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Weather prediction based on LSTM model implemented AWS Machine Learning Platform

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Abstract: ***Climate change has affected the weather forecast on a regular basis compared to reality. Meanwhile, weather forecast plays an important role in daily life and especially it affects developed countries in agricultural fields around the world. When we apply information technology software, we can assess the general weather condition of a given city, and with the help of recent modern scientific methods for more accurate analysis and prediction of weather based on those collected weather data for a period of a week earlier or longer for future weather forecasts. Therefore, in this study, machine learning model was applied and it was allowed to study methods and feature engineering from data pre-processing, so through this, we find an unpredictable model of climatic conditions, a prognostic model is also monitored. For this work, various weather parameters were collected from the national climate data center through available software applications, with the application of the Long Short-Term Memory (LSTM) model is an artificial recurrent neural network (RNN) were trained for different combinations that are implemented on AWS machine learning platform. In the process of predicting weather conditions with today's modern technology, neural networks are practiced using different combinations of weather parameters such as temperature, precipitation, humidity, wind speed, and pressure. After training the LSTM model with these parameters, in addition to the results of the plot of model accuracy for the training and validation sets and performance evaluation metrics to test the model, this study also concluded the results of the weather condition by 2 values (good or bad).***
Keywords: Weather prediction, neural network, LSTM, recurrent neural network, AWS Sagemaker

I. INTRODUCTION

We seems that the weather plays a big role in all activities of human life with many purposes to survive on this earth by earning a living in many different fields such as agriculture, industry, education, and so on. Since then, we have a better life and all our products are made to achieve the desired quality with the support of good weather. But the reality is not exactly as we monitor the weather forecasts collected through the available weather forecast application which has greatly affected our lives and lost a lot of their possessions due to weather conditions we cannot predict the future a long time to have a backup plan.

Artificial neural network (ANN) or neural networks are computation algorithms. Artificial neural network (ANN) is an effective technique to construct a computerized system that is capable of processing non-linear weather conditions inside a specific domain, and make predictions [1]. ANN has a large number of connected processing units that work together to process information. It applied neural network for regression of continuous target attributes. It has three layers as: Input layer, Hidden layer and Output layers [2]. The ANN nature is based on developing a mathematical model capable of recognizing complex patterns on the same line as the active neuron [3]. Basically, ANN was the system that receives the input, processed the data and then gave output with respect to input. Neural networks were multilayered with one input layer, most hidden layers and one output layer. Meanwhile, the weather, it was a data-intensive type, we saw the data set is non-linear and therefore we predetermined the exact weather conditions with the option of applying ANN. Based on our research, many neural networks are designed. Among these various neural networks, the transitional neural network was used for both the purpose of predicting climatic conditions or forecasts of stocks, etc. [4].

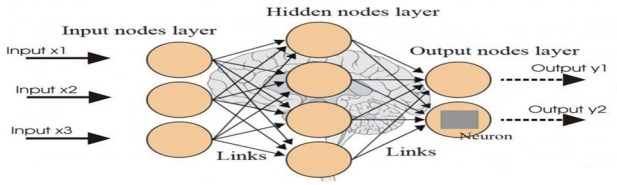

Fig.1: Basic ANN architecture

The above figure shows the architecture of an artificial neural network consisting of three layers. As mentioned earlier, the primary layer has input neurons, the second layer has hidden neurons and the third layer has output neurons. In addition, SNN (Supervised Neural Networks) are trained to deliver important outputs to training inputs. It was trained by providing it appropriate input and output samples [1].

Through those reasons, in this our research, we introduce a new AutoML technology based on Cloud platform that is a trend to develop and assist researchers in the field of artificial intelligence in the training of the model or giving data of metrics result for model evaluation quickly. Machine learning researchers have mostly used Google's Cloud AutoML [5] versus Amazon Web Services (AWS) [6] deploys both models and algorithms directly on Amazon Sagemaker [7]. Both AWS and Google provide following machine learning services, the training custom models with our own data: Jupyter notebook, a hosted model training and Hyper-parameter optimization service, to which training jobs can be submitted remotely; a model repository and scalable model hosting service for inference; built-in algorithms to train our models with just data. Moreover, they are supported LSTM (*Long Short-Term Memory)* technique always work well in series time data science. Table 1 shows a comparison of some Cloud machine learning services and it shows that AWS's Amazon Sagemaker has a few advantages over Google's Cloud AutoML [8].

