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Comparison of Headway Measurement Methods for Heterogeneous Traffic Conditions

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Abstract: ***This paper covers research aimed at determining if moving method (MM) is capable enough to accurately determine traffic parameters including headway, traffic flow, and traffic density on 2-lane highways under heterogeneous traffic conditions of Pakistan. For this, stationary method (SM) is set as base and results obtained by MM are compared. Linear model is developed to compare headway measured using MM. Results indicated that for 2-lane highway, chi-square value is 0.65 indicating 65% of results obtained by MM are compatible to SM. Percentage difference b/w the results obtained by MM and SM for traffic flow and traffic density are 2.32 and 5.17 respectively. Overall performance of MM for traffic parameter determination is quite satisfactory however, these results are only valid in generalized conditions. For specific conditions of traffic and road, these models need to be re-evaluated.***
Keywords: Headway, Moving method, Stationary method, Traffic flow, Traffic density

I. INTRODUCTION

Transportation planning and traffic management have consistently been of significant importance to individuals involved in the construction and administration of highways and transportation systems. In countries such as Pakistan, it is crucial to assess the economic and social aspects before undertaking highway construction. Headway is viewed as an essential factor for analyzing traffic and planning traffic-related activities, both from a traffic analysis and planning perspective. [1]. Headway, which can be determined by measuring the duration and space between vehicles, can be defined either in terms of time or duration. Time headway specifically refers to the time it takes for the selected vehicle and the vehicle behind it to reach the test site. As the most detailed aspect of traffic flow, headway significantly contributes to the analysis of broader traffic characteristics such as flow and density, regardless of the prevailing traffic conditions. [2]. Any modelling and simulation done on any traffic network primarily require accurate and precise calculation of headway measurement [3]. For the traffic conditions of developing countries, it is always preferable to determine traffic parameter like headways for selection of a comprehensive and economical alternative traffic route [4]. Headway measurement has been a well-established concept for quite some time. Typically, researchers have predominantly focused on the stationary method (SM) due to its simplicity and convenience. However, this study introduces a novel approach called the moving method (MM) to assess headway and other traffic parameters. The primary objective of this research is to underscore the enhanced accuracy and precision offered by the moving method when compared to the traditional method. In developing countries like Pakistan, the moving method has not received significant attention from researchers. Therefore, this research aims to evaluate the accuracy of MM in determining traffic parameters in comparison to the traditional method.

II. LITERATURE REVIEW

This research work is inspired by the work done by many researchers across the globe. A study conducted by [5] examined the time gap between vehicles at a signalized intersection. The findings revealed that as the green signal duration increased and when there was a mix of different types of vehicles, the time gap between vehicles decreased. The findings of another study conducted by [6] revealed significant variations in speed and discharge headway in heterogeneous traffic conditions. Consequently, it is incorrect to assume that a single type of traffic would have the same effect on speed and discharge headway. A research conducted by [7] found that the movement of traffic has a significant impact on the headway. The study revealed that the presence of large trucks greatly increases the headways of vehicles trailing behind them. Additionally, the results indicated that as the number of large trucks in the queue increases, the passenger car equivalency also increases. A different study conducted by [8] examined different models in order to ascertain time headway.

The findings of the research indicated that the exponential model is the least appropriate for determining time headway. On the other hand, the Pareto IV models emerged as the most dependable approach, providing the most reliable outcomes for time headways. A study conducted by [9] examined and evaluated the distribution of time headways on two-lane rural roads. Multiple models were developed to assess the distribution of headways, and the reliability of the results from all the models was analyzed and compared under different scenarios. A study conducted by [10] aimed to assess the difference in time gaps between automated and human-driven vehicles. The study employed models to establish the norms and average variances in headways, considering factors such as traffic types, lane distribution, and road division. The findings from multiple regression models indicated that these parameters significantly influence the headways, flow, and density of road traffic. In the study conducted by [11], multiple models were utilized to assess their precision in measuring time and speed intervals between vehicles. The findings revealed that the beta distribution exhibited the most accurate fit for speed intervals. The research ultimately deduced that, regardless of traffic congestion, vehicles tend to maintain a greater interval at low flow conditions. [12] conducted another significant study that examined various parameters. The objective of the research was to assess how these parameters affect the spacing between vehicles near bus stops. The findings of the study revealed that when large buses are present at the sides, the majority of drivers tend to move their cars towards the inner lane. Additionally, it was observed that as the length of the bus stop increases, the time headways of the traffic also increase. According to a study conducted by [13] using the moving car method, it was found that this approach exhibits a stronger correlation with the conventional stationary method when determining traffic parameters. Similarly, another research done by [14] [15] also confirmed reliability of moving method in comparison to the traditional one. Results also suggested that no noticeable difference was observed between the two methods.

