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A Study on Discharge Headway Modeling at a Signalized Intersection under Heterogeneous Traffic Conditions

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Abstract: ***In this research work, the factors affecting the discharge headway in heterogeneous traffic situation along with its characteristics including mixed vehicle composition and missing of lane discipline have been analyzed. Here a new way or method to find and measure the discharge headway has been proposed. Already much work has been done on modeling of discharge headways under homogeneous traffic conditions, as the conditions in some Asian countries like India which falls under heterogeneous traffic conditions very less study has been done. The composition of hybrid vehicles and the awareness about lane discipline has been observed. Therefore, a novel mechanism to model and observed the discharge headways have been proposed to determine the relation between discharge headway and the factors affecting it. To find individual headway discharge the lane is divided into size different sizes with width equal to the space occupied by a motorcycle. The data is collected from five different areas such as M A Road, HMT Crossing, Nowgam, Pantha Chowk and Sanat Nagar respectively. The influence of vehicle length, engine capacity on discharge headway has been analyzed along with morning and evening discharge headway. From the analysis, it has been observed that the factors have significant impact on discharge headway. The model proposed in this work can also be used to obtain saturation flow and capacity at the signalized intersection.***

Keyword**:** ***Mixed traffic, discharge headway, signalized intersection.***

I. INTRODUCTION

The intersection is an important part of the 'urban transportation network'. The entering headway, that is, the time between consecutive stopped vehicles entering a signalized intersection after the traffic light becomes green, is of vital importance to road traffic engineers. The major parameters of the signalized intersection include the discharge headway distance, saturation flow and capacity. Among them, the discharge headway distance is an essential parameter because it is used to determine other parameters such as saturation flow and start loss time at the intersection. These two parameters in turn is utilized to determine the best signal timing. Inaccurate discharge headway Values may cause to non-optimal signal operation. Number of researchers has studied different factors affecting along with the experiment conducted on discharge headway. Discharge headway can be defined as the gap between two consecutive vehicles stopping in a row beyond the intersection line. Normally, discharge headway is used to determine the lost time, saturation flow rate that are the most critical parameters while analyzing the signal control intersection. Also, it is observed that these parameters are affected by different types of geometrical and traffic conditions. The discharge headway is used to determine the minimum green time gap between the stop line and the vehicle movement stopped in a queue by using the following equation:

Here, t is the start-up delay

$Mingreeninterval$=t+ (H_S×n)

H_S is the saturated headway or the point above which the headway become stable? N is defined as the number of vehicles stored between the sensor and the stop line.

The main motive of this research is to design a relation between discharge headway and distance from median, vehicle length, capacity of engine and green light time. Mathematically, can be represented as below:

$Headway=\beta0+\beta1(distanceofvehiclefrommedian)+\beta2(vehiclelength+\beta3(capacityofengine)$

$+\beta4(green\ light\ time)+\beta5\ (day\ time)$

The nature of heterogeneous traffic and the morning & evening headways has been performed on the selected signalized intersection.

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II. DATASET

Data for experiment has been collected by digital camera that captures the traffic movement at five traffic control intersections in Srinagar, India. The headway values have been measured by installing camera onhigh rise building from where the traffic view is clear. The recording of headway values is done during the peak time at the intersections. Vehicles were recognized as per the vehicle length and the capacity of engine. The lane at an intersection have been divided into six strips having a distance of 1.48m between two consecutive strips and the time headway along with the discharge headway is measured. The data was collected during the peak hours in morning and evening. The timing selected was 08:00am to 10:30am in the morning and 04:00pm to 06:30pm in the evening. Then the recorded entries are pre-processed to achieve the discharge headway.

