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Using Google Maps Data for Low-Cost Traffic Speed Monitoring

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Abstract: Every year, millions of lives are lost around the world as a result of violations of traffic laws, especially excessive speeding, which continues to be a considerable issue in road safety management. When assessing the efficacy of a road network, vehicular speed is a critical metric. Inconsistencies and abrupt fluctuations in traffic speed typically indicate the presence of congestion, collisions, or other disruptive occurrences. This study utilizes a Python script in Visual Studio Code, employing web scraping techniques with Selenium to gather and analyse data on vehicle speeds and travel times. A comparison of the traffic patterns on weekdays and weekends was made, with particular attention paid to the variations that occurred at peak, lunchtime, and evening hours. The findings suggest significant differences in speed, with weekdays experiencing considerably lower speeds during morning and evening rush hours, while weekends maintain higher and more consistent speeds throughout the day. These insights can provide strategies for the optimization of traffic flow, the improvement of road safety, and the guidance of metropolitan development plans.
Keywords: vehicular speed monitoring, automated speed data collection, web scraping, peak-hour traffic patterns, road safety.

I. INTRODUCTION

The transportation sector is prominent in urban areas. It is a vital and influential industry that substantially contributes to a city's social, economic, and cultural development while ensuring efficient functioning. Nevertheless, this sector faces significant challenges, such as a lack of public transit infrastructure, extensive traffic law violations, traffic congestion, and road accidents [1]. Numerous factors affect road safety. The primary determinants are driver behavior, vehicle design and condition, and infrastructure. The mean causal network for defining road safety factors comprises three tiers. The initial tier addresses global factors, such as the demographic composition of the population, which subsequently affect the second tier: the host, which is the road user, environmental variables, including infrastructure and traffic conditions, and the vehicle. At the tertiary level, the interactions of various components, influenced primarily by speed, result in collisions and injuries that can range from slight to severe or fatal[2].

When visualizing the status of a transportation system, it is imperative to consider the element of speed. This statistic can produce an informed estimation of the transportation condition in the given region. Furthermore, the emergence of advanced transportation systems has rendered traffic movement a key element within contemporary traffic management systems. The vehicular speed, in conjunction with other quantitative measures such as traffic volume, provides insights into the condition of the transportation infrastructure at a specific moment. The evaluation of travel time, encompassing speed, is crucial for efficiently disseminating accurate data to traveler information systems, and this issue also pertains to public transit. Passengers can receive updates regarding the anticipated scheduled arrival times for specific vehicles. This enables them to optimize their time management by making necessary schedule adjustments. The transportation company derives advantages from obtaining knowledge regarding the duration of time that passengers spend in transit throughout various segments of the road network [3].

Vehicular speedremains a significant risk factor for the incidence of accidents and the severity of injuries.The correlation between speed and road safety shows no signs of diminishing. It is conceivable that new safety technologies in vehicles could render road safety outcomes more responsive to variations in speed. Before implementing features such as automated stability control and emergency brake aid, vehicles may have been incapable of preventing accidents at 55 and 50 km/h, indicating that this speed differential might not correlate with a variation in accident frequency [4].(Batrakova & Gredasova, 2016)[5]revealed a correlation between road condition factors and the driver's functional status markers. Environmental, traffic, road user, and vehicle-related factors affect the incidence of accidents. The optimality criterion pertains to the dependability of the driver's performance. The results are the foundation for developing measures to optimize environmental movement aspects and realistic ways to measure damage from an accident under changing operational settings [5].

II. LITERATURE REVIEW

Wireless networks are becoming a prominent communication technology and a complicated research topic. Many have contributed to ad hoc networks like wireless sensor networks (WSNs) and VANETs. Increasing car traffic has generated interest in vehicular communication systems. The new HSVN (Hybrid Sensor and Vehicular Network) improves road safety with WSNs and VANETs. Cooperative Vehicle and Infrastructure Systems (CVIS) and COMeSafety were launched to improve road safety. This method informs the driver and co-pilot of traffic, accidents, and bad weather. It can reduce traffic accidents and save lives. [6]. Because of vehicle-to-vehicle and vehicle-to-infrastructure connections, vehicular ad hoc networks (VANETs) are predicted to enable several automotive communication-based applications, including in-vehicle leisure and road safety services. [7].