III. OBJECTIVES OF RESEARCH STUDY

The main motivation behind this paper stems from the potential adoption and comparison of headway determination methods. Primary objectives of this research are as follow:

1) Comparison of stationary and moving object method for determination of headway in heterogeneous conditions.
2) To check for various parameters e.g., light and heavy traffic, traffic flow and density on vehicle headway determination by both SM and MM.
3) To analyze if new concept of MM method is more suitable in terms of its results accuracy and how it will assist road researchers and planners in future.

IV. METHODOLOGY

The research work's methodology is established with the outcomes as the foundation. The methodology is carefully crafted to fulfill all the stated objectives, which encompass selecting a site for measuring traffic parameters, acquiring and processing data, deriving results, and ultimately drawing conclusive remarks regarding the research. The main focus of the study involved comparing and examining two headway determination methods: the stationary method and the moving method.

A. Site Selection for data Acquisition

Data was gathered from a 7.5km section of a 4-lane divided highway, where the classification of the highway as a 2-lane road stems from the fact that two lanes are designated for one-way traffic. The Google Earth location for this site is depicted in Figure 1, and it is situated on the Grand Truck (GT) Road.

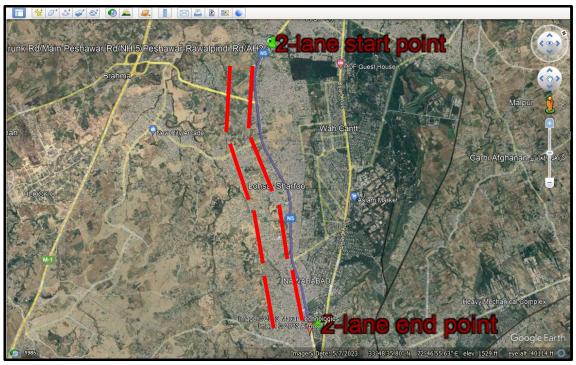

Fig 1: Selected Site for headway measurement for 2-lane highway

B. Headway Determination

The main objective of this research is to assess headway by employing two methods: the stationary method and the moving method. A graphical representation illustrating the definition of headway is included in the research to facilitate a comparative analysis of these two techniques. To measure headway, reference lines were marked on the road, and a video graphic survey was conducted, as depicted in Figure 2.

Headway measurements were taken in both directions of the chosen highway. To accomplish this, a total of 23 trips were undertaken, covering the entire length of the selected section in both directions.

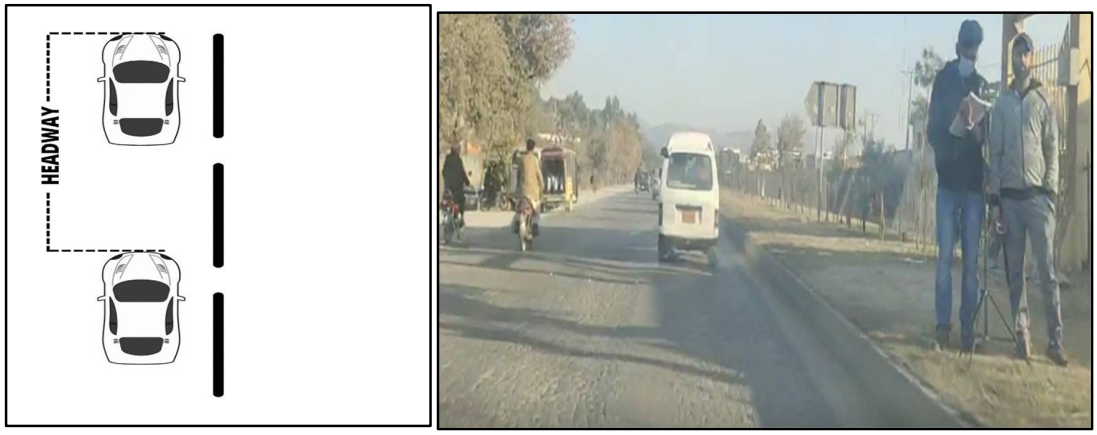

Fig 2: Headway Definition illustration (a), field measurement of headway (b)

In coming lines, equipment setup used in both these techniques is elaborated.