	Amazon	Microsoft	Google	IBM
Automated and semi-automated ML services				
	Amazon ML	Microsoft Azure ML Studio	Cloud AutoML	IBM Watson ML Model Builder
Classification	✓	✓	✓	✓
Regression	✓	✓	✓	✓
Clustering	✓	✓	✗	✗
Anomaly detection	✗	✓	✗	✗
Recommendation	✗	✓	✓	✗
Ranking	✗	✓	✗	✗
Platforms for custom modeling				
	Amazon SageMaker	Azure ML Services	Google ML Engine	IBM Watson ML Studio
Built-in algorithms	✓	✗	✓	✓
Supported frameworks	TensorFlow, MXNet, Keras, Gluon, Pytorch, Caffe2, Chainer, Torch	TensorFlow, scikit-learn, Microsoft Cognitive Toolkit, Spark ML	TensorFlow, scikit-learn, XGBoost, Keras	TensorFlow, Spark MLlib, scikit-learn, XGBoost, PyTorch, IBM SPSS, PMML

Fig. 2: The Cloud machine learning services comparison

II. RELATED WORK AND LITERATURE SURVEY

Researchers are adopting various machine learning methods, including machine learning and the recently supported Cloud AutoML (Google or Amazon) technology [8-9], which has been trying to predict weather condition with best results.

The current survey assesses a number of machine learning models to predict weather condition from real-time data is recorded for a while ago by the available weather data application. The techniques have been used until now such as: logistic regression, support vector machines, neural network and random forests. The performance of all the models tested is evaluated using several metrics, including Accuracy, Recall, F1 score, AUC score (Area under the Curve).

These metrics, derived from the model's exhibited number of true positives (TP), true negatives (TN), false positives (FP) and false negatives (FN), include Accuracy (Eq.1), Recall (Eq.2), F1 (Eq.3) and AUC stands for "Area under the ROC curve" that is measures the entire-dimensional are underneath the entire ROC curve from (0.0) to (1.1).

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$\text{Recall} = \frac{TP}{TP + FN} \quad (2)$$

$$F1 = \frac{2TP}{2TP + FP + FN} \quad (3)$$

In this section, the author presents the review of previous studies in weather prediction. This paper reviewed more details by different researchers with achieved their results below Table 1 [1].

Table 1: The result revised according to the studies

Reference Used	Applied Method	Achieved Prediction	Accuracy (%)	Limitations
Pushpa Mohan et al [10]	Statistical data, the classification like Support Vector Machine (SVM), neural networks.	Rainfall, crop yield and cost of crop in Mysore region, Karnataka, India.	-	No value results of evaluation metrics and features engineering. Asynchronous data collection by each individual application, prediction in a small area and only shows general steps.
P.Shivaranjani et al [11]	ANN, Decision tree algorithms, build a classifier tree, the data mining tool is WEKA, feature extraction.	Rainfall. Value result of evaluation metrics. Gave a performance comparison between C4.5 and Naïve Bayes algorithm (showed that C4.5 was better than Naïve Bayes with accuracy 88.2%). Especially, features engineering for dataset.	88.2	Build a complex model with C5 decision tree.
Amruta A. Taksande et al[12] and A. Dhore et al[13]	Frequent Pattern Growth Algorithm, Decision Tree, metrics of statistics.	Rainfall, calculate MAE, MSE and SD with >90% accuracy Predicted prediction with temperature.	90%	No value results of evaluation metrics and features engineering. Only calculate MAE, MSE and SD belong to metrics of statistics and gave rainfall status result and predicted prediction with temperature.
S. Santhosh Baboo et al [14] and S.S. De et al [15] and B. Musala Reddy et al [16]	ANN, neural networks, Back propagation neural network (BPN), real time dataset.	Weather prediction with temperature Proposed model result compared with practical temperature prediction. Evaluation of performance of model by RMSE (Root Mean Square Error) value.	-	No value results of evaluation metrics and features engineering. Complex proposed model with BPNN. Only temperature prediction to evaluate weather condition and showed performance of ANN by RMSE value.
SaktayaSuksri [17]	ANN, SVM and MLP (with BPN algorithm) model comparison, dataset pre-processing.	General Weather with maximum temperature at a location. Performance of SVM is better than MLP with back propagation algorithm by evaluation of MSE performance measure.	-	No value results of evaluation metrics and features engineering.
A. Subashini et al. [1]	ANN, LSTM - Long Short–Term Memory (traditional RNN), real time dataset	General Weather. LSTM model gave substantial results with high accuracy. The history weather dataset for a long time by available application	-	No value results of evaluation metrics and features engineering