Bluetooth-enabled anonymous automobile trackers track interstate and arterial travel times. Probe vehicle data can correctly measure vehicle speeds and trip times due to its wide spatial coverage. Conventional loop detectors capture almost all autos on a road stretch, providing high temporal coverage. Due to loop detector spacing and geographic sampling, loop detector values only reflect traffic speed at the detector point, not the entire road section[8]. Automobile spatial-temporal dispersion and signal-offering duration differences make vehicular crowdsourcing data coarse. STC (Spatial-Temporal Correlation) addressed roughness and accurately estimated transit speed.STC uses time-delayed cross-correlation factors to exploit vehicle speed temporal-spatial correlations due to road segment travel duration. To calculate this factor, a programmable self-tracking gadget assessed car positions across route segments. Finding a road's unknown vehicle speed was an optimization problem using regional stationary behavior in cross-correlation. The Spatial-Temporal Correlation (STC) technique predicted taxi track data better than conventional methods in experiments[9]. The suggested vehicle detection and categorization approach monitors road traffic with cell phones and Bluetooth beacons. It can identify three vehicle types by measuring radio signals from BLE beacons at different roadway heights. This technology suits crowdsourcing applications that reduce travel time, congestion, and pollution[10].

(Tsuboi, 2020)[11] collected traffic flow information through a traffic surveillance system comprising 14 cameras. This system could effectively monitor several traffic flows, average speed of vehicles, and occupancy at specific locations[11]. (Khazukov et al., 2020) [12] concentrated on acquiring data regarding the speed and trajectory of cars utilizing video feeds from street security cameras. The task's complexity arose from varying viewing angles, distance from the junction, and item overlap. Reference [12] incorporated an extra mask branch into the YOLO v3 neural network architecture and refined the dimensions of anchors to enhance the precision of object identification and classification across varying sizes, hence improving the quality of object tracking [12]. The method for detecting traffic anomalies by utilizing Speed Transition Matrices (STM) for quantifying the length between two STM (Spatial-Temporal Models) relied on employing a Euclidean distance metric to compare the centre of mass (COM) with the mean STM that served as a representation of typical traffic situations and identify the specific benefits such as routing, road safety, and overcrowding prediction [13].

(Pu et al., 2022) [14] Introduced a real-time multimodal traffic speed monitoring system utilizing passive Wi-Fi and Bluetooth sensor technologies. An algorithm was developed to rectify the predicted traffic speed utilizing RSSI (received signal strength indicator) readings. The proposed semi-supervised PCM (Possibilistic Fuzzy C-Means) clustering approach determined the traffic mode for each journey. Moreover, the 5G and 6G communication range is significantly shorter than that of 3G and 4G, suggesting that street-level motions may be inferred from mobile communication data [14]. (Bisio et al., 2022)[15] did a comprehensive analysis of traffic monitoring systems utilizing drones, focusing on applying deep learning techniques that focused on detecting, tracking, and counting vehicles as crucial components in developing solutions for addressing traffic congestion, flow rate, and vehicle speed estimation [15].

The various advancements in traffic management systems, encompassing the utilization of photographic data for traffic analysis and vehicle recording, the implementation of ultrasound sensors and the Normalized Cross-Correlation Algorithm, the integration of vibration sensors and machine learning techniques, the application of neural network classifiers for license plate detection, and utilization of distributed acoustic sensors for classification purpose. Image processing systems are widely used but encounter difficulties in environments with limited light. On the other hand, ultrasound and acoustic sensors have the benefit of functioning in any light. However, they may have constraints regarding close-range detection or accurately detecting particular types of vehicles [16]. An innovative traffic scenario model can discover and alleviate traffic issues. MATLAB Automated Driving Toolbox's Driving Scenario Designer (DSD) and MATLAB Open Traffic Lab create a realistic testing environment by considering traffic volume and signals. This vehicle behavior model simulates real-world traffic scenarios.The adaptive vehicle rerouting method was based on the k-shortest path algorithm and a redirecting approach to dynamic congestion[17]. The alternative metrics use the Hager strand's space-time cube, which temporal and geographical studies have widely examined.