C. Stationary Method

The stationary method involves setting up a tripod with a digital camera to record video. The entire video recording was divided into 20-second intervals for measurement purposes. These videos were used to filter out light and heavy traffic. It is necessary to segregate the data on light and heavy traffic to assess the influence of different traffic types on headway determination techniques. The author employed a speed gun to measure the speed of target vehicles at each location. Figure 3 provides an illustration of the complete setup for measuring headway using the stationary method. The figure clearly shows the position of the stationary observer at a specific point, measuring the time for a vehicle to reach a reference line (referred to as T1). The observer then observed the time taken by the vehicle following the first vehicle to reach the same reference line (referred to as T2). By utilizing both of these measured time intervals, researchers determined the headway in the stationary method. The vehicles utilizing the complete bypass road and those dispersing along the bypass road were tallied as separate entities.

D. Moving Method

To implement the moving method, the researcher employed advanced technology in the form of the droid dash software application. This application accurately measures the velocity of the vehicles while simultaneously capturing video footage of the traffic conditions during that period. An observer vehicle in MM refers to a vehicle equipped with the droid dash software application, which records the speed of the reference vehicle. Time T1 represents the duration taken by the reference vehicle to reach the reference line, while T2 represents the duration taken by the observer vehicle to reach the same reference line. Using this information, the author derived various traffic parameters such as headway, flow, and density. Additionally, video recording was used to distinguish between light and heavy traffic. Finally, the author collected and compiled all the data, and the results are elaborated in the subsequent lines.

V. RESULTS & DISCUSSION

In this section, we present the outcomes achieved once the entire methodology is implemented. These results are extensively discussed and substantiated with factual data. Initially, a comparison is made between the results obtained from measuring various traffic parameters using both the SM and MM. The forthcoming explanation covers the results for headway, flow, and traffic density. Lastly, the overall percentage difference between the results obtained from both methods is compared for each parameter. All the findings from this research will be clearly elucidated in the subsequent paragraphs.

A. Headway Comparison of Head Way

Headway measurement for the selected highways with diverse traffic conditions was conducted using two methods: the stationary method (SM) and the moving method (MM). A total of 23 trips were undertaken, during which video recordings lasting 20 seconds were obtained for both of these approaches. The results depicting headway measurement can be seen in Fig 3.

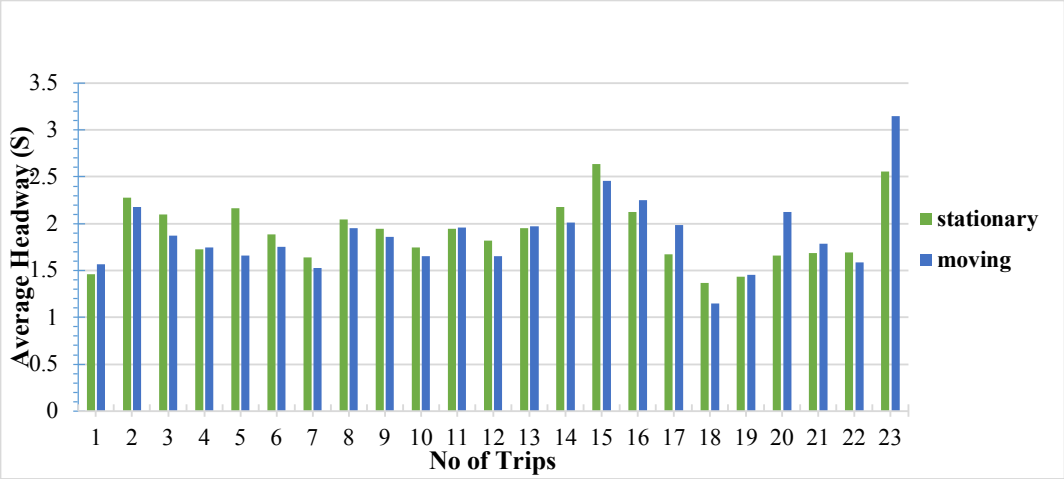

Fig 3: Headway comparison b/w SM and MM method for 2-lane highway

The results indicate that, on average, the outcomes obtained from MM are similar to those from the traditional method, namely SM. The average percentage difference between the results obtained from both methods is only 0.23% for a 2-lane heterogeneous highway. This suggests that MM is a reliable approach for determining headway. Additionally, an important observation from these findings is that the headway measured using MM tends to be on the lower side.