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Through a more detailed comparison of previous researchers with recent years of 2020, showed that as: many models were applied to predict weather condition with some parameters as: Sunrise, Sunset, Chance, Humidity, Wind, Pressure, so on, such as ANN, neural networks, SVM, BPN, and used a WEKA tool was one of the tools in data mining. Since then, they has achieved the desired results achieved for predicting weather conditions for this time, specifically, prediction of general weather or weather forecasts with temperature and rainfall, made comparisons of the prediction models (C4.5 and Naïve Bayes , SVM & MLP), and valuation of performance of models by MSE, RMSE, MAE and SD performance measure. However, there were many limitations such as: No value results of evaluation metrics which only calculated MSE and SD values belong to metrics of statistics, features engineering, used complex model and algorithm as C5 decision tree or BPN and proposed BPNN. Besides, evaluation of performance of models with accuracy ranges was 88.2 – 90% or even, perhaps, most previous authors have not shown a specific value so far.

III. RECURRENT NEURAL NETWORK AND LSTM

Amazon SageMaker [18] is a fully managed service that enables to make quickly and easily integrate machine learning based models into our applications. Machine learning with Amazon Sagemaker describes typical machine learning processes and general ways to accomplish those tasks. Therefore, we preprocess example data in a Jupyter notebook on our notebook instance. We use our notebook to fetch our dataset, explore it, and prepare it for model training.

Neural network finds great application in data mining used in fields. For example: prediction of economics, stock, finance and weather, so on. Typically, neural network includes Input layer, Hidden layer, Output layer.

1) *Input Layer:* Operation of the input unit represents raw information can provided to the network
2) *Hidden Layer:* Determine the operation of each hidden unit. The operation of the input unit and the weights on the connection between the input unit and the hidden unit.
3) *Output Layer:* The outcome of the output unit depends on the operation of the hidden unit and the weight between the output unit and the hidden unit.

Sequence prediction problems come in many form and are best described by the types of inputs and outputs supported. Our sequence prediction problem is Many-to-One which is a sequence of multiple steps as input mapped to class or quantity prediction. Otherwise, Many-to-Many problem is often referred to as sequence-to-sequence, or seq2seq for short, this will research in future.

This research applied a recurrent neural system (RNN) is a class of ANN where connections between units form a coordinated chart along a sequence. This allows it to display dynamic behavior time to arrange a time.

This is not possible for the relay neural network, and the recurrent neural network can use its memory from the internal memory to process a sequence of inputs. RNN can recall important things about the information they get, this allows them to extremely predict what is coming.

This is the highlight behind why they are the preferred technique for sequential data such as time series, weather, and more because they are thoughtfully evolving in its sequence and context, compared to other similar technologies. In recurrent neural network, the data goes through a loop.

When it decides on a decision, it considers the current input and further what it has received from the information it has received earlier. But, so far, then RNN were traditionally difficult to train.

Current, Long Short–Term Memory (LSTM) [19] networks are an extension of recurrent neural network and perhaps the most successful RNN because it overcomes the problems of training a recurrent network and in turn has been use on a wide range of applications [20, 21], which basically expand their memory.

Along these lines it is appropriate to gain from obligatory encounters with long circumstances in the middle. The unit of the LSTM network is the unit that supports the surface of the recurrent neural network, then, commonly called the LSTM network. The LSTM allows recurrent neural networks to recall given information over a long period of time.

