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An Observational Evaluation of Safety Resulting From Driver Distraction

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Abstract - Distracted driving is a dangerous activity that continues to claim lives on roadways throughout the United States. A goal of this research was to collect distracted driving behavior data through observation in the field. A methodological approach was devised to keep data collection consistent across the observation periods. Analysis of the data provided information regarding trends in distraction type or driving behavior while engaging in a secondary activity. In combination with the observational portion of this research, another key component to understanding distracted driving was the crash report narrative key word search. By searching through the crash reports, it was determined which key words have high discriminating powers that indicate distraction was a key component to a crash. Additionally, the key word search demonstrated how accurately distraction related crashes are reported via the crash report form. This research contributed to the existing literature regarding distracted driving and also expanded the methods of research that are currently in use.
Keywords –Driving behavior, Crash reports, Distracted driving.

I. INTRODUCTION

Distracted driving can be defined as "any activity that could divert a person's attention away from the primary task of driving"
Distraction can be further broken down into three types of distractions: visual, manual, and cognitive
The use of a cell phone while operating a vehicle requires the driver to take at least one hand off of the steering wheel to hold the device. When using a phone to text message, the driver also needs to look at the phone screen or keypad and think about the message that he or she is reading or composing. Therefore, texting while driving incorporates all three types of distractions (visual, manual, and cognitive) within a single action and, as a result, decreases driving performance. In particular, distracted driving through the use of cell phones has become increasingly controversial in recent years in part due to the continual increase of the number of cell phones in use. In the INDIA in 2011, distracted driving was listed as a causal factor in 3,331 fatalities and 387,000 injuries, and in 2012 the death toll was similar with 3,328 fatalities and 421,000 injuries (1). Many states within the INDIA have passed laws that restrict cell phone use in an effort to decrease the fatalities and injuries associated with distracted driving on an annual basis. Some states have succeeded in making primary laws against talking or texting while driving, while many other states struggle to pass this regulation. There is concern related to these trends given the increased prevalence of cell phones within the market coupled with the added distraction that may be present from the increased functionality and reliance associated with smart phones.

II. BACKGROUND

A. Crash Citation Narrative Search

In INDIA a crash report form is completed by the responding police officer at the scene of the crash. This report form captures several pieces of crucial information regarding the vehicle, driver, and passenger information. The crash report form data is then collected and stored electronically to evaluate the reason and factor that led to the fatal accident Work zone crashes can be difficult to classify due to varying definitions of a work zone, and distracted driving crashes face a similar issue with the crash report forms. The research group for this work zone study formulated a list of predetermined key words, phrases, and word combinations such as arrow, arrow board, closure, cone, construction, etc. in order to search through the narrative sections of many crash reports.

B. Naturalistic Studies

Naturalistic research entails that the researchers insert various monitoring devices into vehicles for a specified period of time and collect the data at the end of the trial. These monitoring devices typically consist of the following: in-vehicle video cameras, accelerometers, Global Positioning Systems (GPS), forward radar, and devices that measure speed, braking, steering wheel position, etc. Additionally, the researchers also request access to the participants' cellphone data such as received messages, sent messages, and phone call durations. This data is available through the cell phone provider at the consent of the user. All of the variables are

connected by time and date in order to analyze the data with respect to crucial events and driver behavior. . The drivers' behaviors were categorized and organized according to a predetermined list that accounted for a variety of errors such as lane departure, traveling over the speed limit, etc. The results from this study showed that distracted drivers made more errors than non-distracted drivers, and this goes along with the existing literature on distracted driving. They stated, "Drivers made a total of 268 errors when distracted and 182 errors when driving undistracted. All drivers committed to driving errors on each drive, with the average number of errors made per driver higher when distracted compared to when not distracted drivers were 48% more likely to make an error when distracted