III. METHODOLOGY

The process of proposed work is defined in the figure below

1) *Step 1:* Initially, site has been selected as per the saturation flow condition
2) *Step 2:* Since the traffic varies randomly at the intersection point, therefore, it is assumed that the data is distributed normally by keeping standard deviation, estimated mean error and saturation flow rate constant.
3) *Step 3:* The data has been collected with digital camera, which provides images with high accuracy and better quality.
4) *Step 4:* Next step is the data extraction in which the vehicles with different classes are identified on the basis of engine capacity and vehicle length. Selection of reference point is selected near to the intersection's stop line, on the basis of which headway values are measured. To obtained headway of every vehicle, the lane is divided into several strips. The size of every stripe is equal to the space occupied by the motorcycle. Therefore, whenever a vehicle leaves the intersection point, the characteristics and the time stamp has been noted.
5) *Step 5:* The values that are achieved from video camera from the survey area are saved into excel sheet file. The entries such as day time are then used for analysis purposes.
6) *Step 6:* the linear mixed model that used regression values is applied on the data collected by using SPSS software. Also the correlation test is conducted to determine the relation between the several independent and dependent variables.
7) *Step 7:* At last, the designed model is validated for certain intersections and traffic environments. Validation includes the evaluation of the model output with the practical values. The nearer the agreement between the values the better is the model predictability.

