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Towards Analyzing the Prediction of Developing Cardiovascular Disease using Implementation of Machine Learning Techniques

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Abstract: ***Machine Learning is an emerging technique widely penetrated into the prediction of Cardiovascular Disease (CVD) events. Cardiovascular Disease is the leading global cause of death among the diabetes and non-diabetes patients. The main aim of this analysis shows the detailed literature survey of how the different machine learning algorithm is used to predict the CVD events among the type 2 diabetes and non-diabetes patients based on the major risk factors such as age, gender, hypertension, cholesterol, diabetes, smoke, alcohol intake, physical inactivity etc. and the accuracy, sensitivity, specificity of the algorithms is also compared. The early prediction have been supports the physician for medical decision making for the management of CVD for the patients and recommends for the patients to take treatment before it becomes fatal.***
Keywords: Cardiovascular Disease, Machine Learning, Diabetes

I. INTRODUCTION

Diabetes mellitus is a chronic disease that occurs when the pancreas is no longer able to produce insulin or when the body is unable to make use of the insulin produced. The survey done by Indian Council of Medical Research (ICMR) thirty years ago, the prevalence of diabetes mellitus was around 2% in urban and 1% in rural India. Within a span of three decades the prevalence rates have raised to 12 – 16% in Urban and 3-8% in Rural India [1]. Moreover 40 million of population in India has now been diagnosed with diabetes. This shows that India has the highest number of diabetics than any other country in the entire world. The complication of Diabetes is divided into Microvascular Complications such as retinopathy (eye damage), nephropathy (kidney damage), neuropathy (nerve damage) and Macrovascular Complications such as cerebrovascular disease (risk of stroke), cardiovascular disease (risk of heart attack), and peripheral vascular disease (poor circulation to the limbs). Individuals with diabetes most often die due to cardiovascular disease (CVD) rather than the cause uniquely related to diabetes such as hypoglycemia [2]. Cardiovascular disease is the term of all kinds of diseases that affect the heart or blood vessels, together with coronary heart disease. People with diabetes are two to four times more likely to die from heart disease than people without diabetes. American Heart Association considers diabetes as the one of seven major controllable risk factors for CVD. According to world health organization CVD account for one in every three deaths worldwide. It is very important to make the people aware about the risk of CVD.

The Health Care Industry generates large amount of data, therefore there is a need of effective technique like Machine Learning to handle effectively. Machine Learning is an application of Artificial Intelligence and is a category of algorithm that will predict the outcomes accurately. Applying Machine Learning in Cardiovascular Disease research is a best approach for diagnosis, prediction, management and other clinical related administration aspects. Machine learning can help people make a preliminary decision about CVD according to their daily physical examination data and it can be act as a reference for physicians. Maximum in the CVD finding research 14 features are used as input in order to predict CVD and the attributes are classified into continuous and categorical. CVD risks are categorized as low, medium and high. All high risk people are advised to change their diet and other life style factors and probably take medications to control the elevated features. Algorithm works by detecting some pattern in the available input data and build a model using the input data to make prediction for the new data. Regression and Classification algorithms in Machine Learning are mostly used to predict a value from the given features and most common regression algorithms such as linear regression, logistic regression, decision tree, random forest, SVM and gradient boosting are used.

The following literature review was done using 26 published papers in order to predict the CVD using machine learning algorithm in the period from 2012 to 2020.

II. LITERATURE REVIEW

Saiful Islam et al [3] used different machine learning algorithm to classify the risk of having cardiovascular disease and analyze the result obtained by the different algorithm using confusion matrix. Logistic regression gave better accuracy of 86.25% than the other models like SVM, Decision Tree and Naïve Bayes.

Gupta A et al [4] proposed a machine intelligence framework MIFH for diagnosing heart disease. MIFH utilizes the characteristics of FAMD to extract the feature from the dataset and this proposed method is compared with the several baseline methods like LR, KNN, SVM, DT and RF proposed for developing decision support system for diagnosing heart disease.