C. Simulator Research

Driver simulator technology is another popular research method for distracted driving.Through use of a simulator, the researcher is able to also incorporate eyewear technology in order to track the visual focus of the participants in the study. It is also easier for the researcher to manipulate the variables due to the nature of the controlled simulator setting. There are some disadvantages, however, when using a simulator; these issues are participant recruitment, motion sickness, realistic quality of the simulated scenario, etc. Researchers have been able to overcome most of these downfalls with the simulator and produce results that mimic those found in naturalistic studies. In order to complete the phone tasks, the participants were required to own a smart phone in order to participate in the study. A crucial aspect to simulator research is acquiring large sample sizes for a broad range of ages, and this study was able to successfully recruit the necessary sample size. The results from this specific research can be found in **Figure 1**, and the group concluded, "generally, the text message task had the longest durations, followed closely by destination entry…effects of driver age are most evident for text messaging" . With respect to what they called the glance frequency, or total eyes off the road time, "the analyses are consistent in revealing that text messaging required significantly more long glances than any of the other secondary tasks… and text messaging trials required more than 20 seconds of time looking away from the forward roadway view for all age groups" results.

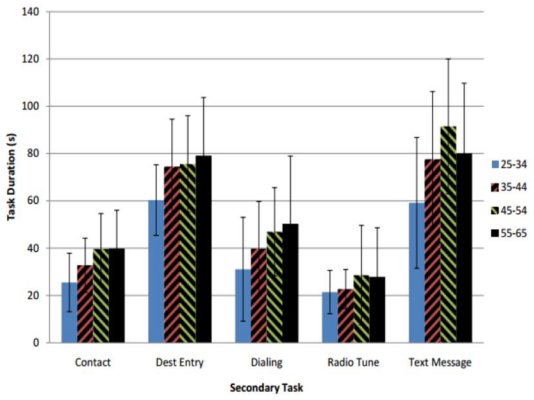

Fig 1 Duration of a Secondary Task

D. Driver Usage Through Direct observation

The National Highway Authority Of India (NHAI) developed a protocol for cell phone usage observations, but this standardized method had limitations.The observations could only be conducted during daylight and at controlled intersections. Three types of electronic device usages were also defined to be a driver holding a phone to the ear, a driver speaking while wearing a visible headseat, and a driver visibily manipulating a handheld device. By conducting these observations at a controlled intersection, the observer would be given enough time to collect driver behavior data while stopped in traffic. Due to the daylight limitation, there would also be ample lighting to accurately see the drivers' actions. This method was used for research in 2012. It was completed as a component of the annual seat belt observation study for the INDIA. This study was composed of 145 observation sites, one observer, and one recorder . The following data was collected from each driver stopped at an intersection: cell phone use, seatbelt use, gender, age, race, vehicle type, state of license plate, and presence of a passenger. In accordance with the NHAI protocol, data was only collected during daylight from 7:00 A.M. to 7:00 P.M. during the month of June . A point of interest in this study is the relation of cell phone usage to whether or not a passenger was present. The results indicate that drivers without passengers had a cell phone usage rate of 8.6 percent, and if a passenger was present, the rate dropped to 1.9 percent. This could happen because the driver might ask to have the passenger complete the cell phone task while the driver focuses on the road, or the driver refrains from

using a cell phone so that the passenger's life is not endangered.

E. Economic Impact of Distracted Driving

Minimizing distracted driving could also improve aspects other than traffic safety. Distracted driving incorporates a broad range of economic impacts including the cost of crashes, decreased fuel efficiency, cost of ad campaigns, and law enforcement. This is by far the most researched aspect of sustainability with respect to distracted driving. The National Safety Council's website states, "A Harvard risk analysis study estimated the annual cost of crashes caused by cell phone use to be 2754 billion" . The behavior of a distracted driver typically consists of sudden stopping due to inattention to the traffic conditions ahead. This has an effect on the fuel efficiency of the vehicle and does not promote "green driving." Two aspects of "green driving" that distracted driving disregards are the following: use engine braking for smooth deceleration and avoid sharp braking . By not incorporating these fuel efficient driving habits, the distracted driver will likely spend more money on gasoline than an attentive driver who embraces these two along with many other "green driving" strategies. Efforts have been made in the past few years to convey the message to the public that distracted driving is a dangerous activity. These ad campaigns cost companies money to create and air on national television and radio airwaves. The hope is that the cost of these ads will be outweighed by the lives and money saved through reduction in distracted driving crashes.