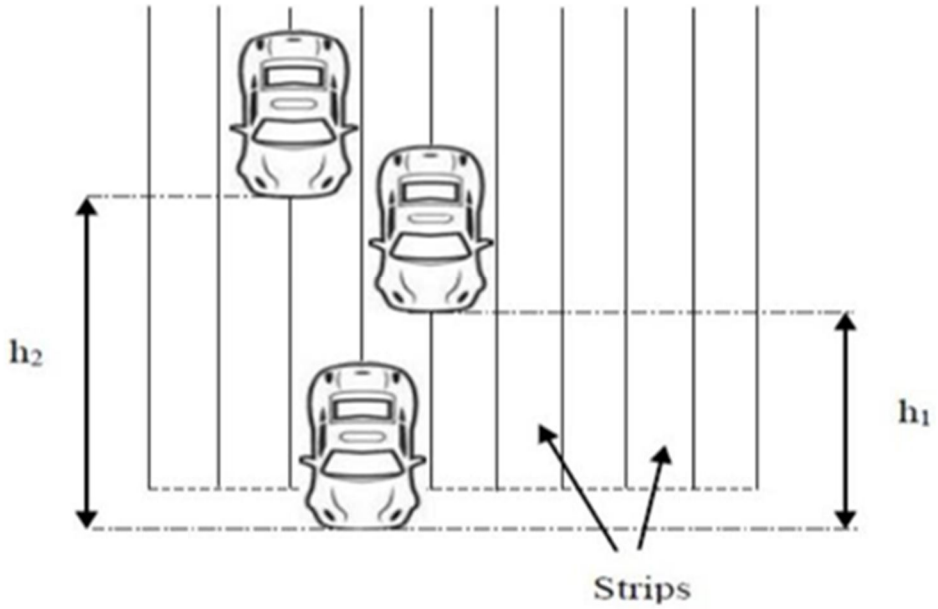

Fig no 1: Vehicle occupying multiple strips

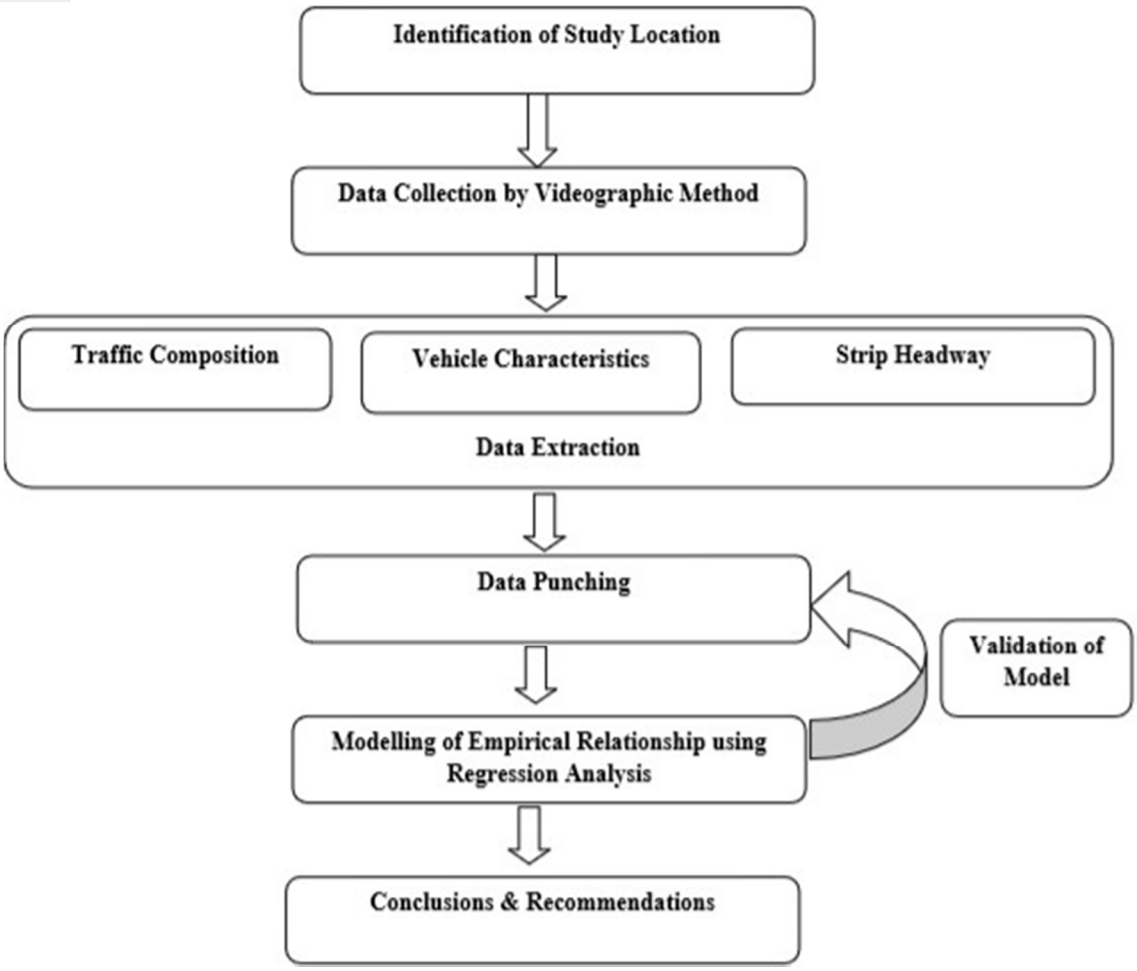

Fig no 2: Flow of work

IV. EXPERIMENTAL ANALYSIS

In this section, the data analysis, understanding the data,

A. Understanding The Data

From the data observed by the digital camera, it is analyzed that the traffic is heterogeneous with several number of vehicle with different classes. The vehicle composition for the particular location is shown in figure below.

