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Prediction of Water level using Time Series on Badkhal Lake

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Abstract: ***Natural resource consumption is increasing with the demand of increasing population. Conservation of these natural resources for future use is an essential task. In this paper we have taken water (natural resource) into account of conserving. Water is most important natural resource for the existence of life on earth. Due to the unnecessary use and wastage, it is wiped out slowly. We need to manage our daily routines and make the water available for present and future generations. The objective of this paper is to predict water level in future for a semi arid area. Distributed approach of time series analysis has been applied in this paper. We have taken several parameters like average rainfall, temperature, humidity, daily needs of population, and agricultural demands into consideration. Past years record's were used to predict the water level using time series prediction techniques in order to estimate future demands and take necessary measures to conserve the water resources in advance. This approach is applied on the collected data for Badkhal Lake, Faridabad district in state of Haryana.***
Keywords: Water Level, Prediction, Times series Analysis, Decomposition Method , Badkhal Lake

I. INTRODUCTION

Prediction is a statement made about the future on the basis of some evidence and past data. Although it is not possible to predict the behaviour of something exactly the same, but with the help of past records and by analyzing the trends from history we can predict the nature of existence up to the level of acceptance and understanding. As part of earlier research different methods and techniques have been used to predict the nature of the different system based on the different parametric values from past.

As water is the most essential resource which is gradually decreasing, we need methods to save and utilize the waste water and water harvesting techniques. With the help of water level prediction we came to know the existence level of water in future. For this prediction we have to predict the rainfall, temperature, population and daily demands of water. Prediction of rainfall is very important as rainfall is a major component of the water cycle and responsible for depositing most of the fresh water on earth [1]. As water is scarce resource, it is insufficient for demanding needs of population. We need to introduce new methods and techniques for water harvesting. For water harvesting we need to predict the nature of water level. The parameters which influenced the water resources include temperature, rainfall, humidity, population and daily needs for irrigation purpose.

Time series forecasting method is used where we have huge amount of data or past records available. It is the statistical method which uses the past recorded data to forecast the nature for future. These methods consider the variables or parameters that have past records in specified interval of time. And it relates the past values of parameters with the forecasting one. For different system specified intervals may vary from minutes, days, months etc. In our case our specified interval for time series is of year, as six years of data has been used. Most of the researchers have followed time series analysis and artificial neural network to predict the behaviour of the different parameters of a system. M.P. Rajurkar *et al. had* applied Artificial Neural Network for Daily rainfall and runoff modelling on the Narmada River in Madhya Pradesh [2].

Janhabi Maher and Ramakar jha use time series method to simulate and forecast mean rainfall obtained using The issen Weights for the Mahandi river basin, India[3].

Shilpi Rani and Dr. Falguni Parekh used Artificial Neural Network (ANN) as an appropriate predictor for real-time water level forecasting of Sukhi River and applications of ANN on Water level forecasting [4,5].

Gaurav Kumar and Rajiv Gupta used time series prediction for Water Resource Management in Semi Arid Zone. In this paper they have used Thornthwaite water balance model and Ingles and Desouza's rainfall runoff model. To validate this model they took case study of nine villages from district Jhunjhunu in Rajasthan[6].

II. STUDY AREA

Badkhal Lake as shown in Fig.1 and Fig. 2 was one of the natural resource of water located in Badkhal village, Faridabad district located in 28º25’ N latitude and 77º 18’ E longitudes near Delhi. The Faridabad district comes under the semi-arid zone with

extremes of temperature (3.5ºC-46º), ranges lies from winter to summer. The annual Rainfall for the Faridabad zone is 542mm. And average relative humidity is 65%. The average ground water level ranges in Faridabad block is from 25-65m.The submergence area covered by the lake was 42 ha. The catchment area of Badkhal Lake was about 1025 ha. It was mainly constructed in 1960s for irrigation purpose under Aravali hills; it was covering the needs of water land of about 600 ha. Sources note that this was once a large lake, where boating and other tourist activities took place. Migratory birds also used to visit the lake [7]. From year 2009 it was totally dried up, due to the unusual rainfall in the area and gradual increase in the population from rural to urban area. There is an utmost need for the revitalization of these water bodies which is important not only from the microclimatic point of view but also is an essential tool for the replenishment of the ground water resources [8].