Measures have focused on vehicle speeds, magnitudes, and duration. Time and distance should be used to measure traffic congestion. Graded and standardized congestion was used to quantify congestion levels and miles per hour. Traffic congestion figures for six months were obtained using the Google Traffic Layer API. GIS was also used to define road parameters and measure traffic intensity [18].

In the future, automobile traffic monitoring systems, especially those that regulate traffic volume and speed, will be essential to road traffic management, road safety, and vehicle collision prevention. A low-energy LoRaWAN sensor network can provide traffic volume monitoring and area-specific speed control. A system's smooth, reliable, and effective operation requires sufficient radio coverage in the targeted area. The elevation of the sending and receiving antennas, radiation patterns, and transmitting antenna gain determine radio coverage in a radio system. However, several technological and economic factors will limit antenna heights. Legal and technological restrictions limit the transmitter's broadcast signal power [19].

Intelligent Transportation Systems promote safety and efficiency by optimizing vehicle performance or providing traffic information. Road layout data like speed limits and sign recurrence can be extracted from digital road graphs. FCD on vehicle speeds and trajectories is gathered, but road measurements are not used to assess how drivers interpret infrastructure and their actions. (Colombaroni et al., 2020)[20]proposed assessing drivers' behavior and road geometry-derived safety speeds. Iterative highway azimuth profiles are created using digital graph geometry, assessing longitudinal stability and safety speed [20].

In recent years, there has been a significant increase in the availability of resources for collecting roadway traffic information. One limitation of stationary detectors is their constrained capabilities, primarily attributed to the considerable expenses associated with their deployment and maintenance. They also may experience vulnerability to many factors, such as destruction, theft, or adverse environmental conditions. Additionally, the extent of their detection of road networks is often inadequate. Regular calibration of sensors is also necessary to uphold their accuracy, which is laborious and expensive. The efficacy of crowd-sensing technology depends on the data provided, which may exhibit limitations regarding its comprehensive coverage across all locations. The variability in the accuracy of information relies on the level of user engagement and the precision of their submissions. Real-time data precision concerns may arise due to a potential time lag between the occurrence of an event and its subsequent reporting. One notable drawback of these technologies is the substantial burden imposed on transmission channels due to the continuous transfer of speed data from many vehicles. Consequently, this aspect is expensive when employing a paid connectivity system. Using complicated neural network models may necessitate substantial computing power, posing challenges to real-time computation capabilities. Deep learning models may encounter challenges in achieving robust generalization across diverse traffic conditions. Collecting data from several sources, such as crowd sensing, sensors, and GPS, can provide challenges due to its inherent complexity, potentially leading to variations and integration concerns.

Adopting an affordable approach to detecting road conditions in metropolitan areas is necessary, as it can present considerable potential for enhancing transportation administration and overall urban living standards. It can also play a significant role in achieving objectives related to sustainability and the environment, such as reducing gasoline use and emission levels and enhancing air quality.

III. METHODOLOGY

The G-T road from Peshawar General Bus Stop to Jahangira Bus Stop, Nowshera, is used to calculate vehicular speed. The length of this route allows researchers to study traffic dynamics across numerous road segments, including speed and traffic trends. These factors can significantly affect travel times and traffic efficiency. The GT Road is a vital transportation route; traffic fluctuates throughout the day due to peak hours, businesses, and special events.Decision-makers can target crowded areas and identify root issues such as road infrastructure, traffic signal timings, and land use to improve mobility and reduce congestion.