This is because recurrent neural networks contain their data in memory similar to the memory of a computer in the context that LSTM can read, write and erase data from its memory. In a recurrent neural network have three gates so far, such as: input, hidden and gate of output.

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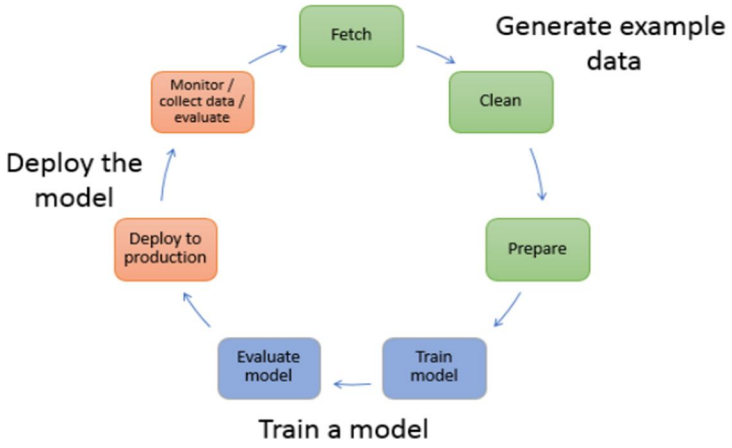

Fig.3: Diagram illustrates the typical workflow for creating a machine learning model

IV. PROPOSED METHOD

In this paper, we propose a new technology, Amazon Sagemaker that predicts the weather recently, it is a machine learning service that has just appeared recently and found its rare context concerned machine learning articles. So, we chose this method to make evaluation of RNN machine learning model based on LSTM algorithm.

Also, we use weather forecasting model which is the recurrent neural network with LSTM algorithm essentially, fit an LSTM for a multivariate time series forecasting [22] and collect data that is weather parameters, like temperature, humidity, pressure, wind speed, so on. These are considered as neurons of input to recurrent neural network. Weather forecasting is done by collecting information related daily weather in regards to the previous and the present condition of the weather and utilizing this information to train LSTM model. The proposed technology for weather prediction with the novels of recurrent neural network is given below Fig.4.