Fig.1 Badkhal Lake

According to survey report released by the Delhi Parks and Gardens Society (DPGS) in March 2014, lake was completely dried up and only depended on rain water. As mining activities increased in this area, the catchment of runoff was declined. If we will take proper treatment for catchment of runoff, it will increase the evaporation component and lake will be revived and restored for use. In order to find out the solution for declining trends, we have to adopt rain water harvesting techniques on rooftops. Those crops, which require less consumption of water, should be grown in place of high consumption crops.

Fig.2 Map of Badkhal Lake

III.METHODOLOGY

The method which has been applied in this research work was based on previous data. From past hydrological studies and past records we have analyzed the present situation and predict the new one for upcoming years. Large numbers of methods are available for forecasting, the popular one is Time-Series methods. In this method, statistical analysis of data was carried out on different parametric values and it will develop the forecast for future. The value of variables that were taken into consideration must be in specified intervals of time. We will assume that past relationship will be followed in future. For Time-Series analysis we need few factors related to time. These factors are given below:-

A. Trends

It normally refers to the direction in which the values of variables were moving and changing. An example of linear trend is shown below in Fig.3. The straight line drawn on graph shows the linearity between the high and low point over a period of time. There are mainly three aspects of trends it may be upward trend, downward trend or stable trends.

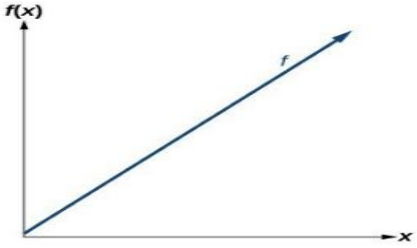

Fig.3 Trend (T)

B. Seasonal Variations

There could be periodic, repetitive variations in Time-Series, which occur because of varying patterns during different times of a year [9]. Describing the effect of seasonal variations helps in understanding its impact on different variables. Usually run- sequence graph plot is used to show the behaviour of seasonality variations. Fig.4 shows the graph plot of seasonal Variations.

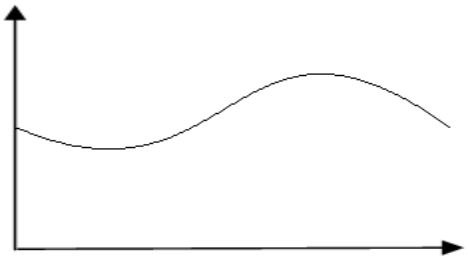

Fig.4 Seasonal Variations(S)

C. Random or Irregular Variations

This factor doesn't follow any trend or seasonal factors. It is irregular in nature, as there may be sudden changes in weather. Due to this factor involvement the prediction regarding the future demand may be difficult. To overcome the effects of this problem we can eliminate it by smoothing the time series data. Random or irregular fluctuations shown below in Fig. 5.

Fig.5 Irregular/ Random Fluctuations

There are many number of forecasting methods present for analysing Time-Series data. In this paper, we are using Decomposition Method.

In this method, we assume the value of Time-Series data at interval time t, that will act as a functional component of different variables, i.e.,

$D_t = f (T_t, S_t, R_t)$, where

T_t = Trend value at time period t.

S_t = Seasonal Component at period t.

R_t = Random Variation and Irregularity at period t.

Depending upon the problem the functional form may either be additive or multiplicative. In this ,we have used multiplicative form. It is written in the form as follows[9] in equation (1):

$D_t = T_t * S_t * R_t$ (1)

The main steps for using Decomposition methods are as follows:

(i) Find moving average for length n. Where value of n is equal to seasonality.

(ii) Compare the value of each period with centred moving average and it will result in seasonality factor:

$S_t = D_t$ / moving average at t (2)

(iii) In this step Time-Series data should be deseasonalized using the formula:

$T_t = D_t / S_t$ (3)

(iv) Estimated value using regression analysis will be calculated.

(v) The forecast value for time period t + m prepared using the equation:

$F_{t+m} = [a+b(t+m)] S_{t+m}$ (4)

,where

a=intercept

b=Slope

IV. CASE STUDY

In our research, we have taken past six years record on Badkhal Lake. Using this previous data from 2011-2016 we will predict the values up to the year 2020.The parameters, which will be taken into consideration are average rainfall, average temperature, average humidity, average population, daily demand of water. Past year statistical records are shown in Table I, Table II and Table III for the variables rainfall, temperature and population of Faridabad district.