F. Laws

The policies and laws for cell phone use while driving vary from state to state. According to the Governors Highway Safety Association, have banned cell phone use for all drivers. States may have bans for hand-held devices, text messaging, and young driver use of cell phone. These three types of laws against cell phone use according to each state are depicted in Figure 5, Figure 6, and Figure 7.show bans for hand-held device use.and text messaging; the bans by state are categorized as all drivers, partial (typically targeting specific age groups or conditions), and no ban.

III. RESEARCH APPROACH

Research objectives, hypotheses, and a series of tasks are proposed in response to the following problem statement.

A. Problem Statement

laws have been passed in many states that prohibit distracted driving behaviors, people disregard these rulings and continue to use various devices while driving. By observing random drivers who may or may not be distracted, this research attempted to find commonalities among drivers and further understand driver behavior while distracted. This type of mobile observation had the ability to shed light on natural driving behaviors without driver manipulation. There was a need for information regarding driver behavior while distracted and distraction through use of mobile observations. By analyzing distracted driving behavior, transportation engineers can incorporate various elements into the roadway design in an effort to enhance traffic safety.Additionally, there was a need for an expanded analysis of the typical approach to interpreting the role of distraction from typical crash analyses, distracted driving crash report analysis and identification of key words that may indicate a crash caused by driver distraction. After completing a thorough analysis, it was possible to determine if there are any commonalities in the crashes involving distracted driving.

B. Research Objectives

The overarching goal of this thesis research was to expand current research and understand driver distraction. Within the framework of this overarching goal, research objectives were developed as outlined in the following section

Objective 1: Identify attributes of observed distracted driving behaviors and determine which behaviors are more common or detrimental to the drivers' ability to operate a motor vehicle. Completion of the research objective led to an improved understanding of the behaviors that currently exist on the roadway and the behaviors that have potential to lead to a crash.

Objective 2: Understand the role and impact of distraction on crashes. Common elements were found in the crash reports with the key words that indicate distraction was a factor in the crash. In combination with Objective 1, it was possible to link crash narrative reports with similar observed driver behaviors, and there was a better understanding of the events that may take place leading up to the time of a distracted driving related crash.

C. Research Hypotheses

The following research hypotheses have been developed based on the research objectives and from the findings in previous studies:
Hypothesis 1: The number of drivers engaging in distracted driving has decreased and the number of distracted driving crashes has been reduced since the existence of the Motor Vehicles Act (1988), National Highways Act (1995)Law due to an increase in awareness of the dangers of distracted driving.
Hypothesis 2: There are crashes that are categorized as non-distracted, but the narrative portion of the crash report provides evidence of a distracted driving related crash. Distracted driving crashes contain narratives that provide insight to the crash event.
Hypothesis 3: There are definite hot spot locations for distracted driving crashes in distraction study. In particular, it is expected that more hot spots will appear on high-speed roadways and near large cities as opposed to local roads.