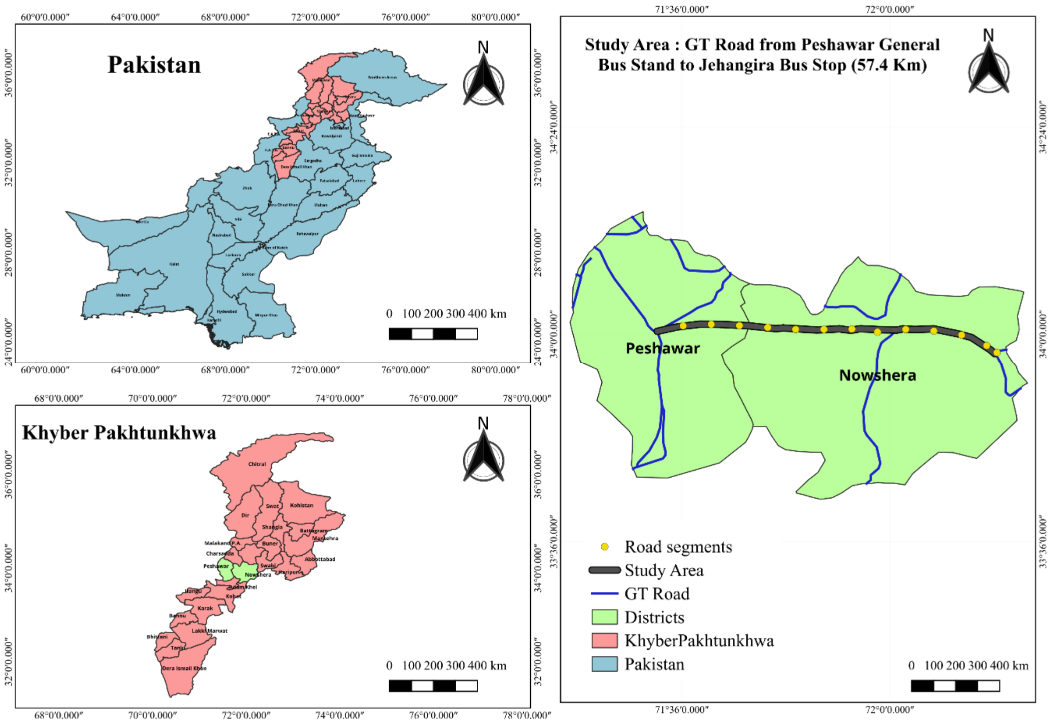

Figure 1. Study Area

Dividing the GT road stretch into 5-kilometer sections is crucial for the study. First, it allows researchers to examine road traffic flow more closely, helping them identify slowdowns and stops. The stretch segmentation helps us understand transportation efficiency variables more precisely. Comparing segment efficiency may help researchers identify bottlenecks or places that need focused interventions to increase traffic flow. Also, examining smaller sections makes it possible to employ ways adapted to each part's demands and features. This leads to improved and more effective traffic flow.

Two key software development and programming tools were used for collecting vehicular speed data: Visual Studio Code (VS Code) and Python. Comprehensive and user-friendly instructions are provided for different technical levels. One can create an efficient Python code authoring and execution environment by following the providedguidelines. Microsoft made Visual Studio Code (VS Code), a versatile, multi-platform source code analyzer that developers use because of its extensibility. Python, a powerful programming language with a simple syntax, is widespread. Developers may use VS Code and Python to create a strong environment for web development, data analysis, and machine learning.

Visit the website of Visual Studio to get the OS system-specific installation for Visual Studio Code. Running the installer and following the instructions on the screen started the installation. The installation process guides users in choosing options, such as adding VS Code to the system's PATH and creating shortcuts for easy access. After installation, Visual Studio Code can be launched from the desktop or start menu and used for coding. The free Python download from the Python website includes installers for numerous operating systems. We downloaded the latest Python and selected an OS-compatible installer. Installing Python in the system's PATH for command line access was one of the installation options. To verify Python installation, open the terminal and run "python-- version" to see the installed version.

