorithm and some of the existing solutions.

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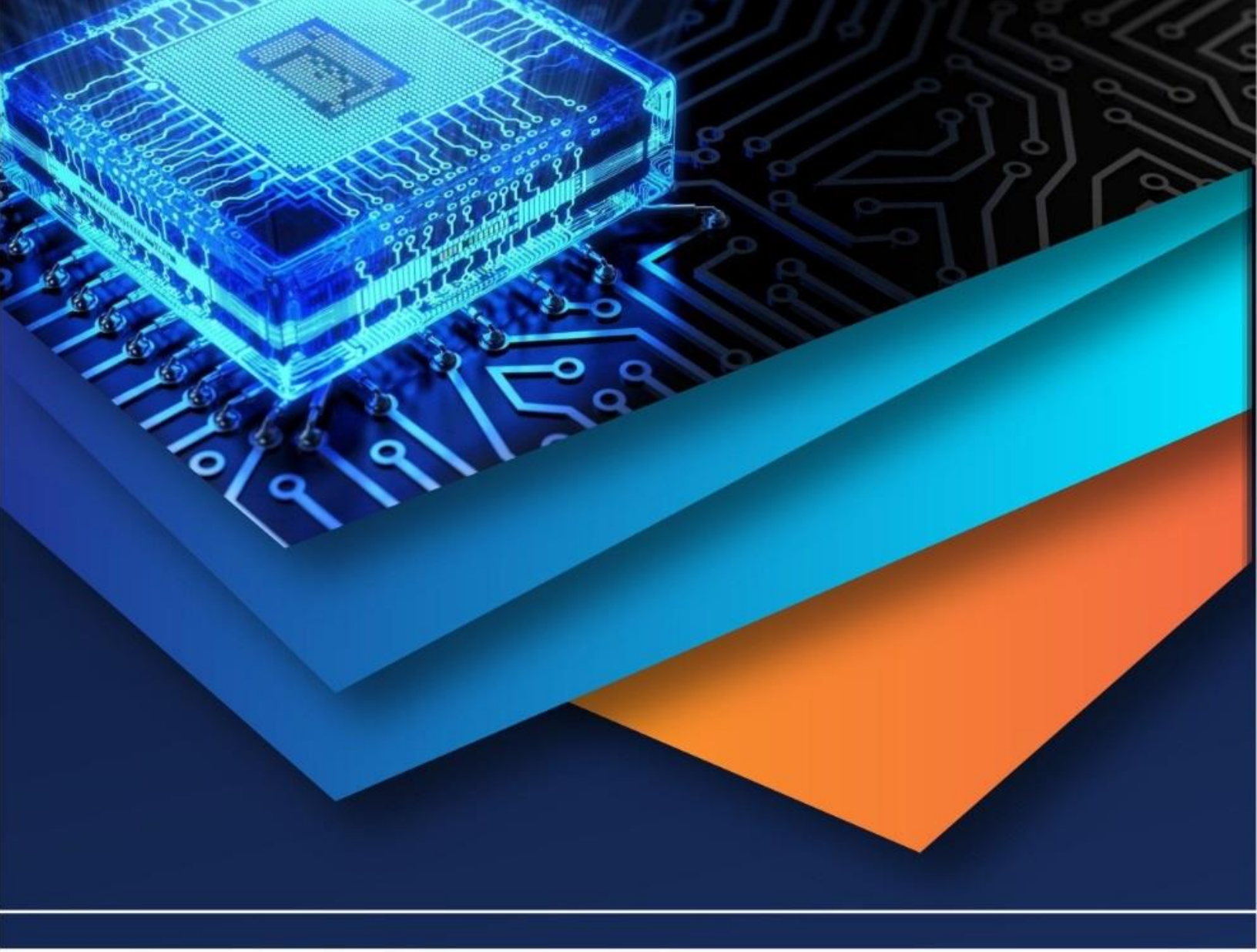

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