1) *Task 1: Perform Literature Review:* A comprehensive literature review was conducted in order to understand past and current distracted driving research. Data collection methods and results from previous research efforts were a key part of this project. There were many distracted driving studies conducted through use of naturalistic instrumentation and driving simulators, but it appeared that no one had published data collected through mobile field observation. This task was initialized and continued through the thesis process.
2) *Task 2: Field Observations* Although states have passed laws against cell phone use while driving and awareness campaigns have been aired on television, radio, and in print, drivers continue to engage in secondary activities while driving. By completing a mobile observation on a high speed roadway, the drivers who were engaging in secondary activities were observed for a short span of time. The aim was to observe distracted drivers in their "natural habitat" as they made the decision to use a cell phone collect data regarding their driving behavior. Before the data collection team was assembled and sent out into the field to observe drivers, several items were addressed. It was important to determine which variables were to be observed and what their level of importance was to the research. A field observation procedure and protocol was then determined so that the manner in which the team performed the observations remained constant. The aim of both of these subtasks was to improve the data quality from the field work so that the results maintained a high level of validity.
3) *Task 3: Determine Variables and Variable Levels for Field Observations* : A list of vehicle, driver, and distraction information of the observed vehicles were recorded by the research team for analysis. Basic information about the location of observation such as timeof day the observations began and ended, roadway type, number of travel lanes, and 21 Speed limit for the given observation area were recorded. If the observation was taken while a vehicle was not at free flow speed (i.e. stopped at an intersection or stopped due to congestion) it was noted by the observer , several variables of interest were determined for the data collection process. The major observation emphasis areas were the following: vehicle type, travel lane positioning, vehicle action, vehicle speed, driver information, and passenger information. The first four boxes described vehicle information, and the fifth box examined the driver's gender, approximate age range, distraction type, and the steering wheel holding position during the distraction. It was important that vehicles with an attentive driver were also be recorded for comparison to distracted drivers. The passenger information of a vehicle was collected for the purpose of determining whether or not the presence of a passenger likely increased or decreased the chance of a driver to operate a vehicle while distracted.

Table 1
Proposed Variables and Variable Levels for Field Observation Data Collection

Vehicle	Travel lane	Action	driver	Age	distraction
Passenger	Left	Passing	Male	16-19	Cell talk
Suv	Right	Non passing	Female	20-39	Cell touch
Pickup	Other	Other	unknown	40-59	Ipad
Mini-van	left			60+	Other
Commercial	left			Unknown	No

IV. RESULTS

The results from the various project tasks and analyses of the data that were completed in response to the stated goal of expanding current research and understanding of driver distraction are presented in the sections below in a format consistent with the methodology. More specifically, results are presented for the field observations, crash report analyses, and narrative search analyses, respectively

A. Field Observations Results

The motivation of the mobile distraction observation task was directly rooted in the desire to evaluate firsthand the prevalence and role of distraction from vehicles within the traffic stream. Many of the direct observation studies completed to date are limited to solely intersection locations with varying degrees of vehicle movement. To that end, a mobile distraction observation study was carried out as outlined previously in the methodology section. Both qualitative and quantitative observations were made on a selected sample of roadways with diverse characteristics. The selected roadways varied across several key independent variables, including number of lanes, shoulder width, speed limits, and traffic conditions. To capture observation data, a single driving observation period was typically segmented into various components with similar cross-section and traffic attributes. The segment designation allowed for the observers to note any changes in roadway characteristics, such as lane configuration or speed limit. For example, if an interstate expanded from two lanes to three lanes, this lane configuration change indicated an end point for the previous segment and a starting point for a new recording segment. This was done so that the driver observations could be analyzed according to similar roadway configurations from different driving periods.

B. Variables and Variable Levels for Field Observations

As noted previously the direct observation experiment was initiated with two separate beta test drives, which provided an opportunity to refine the data collection approach and variables that were possible to accurately capture. For example, some of the initially desired variables proved to be a bit complex for capturing in the field when traveling at high speeds. By comparison additional areas of information were also introduced to help clarify certain aspects of the selected variable levels. A revised version of the form was created and used for the duration of the data collection effort. The revised form is presented

Table 1: Variables and Levels for Field Observations

Vehicle	Travel lane	Action	Driver	Age	Distraction	Holding position
Passenger	Left	Passing	Male	16-19	Cell talk	12.00
Suv	Middle	Non passing	Female	20-39	Cell touch	3.00/9.00
Pick-up	Right	Stopped	Unknown	40-59	Ipad	6.00
Minivan	Other	At crosswalk		60+	Other	Other
Commercial		Other		Unknown	No	

C. Field Observations Procedure and Protocol

During the first beta test drives, the procedure and protocol described within the methodology was slightly revised in an effort to obtain highly-accurate observations in an efficient manner. The original concept was to have one observer dictate observed variables as a driver passed or was being passed while a different research transcribed the results to an observation sheet. Conceptually the idea seemed logical, however this task proved more difficult to reliably capture observations in the field. As a result, each research observer in the vehicle (excluding the driver) made independent observations and recordings. To avoid duplication or missing a vehicle, the research team would assign approaching vehicles to a specific researcher. There was no selection process for deciding which vehicles were recorded because the goal was to record every surrounding vehicle. Throughout the observation process, the driver remained exclusively engaged in the driving task.