Selenium is a robust technology that is mainly employed to automate web browsers. It facilitates automatically testing online applications, simulating user actions, and interacting with web elements. Selenium is compatible with other programming languages such as Python, Java, C#, Ruby, etc. Python is the fundamental programming language used to run Selenium WebDriver. After the installation of Python, proceed to install pip. Pip is the Python package manager, streamlining the Python library installation process. Most Python distributions provide pip as a pre-installed component. Pip facilitates the installation of Selenium. To initiate a command-line interface, such as the Command Prompt on Windows or Terminal on macOS or Linux, use the following command: ' pip install selenium'. This program will utilize the Python Package Index (PyPI) to acquire and install the Selenium library and all the requisite plugins.

A WebDriver is required for Selenium to interact with the chosen browser. WebDriver is a tool utilized to automate the testing of online applications. We selected a specific WebDriver to automate various browsers, depending on the browser used. The most often employed drivers include Gecko Driver for Mozilla Firefox, Chrome Driver for Google Chrome, and WebDriver for Microsoft Edge. After visiting the Chrome Driver website, we have obtained the appropriate version of the Chrome Driver that is compatible with our computer's operating system and Chrome version. Once the Chrome Driver executable file was downloaded, we unpacked it to a specific location on our computer. We have attached the directory that contains the Chrome Driver application to the system's PATH environment variable. This allows for the execution of Chrome Driver from any place in the command line. To confirm the successful installation of Selenium and WebDriver, one can launch an interpreter that supports Python or create a Python script, import the Selenium module, and create a WebDriver instance. Utilize Selenium to initiate a web browser window. If it functions as intended, it can be determined that Selenium has been successfully installed.

Website scraping refers to algorithms that extract data and material from a website. Web scraping is a process that extracts the underlying HTML code and the data contained in a database. This is different from screen scraping, which only captures the pixels displayed. The scraper can replicate the whole content of a website in another location. Web scraping is commonly employed by numerous digital enterprises that rely on data collection. Acceptable use cases include search engine algorithms that crawl websites, analyze their content, and rank them. To accurately identify and retrieve some aspects from HTML documents, use XPath expressions. When scraping dynamic websites, employ techniques like waiting for elements to be loaded or interacting with JavaScript-rendered material using tools like Selenium. Employ error-handling measures to manage mistakes and ensure the uninterrupted execution of scraping operations. To avoid being blocked or flagged as a suspected user, restrict the number of requests you submit to the server. Specifically, while dealing with unorganized or semi-organized content, it is essential to validate scraped data to guarantee its consistency and accuracy.

Launched Visual Studio Code and developed a new Python script for thisresearch project. A new file was createdby selecting "File" from the menu and then "New File." Placed the file in a designated directory and assigned it a significant name. At the beginning of our Python script, we included the necessary libraries. We needed to import the web driver class to use the Selenium module.We imported the web driver module from the Selenium library and other required modules. A web browser (namely Chrome) was initiated by using the Selenium framework. We initiated a web driver object in Python script corresponding to the specific browser.

The web driver was employed to navigate to the Google Maps website once it had been initialized to extract data. This was achieved by invoking the get() method and providing the website's URL as an argument. Once the web page had been loaded, Selenium engaged with its various components. This may involve clicking buttons or retrieving data from certain elements. Selenium has various methods for finding elements on a webpage, including find_element_by_id(), find_element_by_name(), find_element_by_xpath(), and so on. To access Google Maps, Selenium was used to launch a web browser and point it to the Google Maps website. One usually calls the get () function on the WebDriver class and provides the Google Maps URL as an argument to accomplish this. The input forms for specifying the origin (start) and destination (end) points can be found on the Google Maps page. By utilizing Selenium'sfind_element_by_xpath() or comparable techniques, one can locate these fields by examining the HTML of the page and supplying the necessary input. By following the directions displayed on the map, we obtained the required traffic information,including the distance and travel time. Once again, we successfully identified thesecomponents within the page's HTML and extracted the information using Selenium. Upon executing the query, identify the element on the directions panel that included this information to retrieve the distance between two places from Google Maps. Selenium can be utilized to ascertain the distinctive class or ID usually associated with this element. For example, Selenium may locate the distance element on a webpage and extract its contents. We have acquired travel time between starting and end points using Google Maps, like retrieving distance. A web page's elements may delay loading, especially if dynamic or dependent on external data. Before proceeding, initially waited for a specific duration for elements to become visible on the page before attempting to interact with them using Selenium's implicitly wait() method.