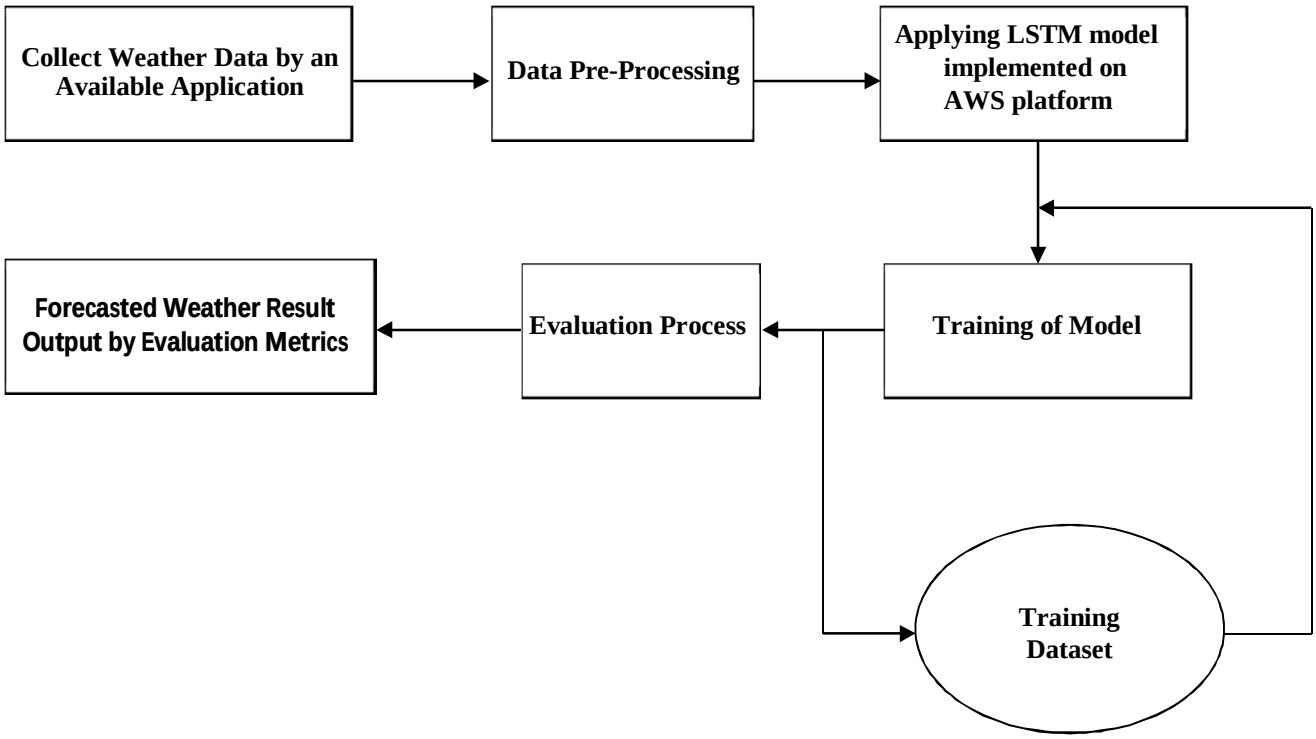

Fig.4: The diagram of proposed method

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V. EXPERIMENTAL RESULT

To experiment the proposed model, the historical weather dataset has taken from available application for 4 months from December 2020 to March 2020. The dataset contain many weather attributes like Sunrise, Sunset, Chance, Humidity, Wind, Pressure, Visibility, and UV, so on. These attributes are the given information to the neural network and trained using LSTM model. From then, our research results have achieved the following highlights, such as:

A. Supervised dataset for Training using the LSTM model shown below. Fig.5
B. Also, we shown the LSTM model layers in the training process shown below. Fig.6
C. Plot training and validation accuracy values of the model, it shown below. Fig.7
D. Finally, the evaluation metrics highlights indicated that the LSTM model has improved results compared to the majority of previous models increasing the ratio of metrics (Accuracy, Recall, F1 and AUC score). The evaluation result shown below. Fig.8
E. Furthermore, the process of saving and loading models automatically in the future when updating data streams by the specified format. This shown below. Fig.9

	var1(t-10)	var2(t-10)	var3(t-10)	var4(t-10)	var5(t-10)	var6(t-10)	var7(t-10)	var8(t-10)	var9(t-10)	var10(t-10 ...	var7(t-1)	var8(t-1)	var9(t-1)	var10(t-1)	var11(t-1)	var12(t-1)	var13(t-1)	var14(t-1)	var15(t-1)	var15(t)
10	0.22222	0.2	0.43478	0.91936	0.10714	0.86667	0.81395	0	0.07692	0.4 ...	0.34884	0	0.30769	0.2	1	0.23729	0	0.61017	1	1
11	0.18519	0.25	0.54348	0.80645	0.32143	0.86667	0.61628	0	0.11539	0.4 ...	0.48837	0	0.23077	0.2	1	0.27119	0	0.57627	1	1
12	0.22222	0.2	0.65217	0.67742	0.25	0.4	0.7093	0	0.19231	0.4 ...	0.36047	0	0.19231	0.17143	1	0.25424	0	0.57627	1	1
13	0.14815	0.15	0.43478	0.64516	0.21429	0.26667	0.69767	0	0.11539	0.2 ...	0.61628	0.88889	0.30769	0.51429	1	0.30509	0	0.67797	1	0
14	0.25926	0.4	0.43478	0.66129	0.10714	0.5	0.81395	0	0.23077	0.08571 ...	0.62791	0.66667	0.15385	0.14286	1	0.28814	0	0.66102	1	0

5 rows × 151 columns

Fig.5: Supervised dataset for Training using the LSTM model

```
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 10, 15)            0
_________________________________________________________________
lstm_1 (LSTM)                (None, 128)               73728
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 129
_________________________________________________________________
activation_1 (Activation)    (None, 1)                 0
=================================================================
Total params: 73,857
Trainable params: 73,857
Non-trainable params: 0
_________________________________________________________________
```