D. Field Observations Results

The resulting field observation trips resulted in a total of 1,575 recorded driver observations. Detailed results for across each of the captured variables are provided in the sections that follow. The variables that were collected include the following:

- Vehicle Type (Commercial, Mini-van, Passenger, SUV)
- Vehicle Travel Lane (Left Lane, Middle Lane, Right Lane, Other)
- Vehicle Action (Passing, Non-passing, Stopped, At Crosswalk, Other)
- Gender (Male, Female, Unknown)
- Age (16-19, 20-39, 40-59, 60+, Unknown)
- Distraction Type (Cell Talk, Cell Touch, iPad/Tablet, Other, No Distraction)
- Holding Position (12:00, 2:00/10:00, 6:00, Other)
- Passenger Age Group (Elder, Adult, Teen, Child, None)

- Passenger Child Information (1 Child, 2 Children, 3 Children)
- Passenger Seating Position (Seated Front, Seated Back)
- Passenger Action (Alert, Cell Use, Sleeping, Other)
- Roadway Characteristics (Speed Limit, Shoulder Width, Traffic Conditions, Pavement Wet/Dry, Start Boundary, End Boundary)

The distraction categories of cell talk, cell touch, no distraction, and other were recorded for each of the 1,575 vehicles. The number of occurrences and percentages of observations for each distraction are provided in The option of "Other" was also accompanied by notes recorded by the research member. The type of "Other" distraction varied, but were also summarized in where the "Other" activity description and number of times the activity was recorded are provided. Categories that had only a single occurrence were grouped into the "Miscellaneous" description type. The "Miscellaneous" activity types include the following: driver had eyes closed/was sleeping, driver was brushing hair, driver was distracted by dog in the car, driver was drinking a beverage, driver was wearing a Bluetooth device, and driver was talking along with the radio.

Table 2 Distraction Type "Other" Descriptions Count (source- self taken)

DISTRACTION TYPE	COUNT
Driver was applying makeup	6
Driver was eating	23
Driver was reading papers	4
Driver was smoking	12
Driver was touching GPS	2
Driver was using Bluetooth	3

of interest was the action of the vehicle at the time the observation was made as it relates to the driver's likelihood of engagement in a distracting task. The two categories of non-passing and passing were recorded in relation to the motion of the vehicle containing the research team.

E. General Trend

The general trends and analyses were constructed using 2012 and 2013 crash data which are representative of the most recent years of complete data. An item of interest was the number of distracted crashes for various ages over this two-year period. As a base condition, the distracted crashes for 2012 were filtered by using the crash data with driver age, driver contributing code "Distracted Fault", and the year 2012. This information was trimmed and is depicted in Figure 8. As shown, the highest number of distracted crashes in 2012 happened for those who are 19 years old (1,077 crashes). In general the number of distraction related crashes was significantly higher between the ages of 16-19 as compared to all other ages. This age range corresponds to the age range used for the field observations because it is a target age group for distraction involved crashes due to driver inexperience and high technology dependence

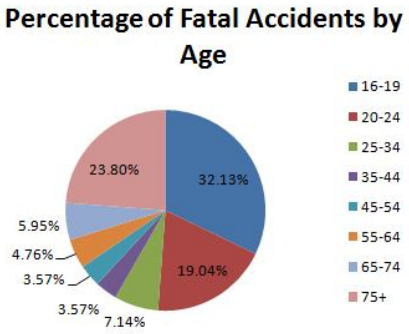

Fig 2
Number of Distracted Crashes by Age for 2012

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V. CONCLUSIONS AND RECOMMENDATIONS

Distracted driving laws in the state of Indian are not as tough as some other states, but they do restrict the use of cell phones for drivers, and contribute to reducing the number of accidents caused by distracted drivers. The current law went into effect in July, 2011 Motor Vehicles Act (1988), National Highways Act (1995),, which stipulates higher fines and imposes restrictions on the use of other electronic devices While driving, in addition to cell phones. Unlike some other states, Indian does not have a hand-held ban for all drivers, but it does ban all drivers from text messaging. This means that drivers older than 18 are allowed to use hands-free cell phones.