Komal Kumar et al [5] has worked 5 machine learning classifier such as Logistic Regression (LR), Support Vector Machine (SVM), Decision Tree (DT), Random Forest (RF), K-Nearest Neighbors (KNN) on heart disease data to predict cardiovascular disease using jupyter web application environment and random forest classifier achieves the highest accuracy.

R. Jane Preetha Princy et al [6] used few machine learning algorithm and compares the result for pre and post dimensionality reduction of dataset. The reduction of dimension affects all algorithms except the decision tree.

Juan-Jose Beunza et al [7] has prepared three different models. Model A was developed using original variables from the Framingham heart disease dataset without any modification, Model B was developed by the original variable but excluded all the observation if it contains atleast one missing variables and Model C was developed if any of the continuous variable is missing in the dataset was replaced by average from the rest of the variables. R studio and rapid miner software tools are used to compare different supervised ML algorithms through the three models. Finally R-Studio is best compared to RapidMiner when comparing the algorithm in terms of accuracy, sensitivity, specificity, positive predictive value, negative predictive value and area under curve.

MD Samiul Islam et al [8] has applied 5 statistical models to check the performance for the dataset. After that applied attention module based LSTM to check the model with the traditional statistical model.

Mohan S et. al [9] has compared the traditional machine learning algorithm with the proposed model named HRFLM (Hybrid Random Forest Linear Method). The proposed model has produces high accuracy and less classification error compared to traditional techniques in predicting heart disease.

Vivekanandan T et al [10] has proposed a hybrid CVD prediction model. In this model differential evolution algorithm is used to identify 9 critical attributes from 13 attributes and cumulative prevalence rates are calculated to the all identified critical attributes of individuals using cox proportional hazard regression and finally 2 mean cluster technique is applied in the cumulative prevalence rates of individual to fall into the four risk level.

Nabaouia Louridi et al [11] has proposed that preprocessing the data is a vital step to achieve accuracy. The algorithms like NB, KNN, SVM with linear and RBF kernel were implemented in the data with the replacement of mean value in the place of missing data and shows the comparative result.

S. Harjai et al [12] has designed a Clinical Decision Support System using multilayer perceptron and shows the performance analysis of proposed model with traditional model.

Sabrina Mezzatestaa et al [13] have used several machine learning algorithms and found LR and SVC with RBF kernel have great predictive power. For better optimized result of SVCR algorithm, Grid search estimator is used and to optimize the loss function.

Sumathi A. e.t al [14] proposed a model to predict diabetic heart disease (DHD) and to classify the possibility of DHD (absence, mild, moderate and severe) related complications with the high accuracy rate using data mining technique. In the proposed model preprocessing is done by mean values, clustering by K-Mean algorithm, and classification by decision tree and J48 algorithm using WEKA tool.

Dinesh, Kumar G., et al [15] researched the early diagnosis of heart disease using R tool. Data preprocessed were performed and then applied the machine learning algorithms like Support Vector Machine, Gradient Boosting, Random forest, Naive Bayes classifier and logistic regression to produce the result.

Zarkogianni et. al [16] developed a risk prediction model for the fatal or non-fatal CVD incidence in T2DM that specialize in Coronary Heart Disease (CHD) and Stroke using Hybrid Wavelet Neural Network (HWNN) and Self Organizing Maps (SOMs). Moreover, a hybrid ensemble was developed by applying a voting scheme to the outputs of the HWNN-based ensemble 4 and SOM-based ensemble 4. The hybrid ensemble integrates the inherent advantages and features of both the HWNN- and the SOM- based ensembles offering the opportunity to produce more flexible relationships between risk factors and the CVD risk.

Esfahani H.A et al [17] constructs a pattern recognition model by combining different classifier models and achieves F-Measure value of Rough Set, Naïve Bayes and Neural Network as high performance so these three classifiers are combined by using fusion strategy to produce ensemble classifier to predict cardiovascular disease.

Saeed Farzi et. al [18] proposed a study toward predicting some important complications of Type 2 diabetes such as heart disease, retinopathy, and diabetic foot etc. using classification algorithm. This prediction has been used to inform the patient about their future disease through early prediction of the complications.

The data set was divided into five targeted features and examined there was an imbalance occurred. The imbalance leads to a problem which is tackled by SMOTE algorithm.