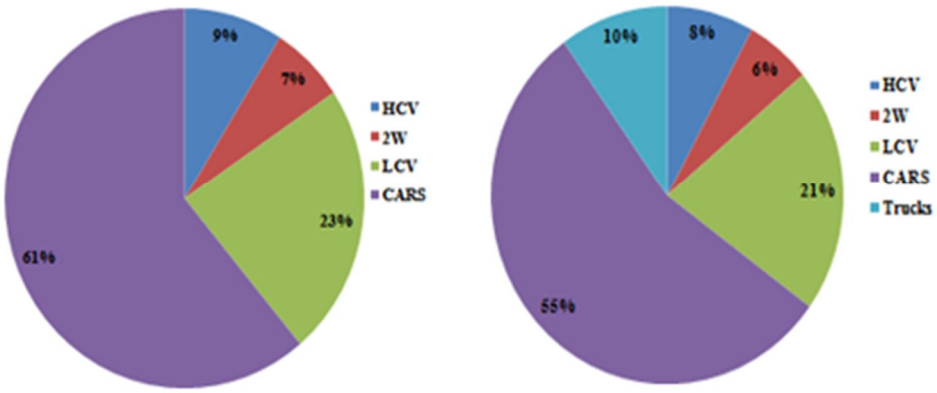

Fig no 3: M A Road and HMT Crossing

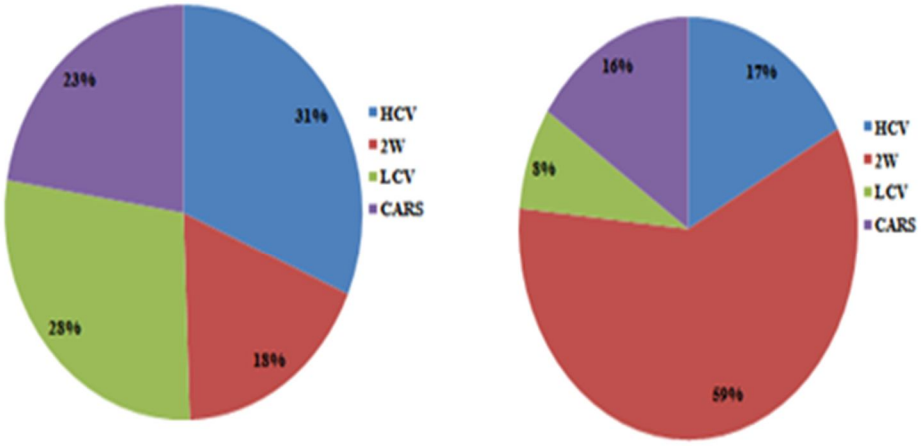

Fig no 4: Nowgam and SanatNagar

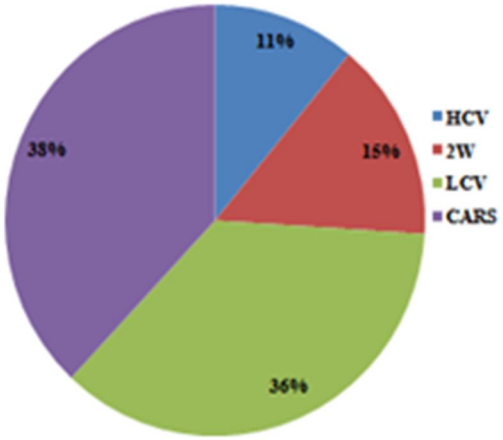

Fig no 5: Pantha Chowk

The above graph represents the vehicle composition at different study area such as inside CBD and outside CBD. In inside CBD the areas consists of M A Road 3 legged intersection and HMT Crossing 4 legged intersection whereas in Outside CBD: the areas are Nowgam 4 legged intersection, Pantha Chowk 3 legged intersection and Sanat Nagar 4 legged intersection. The percentage of vehicles appearing in different study areas are shown in figure above. From the graph it is concluded that the traffic due to car is more and the vacant space has been occupy by the two wheelers and hence increase discharge of vehicles.

B. Analysis Report For Intersection Inside Of Cbd

Table no 1: Internal intersection of CBD model summery report

Model	R	R^2	Adjusted R^2	Estimated standard error
1	0.846*a*	0.715	0.741	0.19160

Table no 2: Internal intersection of CBD's coefficients

Model		Coefficients	Std. Error	P Value
1	(Constant)	-2.152	0.118	0.000
	Distance from Median	0.221	0.008	0.000
	Vehicle's length	1.12	0.038	0.000
	Capacity of engine	0000	0.000	0.000
	Green light time	-0003	0.002	0.060
	Day time	0.191	0.030	0.000

From the above values observed during analysis, it has been analyzed that the distance from median is directly proportional to the vehicle's length and discharge headway. The negative values observed for the green time and constant depicts that the discharge headway reduces with the increase in the green time along with engine capacity. The relation between different parameters for internal intersection of CBD is written below:

$Headway$=0.22($mediandistance$)+1.12($vehiclelength$)−0.00031($enginecapacity$)
− 0.0032 ($green\ light\ time$) + 019 ($day\ time$) − 2.1

C. Analysis Report Of Intersection Outside Of Cbd

Table no 3: Outside intersection of CBD model summery report

Model	R	R2	Adjusted R2	Estimated standard error
1	0.596a	0.356	0.349	0.3079

Table no 4: Outside intersection of CBD's coefficients

Model		Coefficients	Std. Error	P Value
1	(Constant)	0.423	0.218	0.000
	Distance from	0.271	0.028	0.000
	Median			
	Vehicle's length	0.662	0.066	0.000
	Capacity of engine	-.001	0.000	0.000
	Green light time	0.015	0.005	0.001
	Day time	0.441	0.117	0.000