To save the data collected from Google Maps using Selenium into an Excel file, the openpyxl package was used in Python. This library enables the creation, reading, and modification of Excel files. The distance and journey time data were stored in an Excel file in the specified format. The pip package manager was used to installpip and import the requisite modules from the openpyxl library. Utilizing the openpyxl library, a fresh Excel workbook and worksheet were generated. Subsequently, we input the retrieved distance and travel time data into the Excel spreadsheet. The Excel file was successfully saved with the specified filename. To terminate the Python script, we utilized the sys. Exit() function, which stops the program's execution. Once the current time surpasses the predetermined end_time, the script ends execution, hence stopping any subsequent operations.

IV. RESULTS

This section discusses the findings of the research carried out to assess a low-cost approach for collecting data on vehicle speeds with the goal of identifying patterns of traffic speed on highways. The results focus on the morning and evening periods of highest traffic volume and emphasize significant patterns and trends for both weekdays and weekends.

It was evident that the average speed of vehicles and the level of traffic congestion were inversely correlated. The concept that vehicle speed is a reliable indicator of traffic congestion was confirmed by the consistent decrease in average speeds that resulted from the increase in congestion.

The hourly data analysis revealed distinct temporal patterns in traffic speed. The study identified peak traffic periods that occurred during the morning and evening commute hours, which led to substantial reductions in vehicle speeds during these times. The implementation of specific actions during periods of high demand is facilitated by an examination of time, which is essential for urban planning and traffic management.

The study illustrated the diversity of traffic conditions across various routes and locations. In contrast to urban centres and high-traffic corridors, suburban areas experienced smaller decreases in average speeds. This spatial analysis can be beneficial in the optimization of the movement of vehicles in densely congested regions and the prioritization of infrastructure enhancements.

The findings of this investigation provide traffic management authorities with valuable insights. Authorities can develop more effective strategies tooptimize traffic signal scheduling and improve the overall flow of traffic by incorporating data on the average speed of vehicles. Furthermore, the implementation of real-time speed monitoring can facilitate the rapid response to traffic incidents, which can lead to a reduction in the duration of congestion and an improvement in road safety.

To improve traffic flow and safety on GT Road, it is suggested that adaptive signal control devices be implemented at key intersections, enabling real-time modifications to traffic light timing according to prevailing conditions. Enhancing public transit's reliability, consistency, and coverage will offer a feasible alternative to private vehicles, especially during peak hours. Furthermore, forming a specialized emergency response team to promptly address mechanical failures and incidents will mitigate disruptions and ensure the continuity of traffic flow. Public awareness programs regarding the advantages of complying with speed limits can enhance road safety and efficiency. Implementing these methods will bolster traffic management capacitiesand improve overall passenger satisfaction on the GT Road.

While there are some limitations, including data accuracy, dependence on third-party platforms, and difficulties in detailed vehicle tracking, the suggested method offers a budget-friendly option compared to costly sensor-based systems. Incorporating automated data extraction methods, employing machine learning for filtering, and working alongside local authorities can significantly improve this approach's validity and practicality.

V. CONCLUSIONS

The study's objective was to evaluate the feasibility of employing the average speed of vehicles as a measure for monitoring and assessing traffic condition patterns. The efficacy of this approach was illustrated by the acquisition of numerous significant insights through comprehensive data collection and analysis. In summary, using average vehicle speed as a metric for observing traffic conditions is a practical and effective method. The insights obtained from this study have the potential to make a substantial contribution to the advancement of more efficient and intelligent urban transportation systems, which will ultimately result in a higher quality of life, improved air quality, and reduced congestion for urban residents.

Future investigations should focus on enhancing data processing methodologies, integrating supplementary traffic metrics such as volume and density, and examining hybrid models that amalgamate various low-cost data sources. Technological advancements present low-cost vehicular speed monitoring methods that could significantly enhance traffic management strategies, optimize signal control, and improve road safety in urban and highway environments.