Gokilam, G.G. et. al [19] proposed a model by taking two kinds of dataset such as diabetes and heart datasets and build a dataset relate with their matching fields then apply the classification algorithm like J48, Random Tree, Random Forest, REP, Naïve Bayesian in diabetes heart dataset in WEKA tool to predict a chance of heart disease or not.

S. A. Sabab et al [20] used three algorithms such as NB, SVM and DT to generate the model and to improve the accuracy of model rankers algorithm was applied. Feature with high ranking yields good accuracy was proved.

Omar Boursali et. al [21] has collected real data which was processed through noise reduction, feature extraction and data normalization technique and the output generated from these are the inputs to the SVM classifier. It classifies the risk level as "continued risk" or "no longer at risk".

Kalaiselvi, C. et. al [22] has predicted heart disease and cancer among diabetic patients from the diabetic dataset with important attributes of diabetes.

First the data is normalized using Particle Swarm Optimization (PSO) algorithm to get the values in the range. After normalization, the data is classified using Adaptive Neuro Fuzzy Inference System (ANFIS) with Adaptive Group-based K-Nearest Neighbor Algorithm (AGKNN). It uses member functions for each of the input and predicts the results. The experiment is done using MATLAB.

Kalaiselvi, C. et. al [23] has examine the association between diabetes and heart diseases. The data are collected from the diabetes patients. From these data, relevant features are selected using ant colony optimization and those selected features are classified into normal and abnormal data using hybrid PSO-LIBSVM algorithms.

Radha, P. et. [24] has proposed a hybrid prediction model that should perform unsupervised classification algorithm to exactly classify newly diagnosed patients into a group that is likely to develop type 2 diabetes using Improved Fuzzy C Means Clustering (IFCM) and then perform supervised classification to develop a heart disease prediction models using Support Vector Machine (SVM).

Radha, P. et al [25] has proposed a hybrid prediction model to predict CVD in type 2 diabetic patients by applying principal component analysis and dimensionality reduction to perform the attribute analysis based on IG and entropy values, and then Hybrid prediction model performs the prediction based on clustering methods to measure the similarity among the attributes for labeling the classes and then support vector machine learning based classification task for prediction.

Dalakleidi, et al [26] describes that algorithm such as Genetic algorithm and K-Nearest Neighbors are used to select the important clinical features that are strongly associated with nonfatal and fatal cardiovascular events in patients with Type 2 diabetes. Sensitivity and accuracy are calculated by achieving the best subsets of features selected by 3 versions of GA for different number of the k nearest neighbors.

Parthiban, G. et al [27] has proposed classification predictive model using Naïve Bayes and Vector Machine to detect whether diabetic patient is suffering from heart disease with signifying levels.

Using 10 fold cross-validations, each instance of the whole training set is predicted one time and the cross-validation accuracy is the percentage of correctly classified data.

Bhuvaneswari Amma N.G [28] in his work proposed a system using Multilayer Feed Forward Neural Network and the weights applied to the Neural Network are determined by using Genetic Algorithm.

In the preprocessing stage, the attributes are normalized using min-max normalization and classified into five classes. The classes are classified based on severity.

III. COMPARATIVE ANALYSIS OF THE EXISTING WORK

The results in the table 1 provides the list of recent papers in predicting CVD using machine learning algorithm and the dataset, techniques to find and finally

one of the metrics like accuracy are compared. Most of the papers are used the traditional supervised machine learning for the diagnosis and also these algorithms are having their own merits and demerits so finding of enhanced or hybrid approach is essential.