B. Comparison of Flow

This research incorporates traffic flow as an additional parameter. Determining the queue time and calculating the overall delay at specific road sections heavily relies on traffic flow. The credibility of the moving method in accurately assessing traffic flow is demonstrated, as its results are comparable to those obtained through the traditional stationary method, with a minimal percentage difference of only 2.32, as illustrated in Fig 4. On average, the moving method consistently indicates a slightly higher traffic flow than the stationary method, as observed on a 2-lane highway.

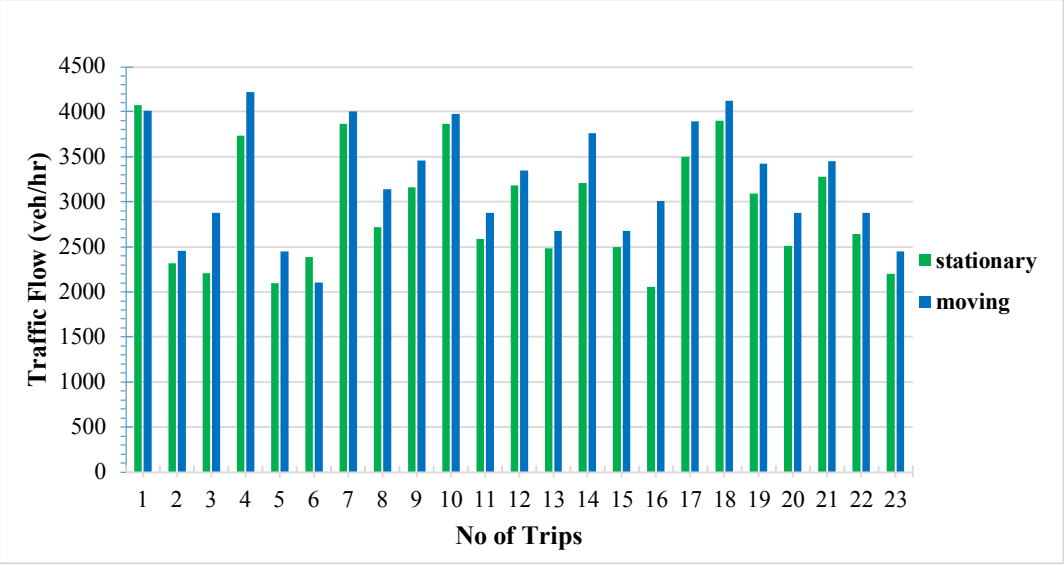

Fig 4: Flow Comparison b/w MM and SM for 2-lane highway

C. Density

The research work addressed the concern of traffic planners regarding traffic density. Both the MM and SM methods were used to measure traffic density on a 2-lane heterogeneous highway. The measurements of traffic flow obtained from both methods were found to be comparable. The results depicted that MM accurately determines traffic density for the specific 2-lane highway, as illustrated in Fig 5. There was a 5.17% difference in the traffic densities measured using MM and SM methods. Interestingly, unlike headway and traffic flow, where MM and SM showed opposite trends for 2-lane highways, MM yielded higher values for traffic density on the selected highways. This suggests that MM provides consistent results for traffic density on a 2-lane highway under such heterogeneous traffic conditions.