From the above table it has been analyzed that the discharge headway increases with the increase in the various factors such as distance from median, vehicle's length, green light and day time. The less value of R square indicates the high variability in the data. The values of headway observed for outside intersection is listed below:

$Headway$=0.27($mediandistance$)+0.66($vehiclelength$)−0.001($enginecapacity$)
+ 0.015 ($green\ light\ time$) + 0.44 ($day\ time$) − 0.42

D. Average Headways

The comparison of average headway for six different lanes measured at morning time and evening time has been represented in the graphical form. From the comparison it has been analyzed that the morning headway is more than that of evening headway.

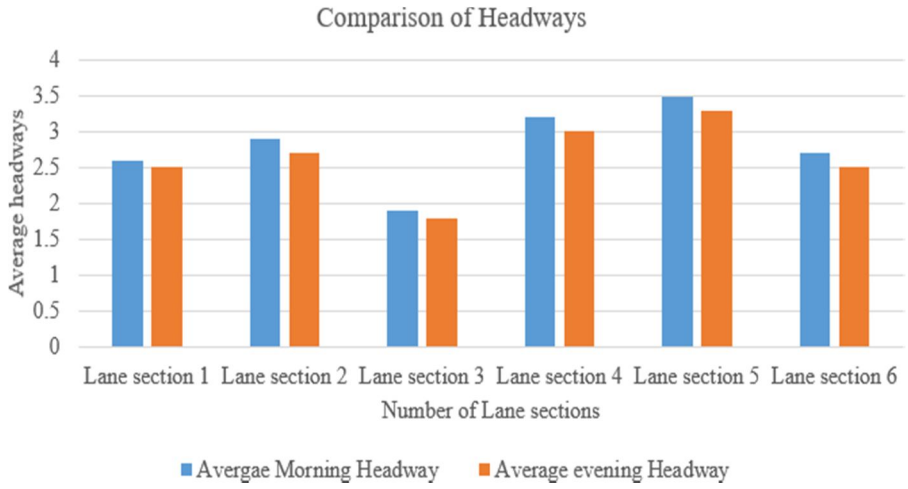

Fig no 5: Comparison of headways

V. MODEL VALIDATION

The designed model has been validated for various traffic conditions as well as different intersections. The comparison of model has been performed with the values observed by the camera. If the results obtained via the model obtained are closer to the observed values, then the model is better. The justification of the work can be represented in the tabular form as shown below.

Table no 1: Measured values

Observed	Calculated	Error	% Error
3.7	4.2	0.135	13.51
2.2	2.46	0.118	11.8
1.7	2.16	0.270	27.05
3.7	3.94	0.064	6.4
3.6	3.8	0.055	5.55
3.4	3.76	0.105	10.5
2.7	3.1	0.148	14.8
3.8	4	0.052	5.2
3.7	4.02	0.086	8.64

3	3.24	0.08	8.00
2.9	3.13	0.079	7.931
2.7	2.9	0.074	7.407
2.8	3.22	0.15	15.00
3.4	3.66	0.764	7.647
3.3	3.57	0.0818	8.181
3.3	3.61	0.093	9.393
2.7	3.05	0.129	12.962
2.7	3.08	0.140	14.074
2.6	3.06	0.176	17.692
3.4	3.62	0.064	6.470
2.8	3.31	0.182	18.214
2.3	2.7	0.173	17.391
3.7	4.22	0.140	14.054

VI. CONCLUSION

This study aims to understand the discharge headway and their influencing factors. Different traffic conditions and development models are used to represent discharge headway. The value of discharge headway remains same for homogeneous traffic after 4/5 vehicles. The parameters such as length of vehicle, engine capacity, and position of vehicle on road as well as elapsed green time have been measured. From the results, it has been concluded that the:

A. Road traffic was mostly due to car about 60 % which is followed by LCV and HCV.Respectively.
B. From the analysis it has been observed that the discharge headway appear in the evening is less than the discharge appear in the morningtime.
C. The green time and engine capacity is inversely proportional to the dischargeheadway.
D. For internal intersection with the increase in green time, discharge headway decrease and for external intersection, the discharge headwayincreases.
E. This Study thus can be used to find the saturation Flow , Optimum signal timing, vehicle capacity and future road expansion plans.