Table 1: Various machine learning approaches used for the prediction of Cardio vascular diseases

S.No	Paper / Journal published	Author	Dataset	Year	Technique Used	Result
1	Cardiovascular Disease Forecast using Machine Learning Paradigms	Saiful Islam et al [3]	UCI Heart Dataset	2020	Logistic Regression, Support Vector Classifier, Decision Trees, and Naïve Bayes	86.25% accuracy (logistic regression)
2	MIFH: A Machine Intelligence Framework for Heart Disease Diagnosis	Gupta A et al [4]	UCI Cleveland Dataset	2020	FAMD (Factor Analysis of Mixed Data) with state of art ml approaches	93.44% accuracy (FAMD+RF)
3	Analysis and Prediction of Cardio Vascular Disease using Machine Learning Classifiers	Komal Kumar et al [5]	UCI Heart Disease Dataset	2020	Logistic Regression, Support Vector Machine, Decision Tree, Random Forest, K-Nearest Neighbors.	85.17% accuracy (random forest)
4	Prediction of Cardiac Disease using Supervised Machine Learning Algorithms	R.Jane Preetha Princy et al [6]	Kaggle Dataset	2020	Naive-Bayes, Decision Tree, Logistic Regression, Random Forest, SVM and KNN	73% accuracy (decision tree)
5	Comparison of machine learning algorithms for clinical event prediction (risk of coronary heart disease)	Juan-Jose Beunza et al [7]	Framingham study open database	2019	Decision Tree, Boosted Decision Tree, Random Forest, SVM, Neural Network and Logistic Regression.	R-Studio provides better result
6	Intelligent Healthcare Platform: Cardiovascular Disease Risk Factors Prediction Using Attention Module Based LSTM	MD Samiul Islam et al [8]	Different hospitals, medical stores	2019	Attention module based Long Short- Term Memory (LSTM)	95% accuracy
7	Effective Heart Disease Prediction Using Hybrid Machine Learning Techniques	Mohan S et al [9]	UCI Cleveland Dataset	2019	Hybrid Random Forest with a Linear Model (HRFLM)	88.7% accuracy
8	A hybrid risk assessment model for cardiovascular disease using Cox regression analysis and a 2-means clustering algorithm	Vivekanandan T et al [10]	UCI Cleveland Dataset	2019	Modified Differential Evolution (DE) algorithm, Cox regression analysis and 2-means clustering	91% accuracy (cox regression)
9	Identification of cardiovascular disease using machine learning	Nabaouia Louridi et al [11]	UCI Heart Diseases Dataset	2019	Naive Bayes, K Nearest Neighbour, SVM with linear, RBF kernel	86.8% accuracy (SVM with linear kernel)
10	An Intelligent Clinical Decision Support System Based on Artificial Neural Network for Early Diagnosis of Cardiovascular Diseases in Rural Areas	S. Harjai et al [12]	Cleveland Heart Disease Dataset	2019	Correlation-based feature selection (CFS) and Multilayer Perceptron classifier	89.2% efficiency
11	A machine learning-based approach for predicting the outbreak of cardiovascular diseases in patients on dialysis	Sabrina Mezzatestaa et al [13]	Italian dataset from Calabrian dialysis registry, American dataset from (NIDDK) repository	2019	Nonlinear SVC with RBF kernel algorithm, GridSearch	95.25% accuracy Italian dataset and 92.15% American dataset
12	Prediction of Heart Disease Complication for Diabetic Patient using Data Mining Techniques	Sumathi, A. et al [14]	Diabetic Heart Disease dataset	2018	Decision Tree , J48 classification algorithms and K-mean clustering techniques	J48 provides best accuracy