Fig.6: The LSTM model Layer

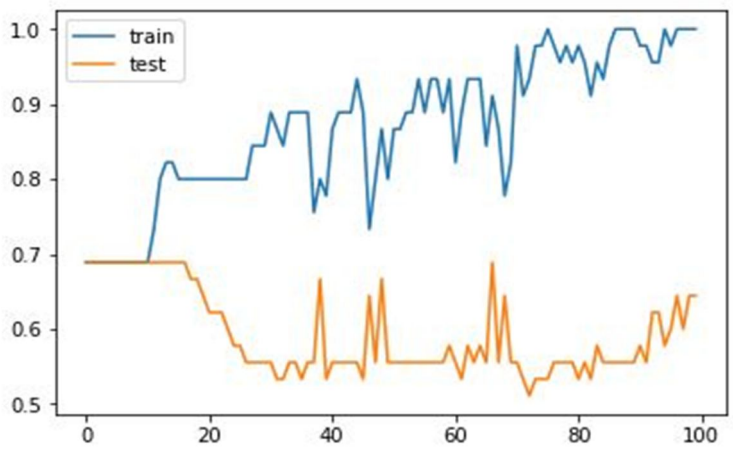

Fig.7: Plot training and validation accuracy values of the model

Test set

```
from sklearn.metrics import f1_score, precision_score, recall_score, accuracy_score
test_yhat = np.around(model.predict(test_X))

f1 = f1_score(test_y, test_yhat)
precision = precision_score(test_y, test_yhat)
recall = recall_score(test_y, test_yhat)
accuracy = accuracy_score(test_y, test_yhat)
```

```
print("F1 Score:{}\nPrecision: {}\nRecall: {}\nAccuracy: {}".format(f1,precision,recall, accuracy))
```

```
F1 Score:0.7647058823529411
Precision: 0.7027027027027027
Recall: 0.8387096774193549
Accuracy: 0.6444444444444445
```

Train set

```
from sklearn.metrics import f1_score, precision_score, recall_score, accuracy_score

train_yhat = np.around(model.predict(train_X))
f1 = f1_score(train_y, train_yhat)
precision = precision_score(train_y, train_yhat)
recall = recall_score(train_y, train_yhat)
accuracy = accuracy_score(train_y, train_yhat)
```

```
print("F1 Score:{}\nPrecision: {}\nRecall: {}\nAccuracy: {}".format(f1,precision,recall, accuracy))
```

```
F1 Score:1.0
Precision: 1.0
Recall: 1.0
Accuracy: 1.0
```

Fig.8: The best evaluation metrics result of the two sets

Save model

```
model_json = model.to_json()
with open("model.json", "w") as json_file:
    json_file.write(model_json)

model.save_weights("model.h5")
print("Saved model to disk")
```

```
Saved model to disk
```

Load model

```
from keras.models import model_from_json

# load json and create model
json_file = open('model.json', 'r')
loaded_model_json = json_file.read()
json_file.close()
loaded_model = model_from_json(loaded_model_json)
# load weights into new model
loaded_model.load_weights("model.h5")
print("Loaded model from disk")
```

```
Loaded model from disk
```

Fig.9: The process of saving and loading models automatically

VI. CONCLUSION

Sagemaker configures tuning job quickly thanks to its Tuning Hyperparamter built-in function. Moreover, it also provides Python SDK to manually develop by developers. The LSTM model implemented in Amazon Sagemaker, after there is a trained model, it can be deployed as an endpoint API which can be use easily by many machines and systems. So, we can do it quickly and easily without much effort in the future. Machine learning algorithm uses supervised weather data, in fact, shown more accurate weather or climate forecasts than conventional prediction, since then, proving that review long time period, our model shows better than other complete models. In this research work, a proposed technology for forecasting weather system is implemented using recurrent neural network with LSTM technique implemented AWS platform. In this model, the data is trained using LSTM method. From experimental results, they were observed that LSTM neural network gives substantial results with high accuracy among the other weather forecasting techniques. Future work may explore ways to expand the proposal here to allow weather stations to be added or deleted over time. Another possible research approach is to explore ways to take advantage of a dataset in which different values have different predictive variables.