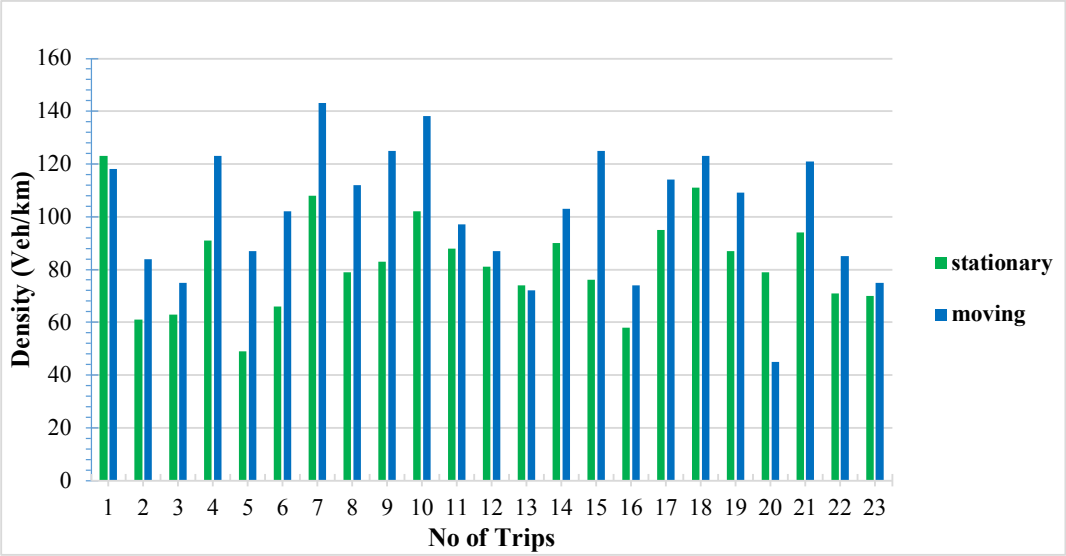

Fig 5: Density comparison b/w MM and SM on 2-lane highway

D. Establishing a Correlation between MM and SM to determine Headway

The primary focus of this research study was to evaluate the effectiveness of the moving method (MM) versus the traditional stationary method (SM) in determining headway on a 2-lane highway. The headway results for both SM and MM were compared and analysed using the chi-square test to assess data reliability. The chi-square coefficient (R2) was utilized to determine the goodness of fit between the measured and expected values. The findings revealed that, in the case of a 2-lane highway, MM provided 65% accurate and reliable results when compared to the traditional SM, as depicted in Fig 6. These results demonstrate the superior accuracy and reliability of MM compared to SM.

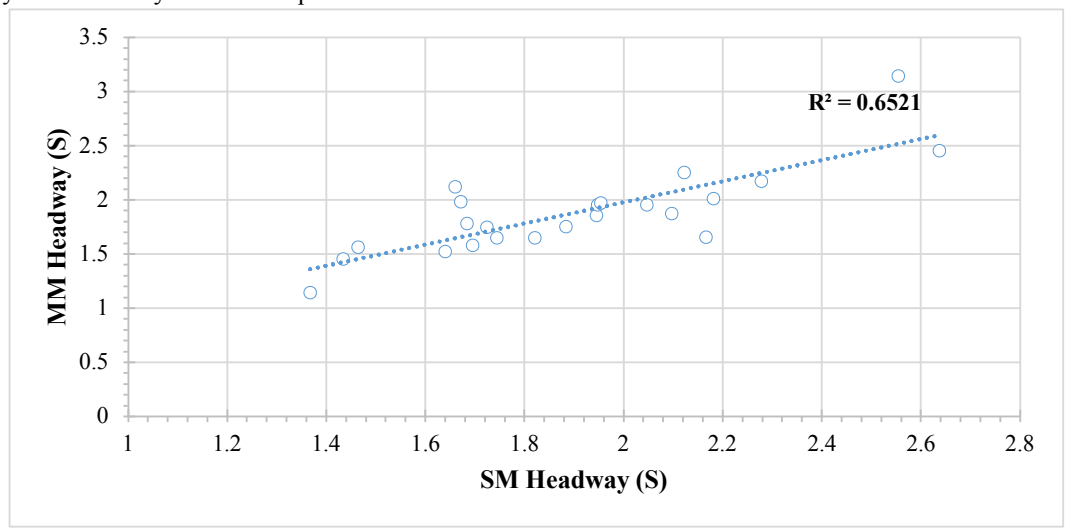

Fig 6: Correlating Headway measured using SM and MM on 2-lane highway

VI. CONCLUSION

This research assessed the results accuracy of moving method (MM) in comparison to stationary method in heterogeneous conditions of 2-lane highway. Following conclusions can be drawn from the results:

1) Moving method proved to be an accurate and reliable method for measurement of traffic parameters.
2) On 2- lane highway results for MM varied only 0.2 percent when compared to SM. This suggested that MM results are good on 2-lane highway.
3) When model fitness test is applied for headway on 2-lane highway, results suggested a reliable result i.e. 65% of MM fits with that of SM on 2-lane highway. This will pave ways for future research work and models will be made to get traffic headway results for MM only using equations and best fit.
4) Similarly, traffic density values were comparable to SM. Only 5.17 of percentage difference was observed b/w values of densities obtained by both the methods on 2-lane highways.