13	Prediction of Cardiovascular Disease Using Machine Learning Algorithms	Dinesh, Kumar G., et al [15]	UCI machine Learning Repository	2018	Support Vector Machine, Gradient Boosting, Random forest, Naive Bayes classifier and logistic regression	86.5% accuracy (logistic regression)
14	Comparison of machine learning approaches towards assessing the risk of developing cardiovascular disease as a long-term diabetes complication	Konstantia Zarkogianni, et al [16]	Hippokration General Hospital of Athens (5 year follow up Data)	2017	Hybrid Wavelet Neural Networks (HWNNs) and Self-Organizing Maps (SOMs)	71.48%
15	Cardiovascular disease detection using a new ensemble classifier	Esfahani H.A et al [17]	UCI Machine Learning Repository	2017	Decision Tree, SVM, Neural Network, Logistic Regression, NB and Rough Set	Accuracy 89% F-Measure 86.8% (Ensemble classifier)
16	Predicting Serious Diabetic Complications using Hidden Pattern Detection	Saeed Farzi, et al [181]	Medical Records in Kermanshah province of Iran	2017	J48 (Decision Tree), LMT, NBTree, Random Forest, SMO, MLP (Multi-Layer Perception neural network), Naïve Bayes, Bayes Net, and RBF (Radial Base Function).	Random Forest is best 83% accuracy & Naïve Bayes is worst
17	Performance Analysis of Various Data mining Classification Algorithms on Diabetes Heart dataset	Gokilam, G.G. et. al [19]	Pima Indian Diabetes & Heart disease Database	2016	J48, Random Forest, Random Tree, Reduced Error Pruning (REP) Tree and Naïve Bayesian classifier	95% Accuracy (J48) 0 Seconds to Build (NB)
18	Cardiovascular Disease Prognosis Using Effective Classification and Feature Selection Technique	S. A. Sabab et al [20]	Goldsmiths University of London	2016	Naïve Bayes, Support Vector Machine and C4.5 Decision Tree	82.8% without ranker, 87.8% with ranker accuracy (SMO)
19	M4CVD: Mobile Machine Learning Model or Monitoring Cardiovascular Disease	Omar Boursali et. al [21]	real data from clinical databases and wearable sensors	2015	Support Vector Machine (SVM)	90.5% accuracy
20	Prediction of Heart Diseases and Cancer in Diabetic Patients Using Data Mining Techniques	Kalaiselvi, C. et. al [22]	Leading diabetic center	2015	Particle Swarm Optimization, Adaptive Neuro Fuzzy Inference System (ANFIS) with Adaptive Group based K-Nearest Neighbor Algorithm.	98% Accuracy
21	Classification and Prediction of Heart Disease from Diabetes Patients using Hybrid Particle Swarm Optimization and Library Support Vector Machine Algorithm	Kalaiselvi, C. et. al [23]	Diabetic Patients	2015	Ant colony optimization, Hybrid Particle Swarm Optimization and Library SVM Algorithm	-
22	Diagnosing Heart Diseases for Type 2 Diabetic Patients by Cascading the Data Mining Techniques	Radha, P. et. al [24]	UCHT (Diabetic Clinical Information system)	2014	Improved Fuzzy C Means (IFCM) clustering algorithm, principal component analysis (PCA) and support vector machine (SVM).	93.8 % Accuracy 90.4% Sensitivity 54.7% Specificity
23	Hybrid Prediction Model for the Risk of Cardiovascular Disease in Type-2 Diabetic Patients	Radha, P. et. al [25]	UCHT (clinical diabetic patient's records)	2014	PCA, Improved Fuzzy C Means clustering (IFCM) and Support vector machine (SVM).	93.8% Accuracy 90.4% Sensitivity 54.7%

						Specificity
24	A Hybrid Genetic Algorithm for the Selection of the Critical Features for Risk Prediction of Cardiovascular Complications in Type 2 Diabetes Patients	Dalakleidi, et al [26]	Hippokration General Hospital of Athens	2013	Weighted k-nearest neighbor classifier & Genetic Algorithm	0.96 Accuracy 0.80 Sensitivity 0.98 Specificity (16 features, GA version 3)
25	Applying Machine Learning Methods in Diagnosing Heart Disease for Diabetic Patients	Parthiban, G. et al [27]	Diabetes healthcare institute	2012	Naïve Bayes Method and Support Vector Machines	94.6% Classification Accuracy
26	Cardiovascular Disease Prediction System using Genetic Algorithm and Neural Network	Bhuvaneswari Amma N.G. [28]	UCI Machine Learning Repository	2012	Feed Forward Neural Network and Genetic Algorithm	94.17% classification accuracy

A. Machine Learning Algorithm Used Versus Accuracy of the Algorithm

The fig 1 compares the accuracy value against the machine learning algorithm in the prediction of non-communicable disease CVD among the diabetic and non-diabetic patients from the journal paper discussed in the literature review and noted that the accuracy ranges from 71% to 98%.