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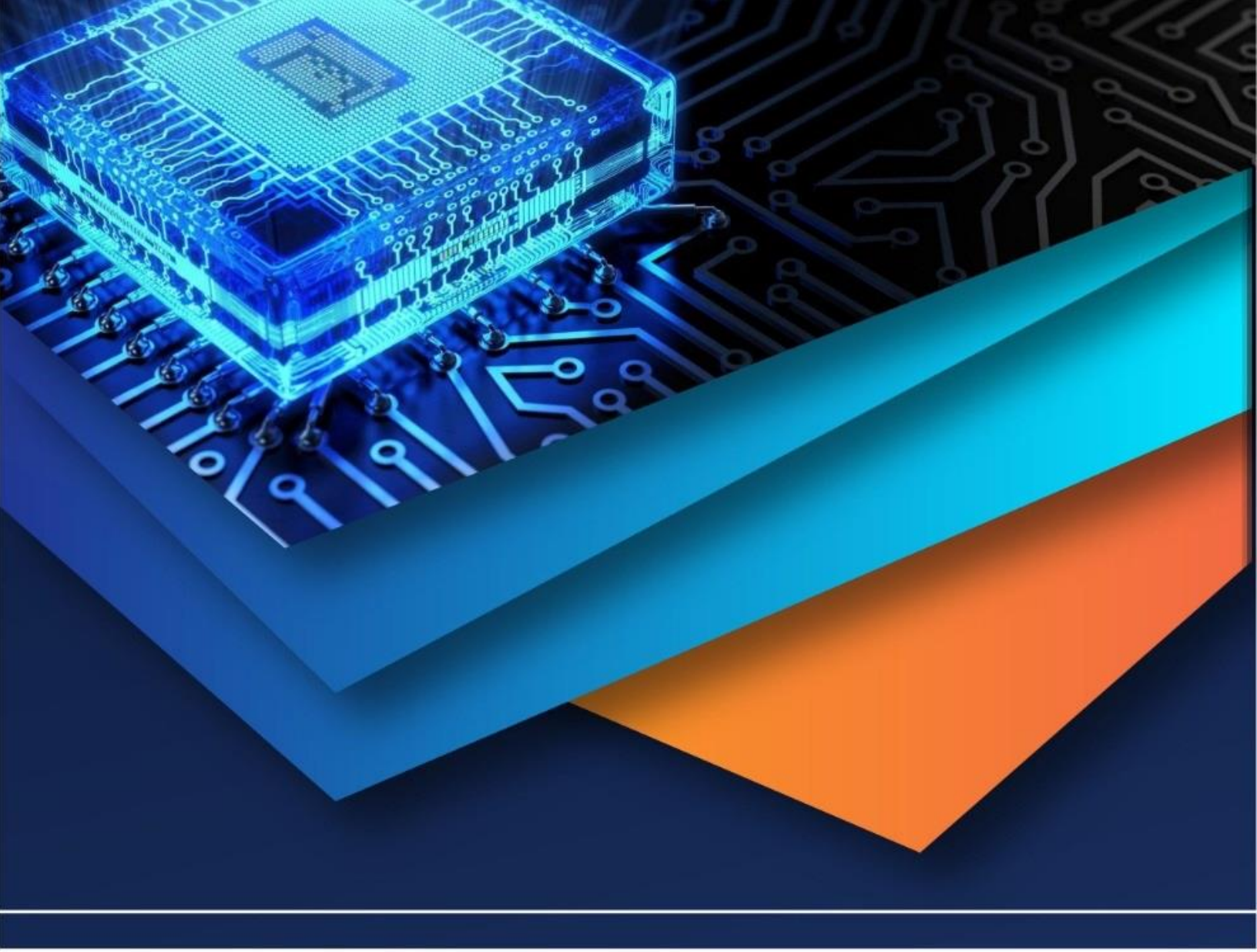

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