TABLE I

AVERAGE MONTHLY RAINFALL FROM 2011-2016

Month/Year	2011	2012	2013	2014	2015	2016
Jan	0.0	14.8	40.8	18.6	35.8	0.0
Feb	49.9	0.0	109.4	63.5	0.0	1.4
Mar	2.3	19.2	12.6	63.5	201.8	17.8
Apr	2.2	9.0	11.6	16.4	51.8	0.6
May	33.4	13.6	0.0	79.6	0.8	30.8
Jun	104.2	12.4	151.0	59.6	124.4	17.4
Jul	33.8	139.8	459.8	227.8	377.8	540.9
Aug	272.4	274.0	521.9	98.9	261.3	388.2
Sep	163.6	57.0	108.1	124.3	67.2	173.4
Oct	0.0	11.0	109.0	0.0	0.0	37.8
Nov	0.0	0.0	0.4	0.0	2.2	0.0
Dec	0.0	8.6	6.8	26.4	0.0	0.0

TABLE II

AVERAGE MONTHLY TEMPERATURE OF THE REGION

Month	Avg.Temp. (°C)	Min.Temp. (°C)	Max.Temp. (°C)	Precipitation/ Rainfall(mm)
Jan	14.4	7.4	21.4	17
Feb	17.1	10.1	24.1	6
Mar	22.7	15.1	30.4	12
Apr	28.6	20.9	36.4	3
May	33.5	26.4	40.7	6
Jun	34.2	28.6	39.9	31
Jul	31.2	27.1	35.3	184
Aug	29.7	26	33.5	188

Sep	29.2	24.5	34	118
Oct	25.9	18.7	33.1	31
Nov	20.3	11.8	28.8	3
Dec	15.7	8	23.5	5

TABLE III
AVERAGE MONTHLY TEMPERATURE OF THE REGION

Year	2011	2012	2013	2014	2015	2016
Population(Million)	1.4	1.5	1.6	1.69	1.81	1.9

Using this data on Time-Series analysis prediction for upcoming years has been carried out with the moving average method. Predictions results of these variables are shown below with the help of line graphs. Fig.6(a) shows the time series plot of predicted value of population upto 2020 year. On Y-axis population is placed with respect to year over X-axis.It is clear from the graph, that the population is increasing very rapidly over the period of time interval.

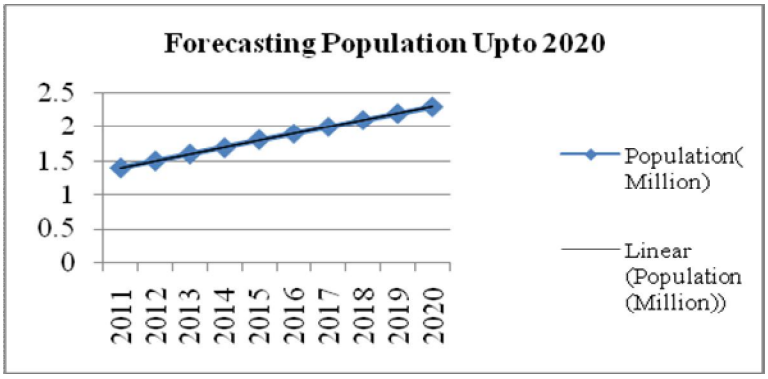

Fig. 6(a) Forecast Population Graph

Average Rainfall prediction results are presented in Fig. 6(b) at Y-axiswith respect to years at X-axis .

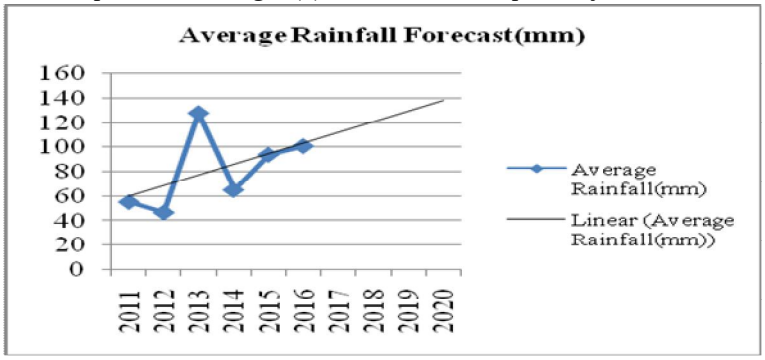

Fig. 6(b) Forecast Rainfall Graph

In Fig.6(c), we represent the average temperature prediction for future with respect to years.