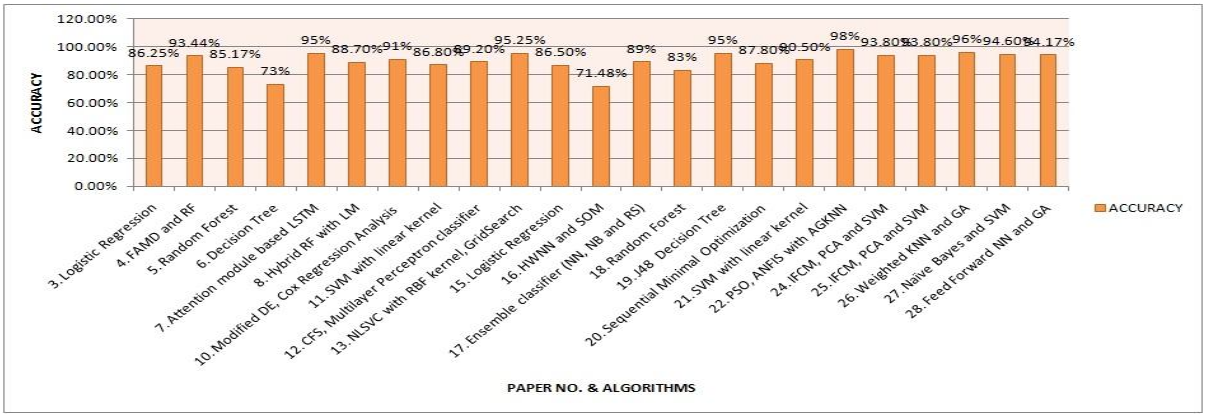

Fig 1: Accuracy of the Machine learning Algorithm in the prediction of CVD

B. Count Of Machine Learning Algorithm used in the Prediction of CVD

The fig 2 depicts that the Decision Tree and Naive Bayes are the traditional machine learning algorithms mostly contributed in detecting non communicable leading disease among 28 research paper discussed above.

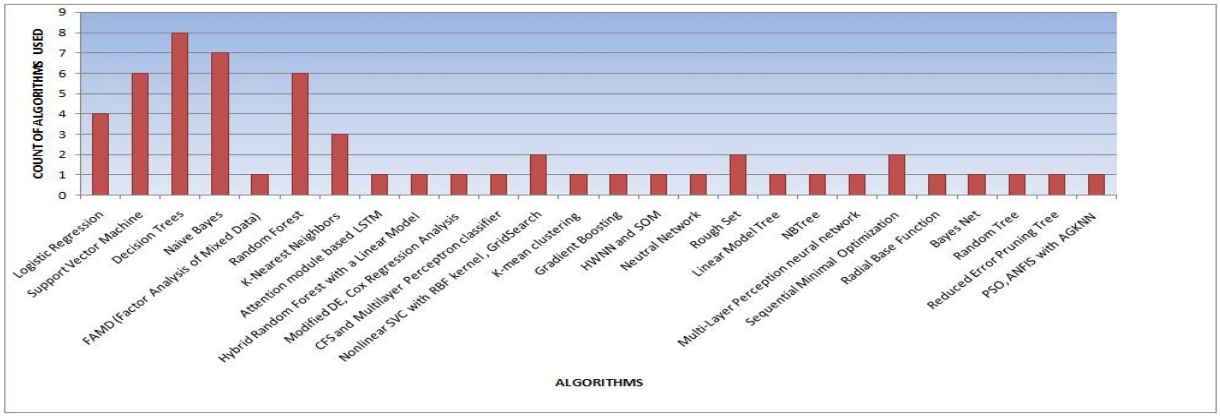

Fig 2: Number of times the algorithm used

IV. CONCLUSION AND FUTURE WORK

The above study shows the comparative assessment of the different machine learning approaches towards the developing of CVD among the type 2 diabetic and non diabetic patients. The result obtained reveals that more sophisticated approach is to be applied for achieving the accuracy and reliability. More number of related features will be used to improve the investigation of early prediction and the risk levels are identified to appropriate changes in the treatment.

The above research papers provide additional information that the changing of number of attributes the performance may differ. Our research will be on an open dataset in which we focus on improving the prediction of CVD in diabetes patients by implementing the machine learning algorithm. By this papers we will find the accuracy of the implemented algorithm and then identify the efficient technique among them. In the future hybrid algorithms or enhanced machine algorithms are to be implemented for the better prediction value for the diagnosis of CVD. Most of the discussed papers are implemented using the traditional supervised machine learning but the algorithms have its own merits and demerits so combining or enhancing the algorithm yields better value.