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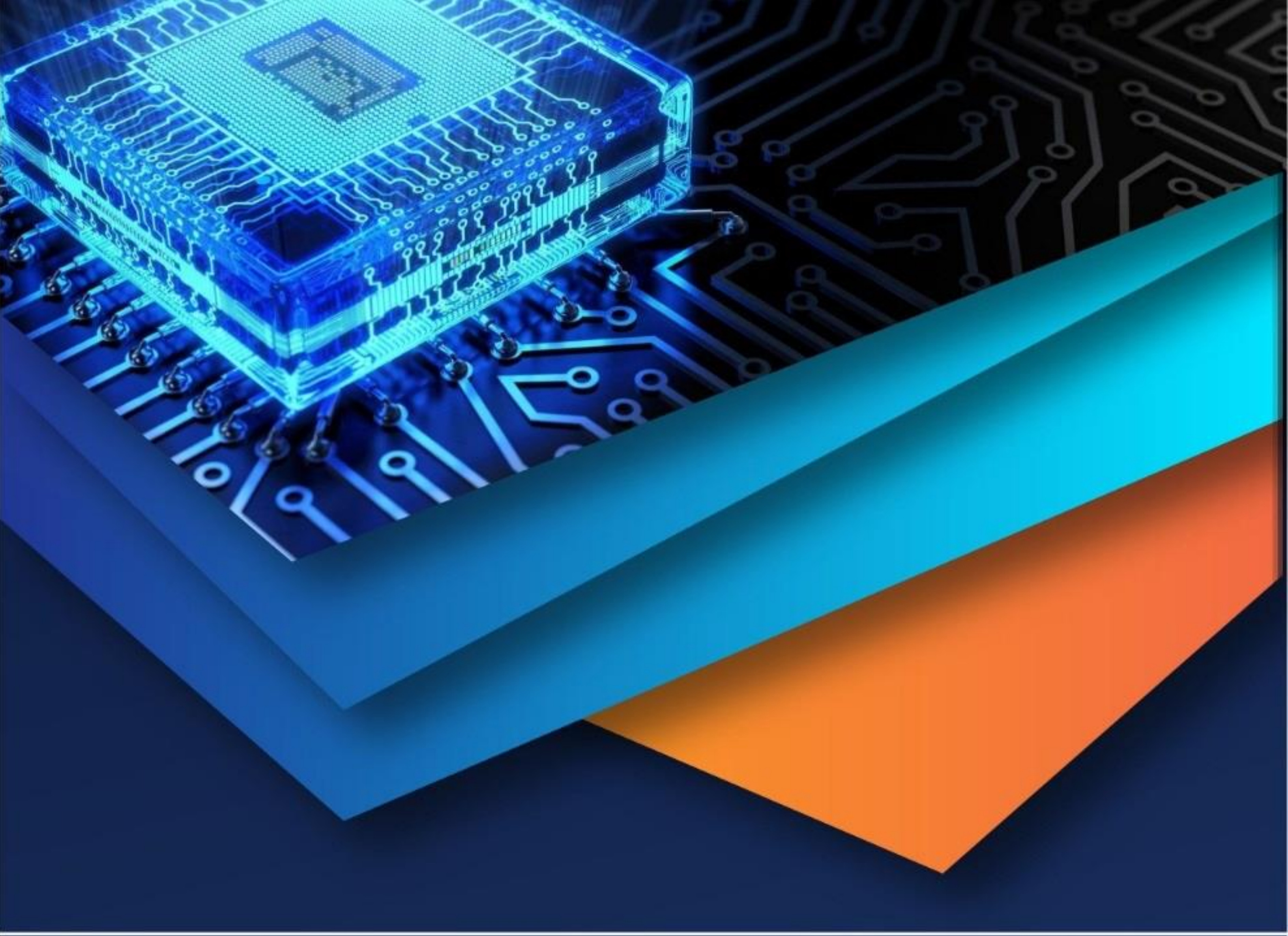

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