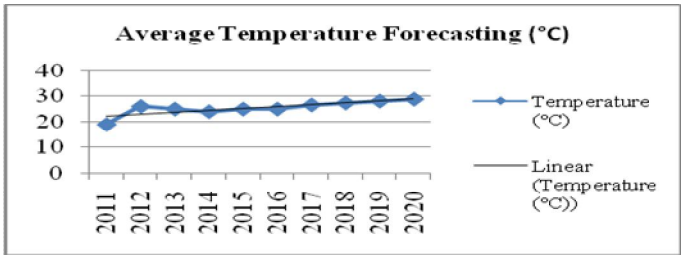

Fig.6(c) Forecast Temperature Graph

Prediction of total daily water requirement for irrigation and daily needs of the population is represented by the Fig.6(d), where X-axis represents the daily needs in million liters per day(MLD) with respect to years.

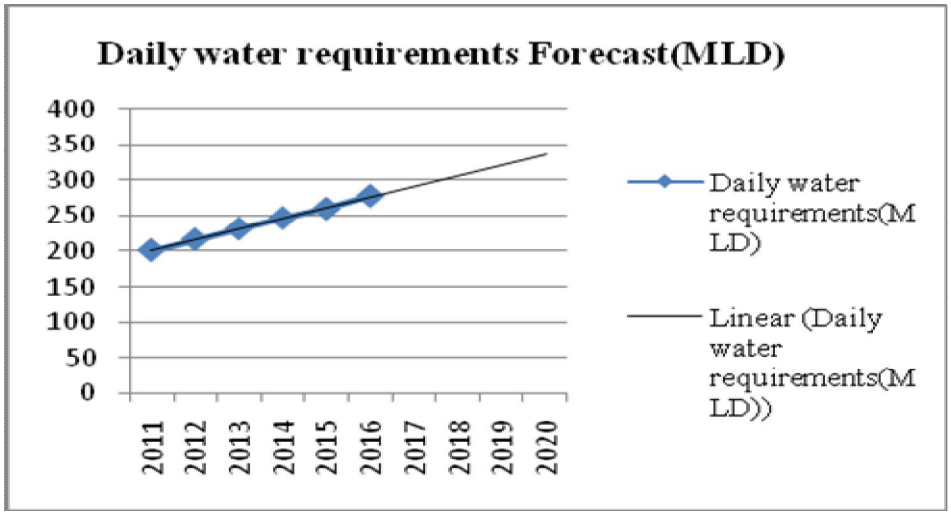

Fig. 6(d) Forecast Graph for Daily Water Needs

Fig.6(e) shows the future humidity percentage upto year 2020.

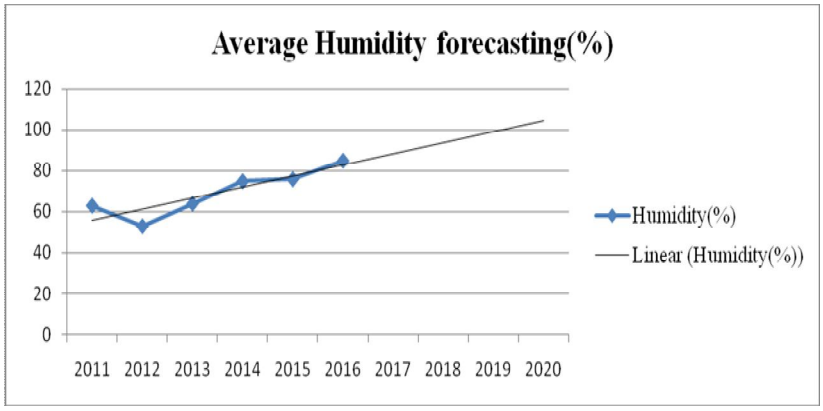

Fig. 6(e) Forecast Graph for Average Humidity(%)

From Fig.6(a) and 6(d), we can conclude that the population will increase over a period of time. And daily water requirement of population is also increasing, which in turn implies that the future demand of water will be more. The present scenario and water demands of future have been shown in the Table IV given below.