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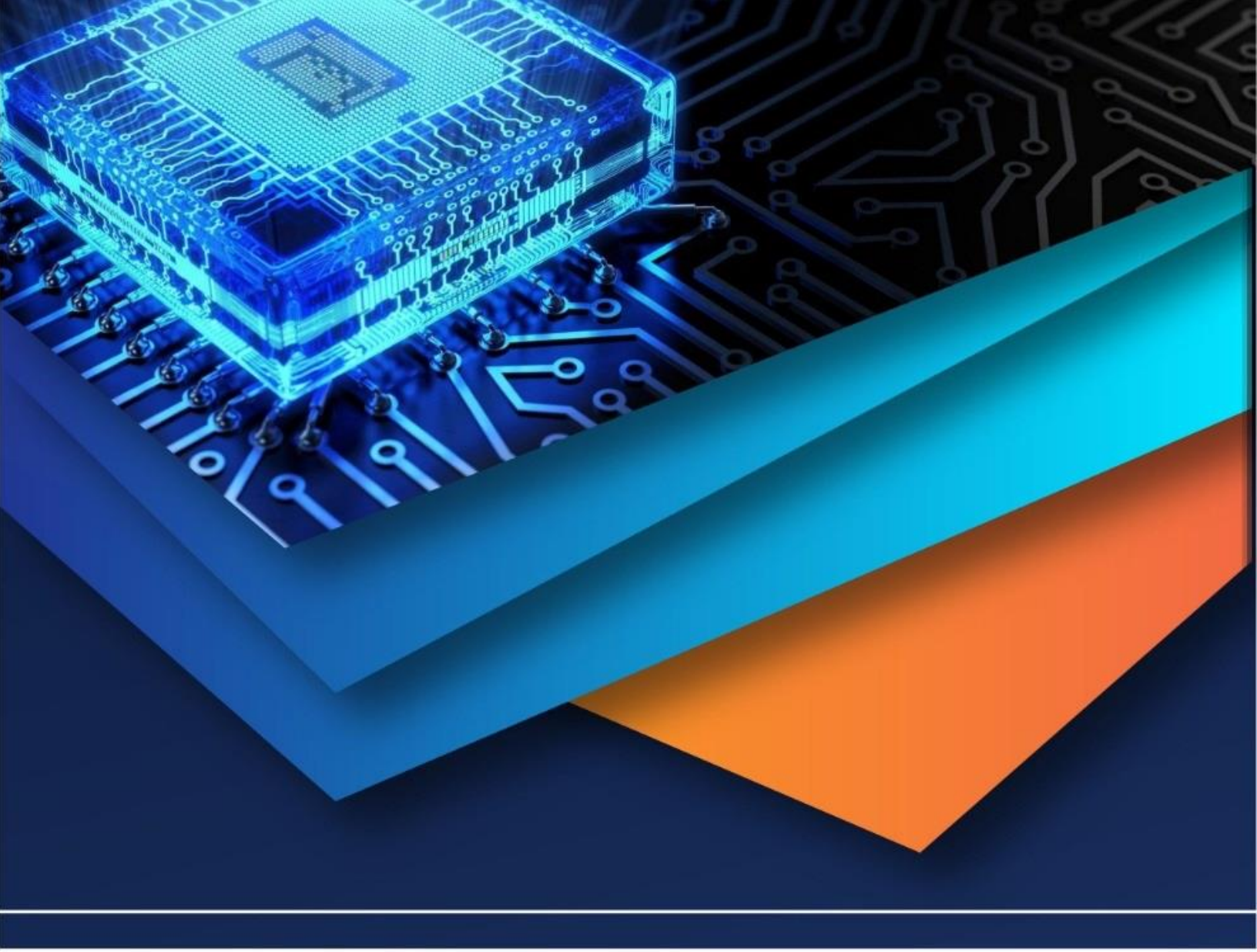

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