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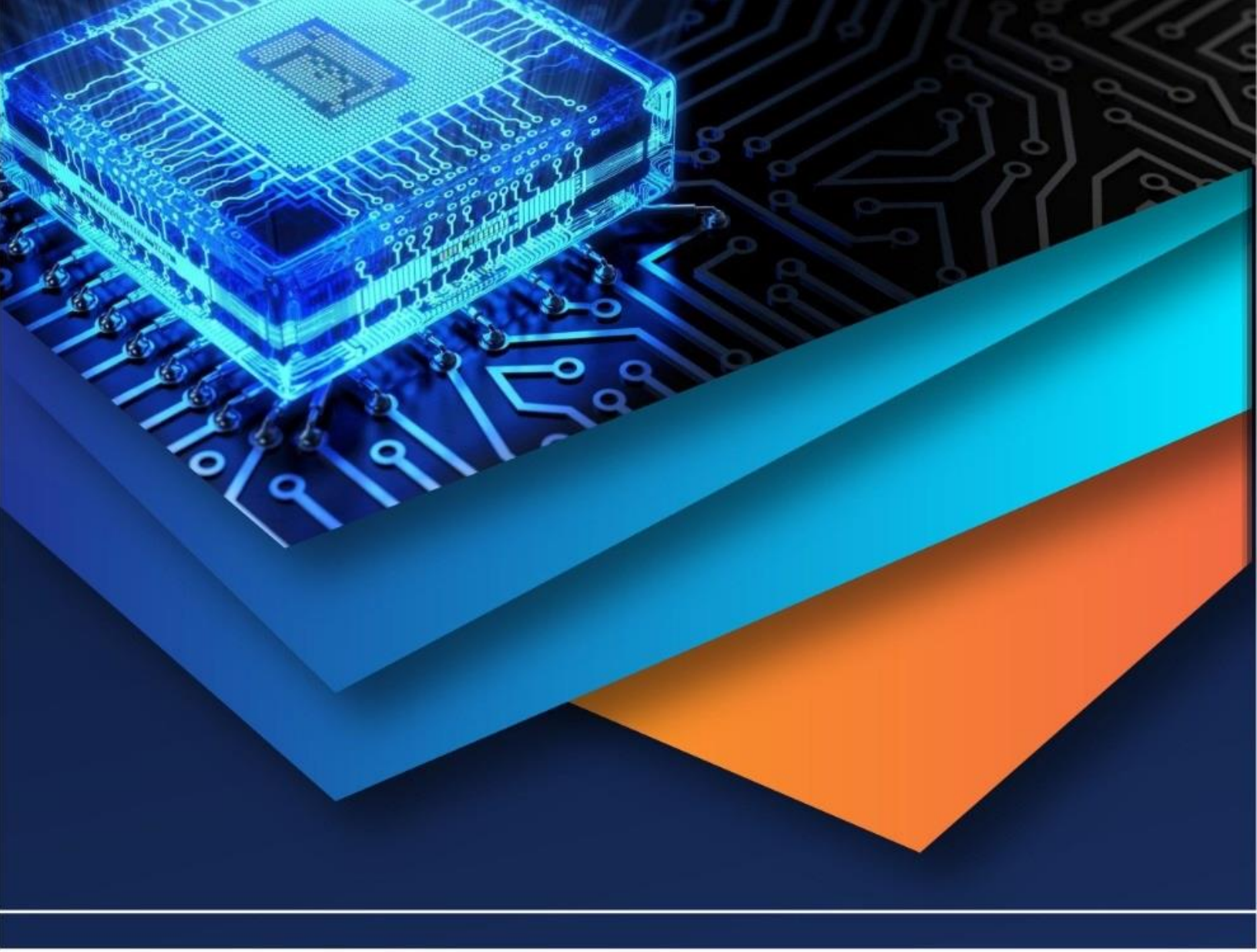

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