TABLE IIIV
GROUND WATER RESOURCES OF FARIDABAD

Name of Block	Net Ground Water Availability (Ha-m)	Allocation for Domestic/Industrial use (Ha-m)	Existing GW Draft for Irrigation (Ha-m)	Net Ground Water Availability for further Irrigation (Ha-m)	Stage of Ground Water Development (%)
Faridabad	10,105	2,045	6,343	1,656	83

The exploitation of ground water reaches at the alarming stage in Faridabad district in unsustainable manner.It is necessary to take immediate steps to conserve water. We need to balance water inflow and outflow.Water Balancing can be described as the total water inflow and out flow of the system. In Fig. 7, water balance model has been shown, that represents the total inflow consisting of Surface water and ground water as well as surface and ground water from the rainfall.

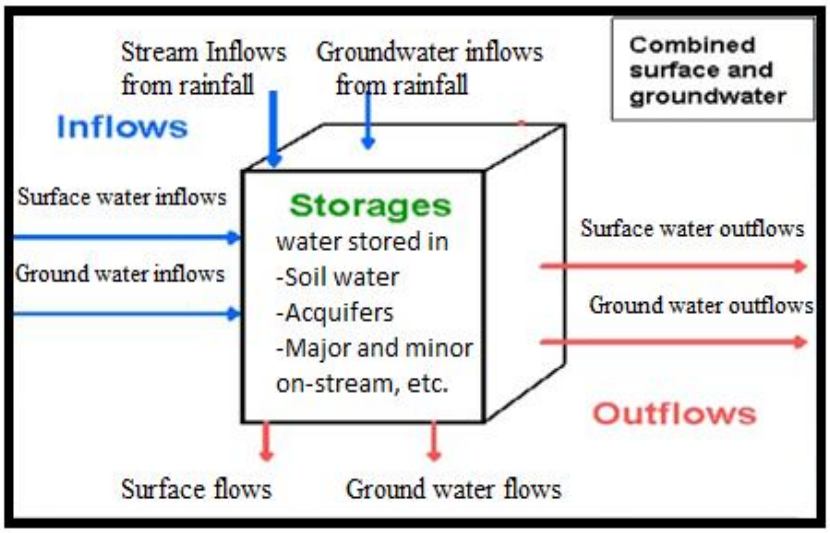

Fig.7 Water Balance Model

And storage part consists of the water stored in soils, acquifers ,major and minor on stream,etc. This model shows that the total inflow and total outflows must be balanced in nature.

V. RESULTS AND DISCUSSION

The Badkhal Lake situated in the backyard of Delhi in the foot hill of Aravali was once a tourist hot spot[10]. But due to the mining activities, blasting over the years and unussual rainfall the catchment area of lake has been deprived.

According to the present situation the per capita availability of water has come down over a period due to urbanization. A major part of Faridabad district has witnessed the problem of ground water declination.From past 20 years the decline in ground water has been 3-7 meters. High consumption rate, urbanization, lack of ground water discharge, reduction in run-off of rain water are the major causes of water replenishment.

We need to take urgent action for conserving water resources. For this we are required to use micro irrigation and water saving techniques, like Sprinkler system and Drip system. Rain-water harvesting techniques should be introduced.These systems will boost the production of grains/ Crops which in turn save water.

VI.CONCLUSION

As part of earlier research work, Time-Series analysis has been done for different prediction system. In this research work Time-Series decomposition approach has been applied to predict water level for Badkhal Lake. Past six years data from 2011-2016 were used to find out the trend and seasonality component. On the basis of these records we have predicted the future values of these variables. Overall the study indicates that the net ground water available in future is less than the daily demands of Population and agriculture. Hence Proper measure must be taken to conserve the water so that it can be available for future generations.

VII. FUTURE WORK

Research work will always be extending in continuity so that new facts can be drawn from search of knowledge that will provide better results with more accuracy and efficiency. In this paper, Time-Series forecasting technique has been applied. The extension of this work can be done by applying Artificial Neural Network(ANN) tools to train our network and predict the nature of different parameters. For the improvement of quality of their performance we can compare the predicted values of both the approaches and validate the output with each other.