VII. RECOMMENDATION

This research has opened up opportunities for further studies in Pakistan's traffic parameter determination, taking into account different pavement and traffic conditions. The author recommends the creation of machine learning models to improve the accuracy of results related to various traffic parameters in this field. These findings can be valuable for future road expansion or traffic redirection. Additionally, future research could focus on creating specific traffic scenarios to obtain the desired traffic parameters. The author suggests that researchers thoroughly explore and analyze this methodology of measurement in a more comprehensive manner.

VIII. ACKNOWLEDGMENT

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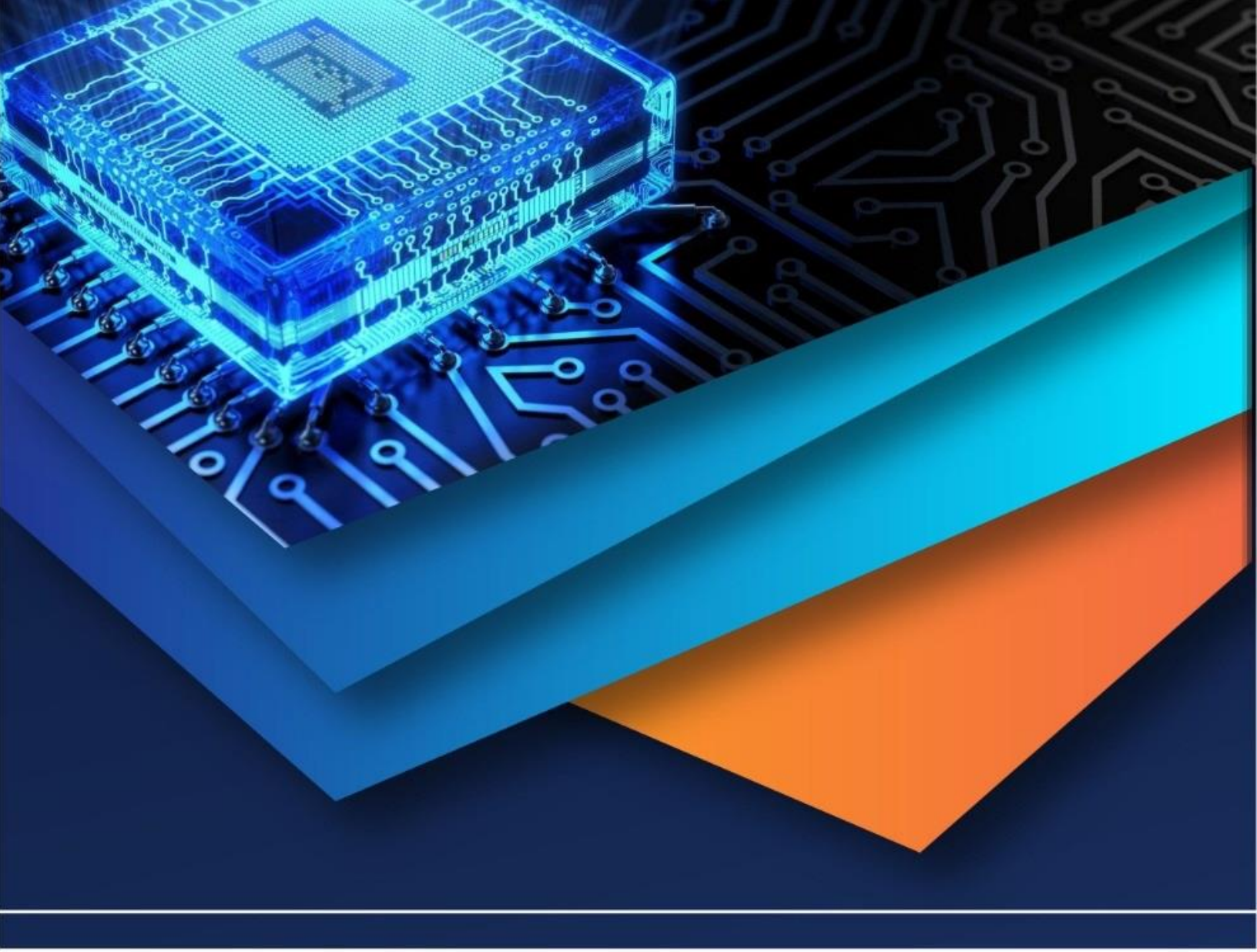

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