A. Novice Drivers

Novice drivers, which means drivers under the age of 18, are prohibited from all cell phone use, which means that they are not allowed to talk on their cell phones or compose or send text messages while driving, be it on a hand-held or a hands-free device. Furthermore, they are not allowed to use any sort of electronic device behind the wheel. This is a primary law, which means that a police officer does not have to witness some other traffic violation in order to pull you over.

B. Text Messaging Ban

Since texting while driving is a huge distraction, there is a ban on text messaging for all drivers. This is also a primary law, and the minimum fine for everyone who breaks it is 1000, with the maximum fine set at 5000

D. Field Observations

The field observations were completed in an effort to standardize an additional method for driver data collection. Since there was no prior research to base the procedure on, there were several slight changes that were made as the research progressed. It was not surprising that more people seemed to engage in distracted behaviors on roads with lower speed limits. There is a sense of lower risk when a driver is using the phone on a 35 KMh arterial or local road rather than a 65 KMh interstate. The data collection process went fairly well with limited issues. Since nearly all of these observations were taken from a passenger car, it would have been better to make observations from a higher vehicle such as an SUV. This way, the collectors would be able to look either slightly down or directly into vehicles due to the raised seat height. Additionally, the data was collected in hardcopy form on printed spreadsheets and then entered manually on an electronic spreadsheet for all 1,575 driver observations and accompanying variables. It would be time and cost efficient to transform this spreadsheet into an interactive electronic application of some sort, and perhaps this could be done using a touch screen tablet. Since all of the data was collected without having any information on the passing drivers, there is no way to know how accurate the age data was. It was especially difficult to determine whether a younger driver was 16-19 years old or 20-39 years old, so a driver who was 18 years old may have been categorized as 20-39 years old. Perhaps some training could be established in order to help a research team determine various ages for drivers of different genders and ethnicities. On roadways where traffic was moving at a slower speed, it was easier for the research team to collect data without feeling rushed because fewer cars would pass quickly due to the nature of the road.

E. Crash Report

The subtasks within the crash report analysis provided insights about the trends and challenges Some issues with the crash data involve various typos in the electronic system due to human error. For example, many ages were listed as negative numbers or numbers extending beyond 600 years old. These errors may cause the results of this study to be slightly off or underestimated. For the purpose of this research

F. Crash Report Narrative Double Blind Search

The crash report narrative demonstrated that there is a broad range of words or phrases that may indicate distraction, and every crash narrative is unique. Some narratives are informative and give detailed information while others lack a thorough description and do not explain why the report was labeled as distraction involved. This inconsistency is often a problem with crash report narratives across the various crash codes. Several distraction involved crashes did not have specific key words or phrases that indicated distraction, so the reviewer ultimately decided that the narrative referred to a non-distraction related crash. On the other hand, some of the randomly pulled non-distraction related crashes contained key words or phrases that indicated distraction, and these narratives were incorrectly categorized by the reviewer as distraction related.

G. Future Research

This research contributes to the continuous research within the field of distracted driving, and it is the first mobile observation research of its kind. It provides a new methodology for realtime data collection, and it also allows potential windows for future research. Some of the previously mentioned recommendations could be taken into account and a research team could 60 attempt to replicate the data collection procedure. One item of interest would be to determine a popular time of day for distraction involved crashes. This could be done through the use of field observations and crash report analysis. It is evident that crash reports often leave out crucial areas of information or the cause of the crash is labeled incorrectly. Future research might include training for distraction involved crash identification. Police may need to use some of the key words of phrases that indicate distraction so that there is no confusion about whether a crash was or was not caused by distraction. Since distraction has somewhat of a broad definition, it can often be confused with driver inattention.