Presently the work done in this paper is limited in scope and only experimentally tested on six year records. In future, the domain can be broadened and different techniques can be introduced to predict more accurately and efficiently.

VIII. ACKNOWLEDGMENT

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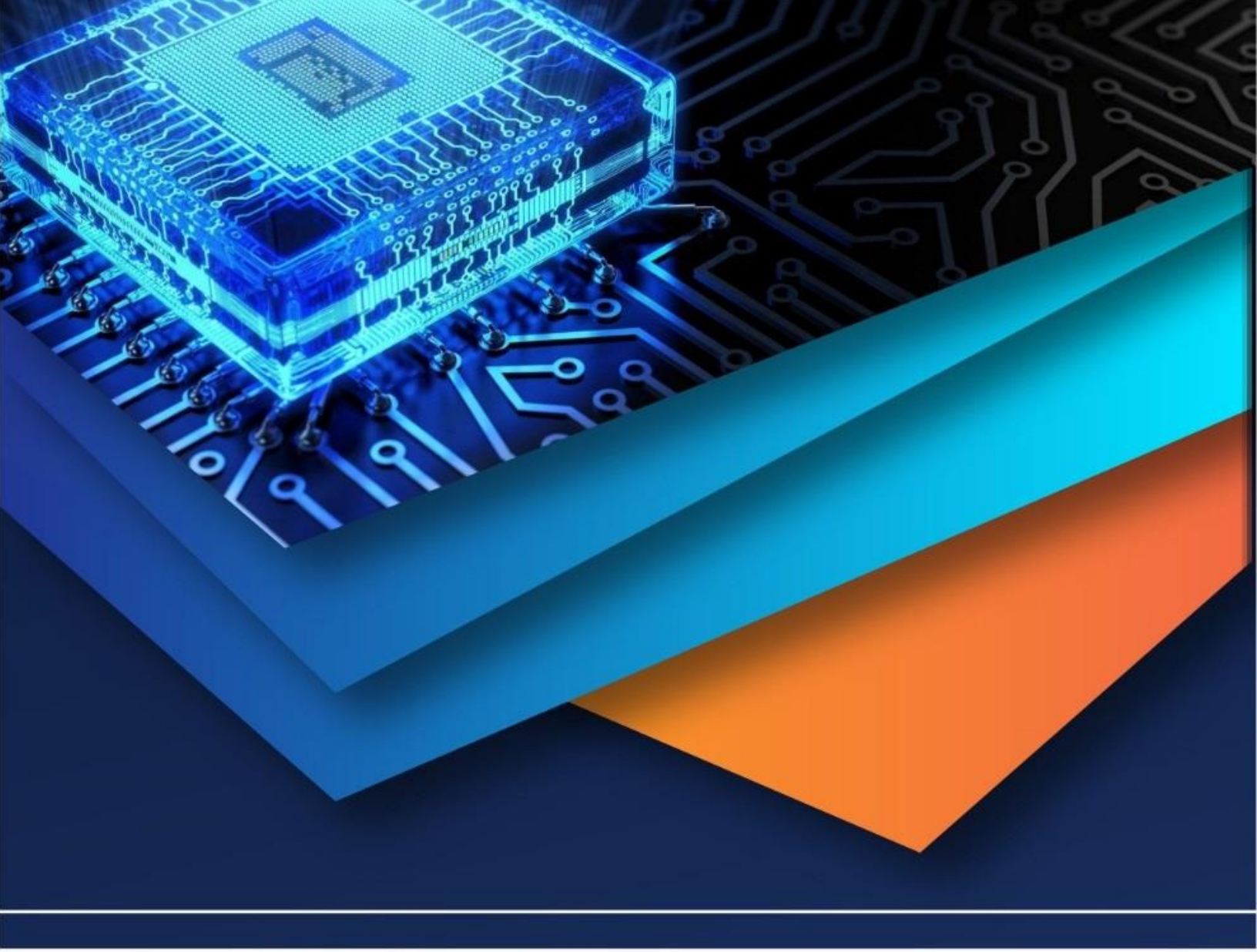

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