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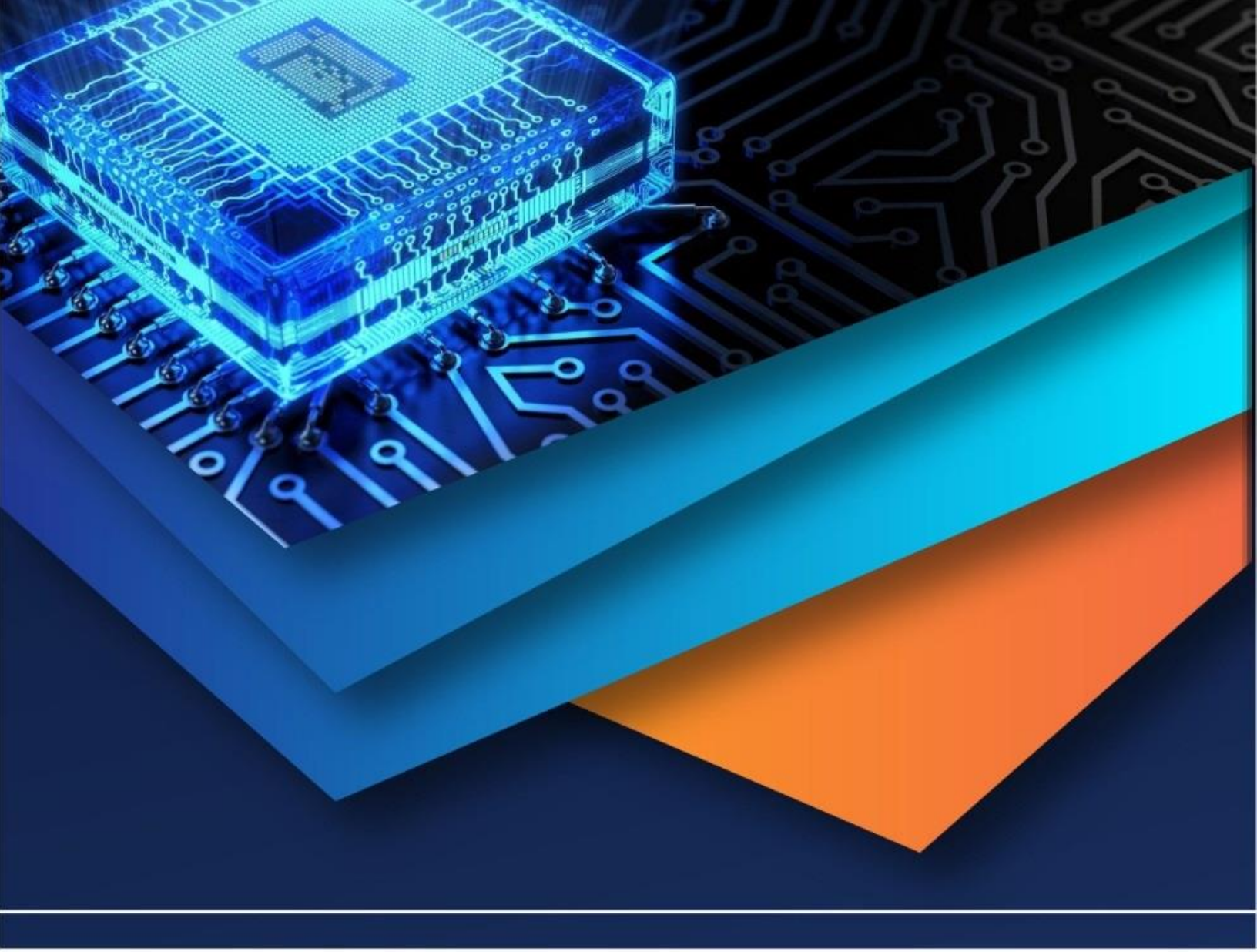

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