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Operations Research in Theme Parks

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Abstract: ***The service sector all around the world has been growing at an increasing rate. While services such as airlines and telecommunications have been at the forefront of this growth, the theme park industry has also created a space for itself in this industry. This paper describes a) How we can use linear regression to come to the conclusion of visitor flow on the profits of not only the theme parks through tickets, but also the stores within these theme parks b) The importance of wait time in queue and well distributed visitor with solution to reduce the total wait time c) Use of Linear Programming Problem to optimise limited resource allocation for the achievement of goals.***
Keywords: Theme Parks, Visitor Flow, Regression Analysis, FASTPASS, Operations Research

I. INTRODUCTION

A Harris Poll survey showed that 78% of millennials would choose to spend money on a desirable experience or event over buying something desirable whilst 72% said they wanted to increase their spending on experiences rather than physical things.
Worldwide spending on theme parks surged by 5% to a record $44.8 billion in 2017 driven by the increasing importance to consumers of posting photos on social media.
According to a report from IAAPA, “an emerging trend is the growing preference among consumers to spend on experiences rather than products. This same trend is believed to also be contributing to on-going growth for theme parks, which market their unique experiences.” By 2022, about 601.2 million people are expected to visit parks in Asia Pacific region. This would be further driven by new openings including Universal Studios Beijing, which is expected to be the world’s biggest theme park development.
Operations Research is the application of scientific methods, techniques and tools to problems involving the operations of a system so as to provide those in control of the system with optimum solutions to the problems. It helps in maintaining better control, better decision making, better coordination of departments and increased business productivity.

1) Some of its applications in the business world include solving;
a) Problems dealing with the waiting line, the arrival of units or persons requiring service.
b) Problems dealing with the allocation of material or activities among limited facilities.
c) Equipment replacement problems.
d) Problems dealing with production processing i.e., production control and material shipment.
2) Research Operations can improve the efficiency of theme parks in various ways.
a) Park Operations: Operation at capacity, efficiency programs
b) Hotel Optimization: Front desk queuing, allocation of rooms, laundry facility optimization
c) Project Development: Theme park development, new products and services, premise expansion
d) Queuing theory
e) Fast pass (Disney)
f) Efficient pricing strategies
g) Cleaning the rides and park
h) Forecasting and simulation

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A. Overview

Theme parks can be defined as a subset of visitor attractions. Visitor attractions are described as permanent resources which are designed, controlled and managed for the enjoyment, amusement, entertainment, and education of the visiting public
Theme parks are star players and the main motivators in the tourism industry, and play a special and important role in generating tourism demand. They are core elements of the tourism product. Competition in the theme park market is growing also in terms of an increasing number of parks, but also relative to other uses of leisure. But in different areas, the theme park market in seems to be

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reaching its saturation point and the parks have to cater for visitors who are getting more and more experienced and demanding. Given these trends of growing theme park supply, environmental constraints and increasingly discriminating consumer demand, it can be concluded that theme parks, to survive in this competitive market, must optimize is, given an ever-increasing number of parks and future trend of consumer behaviour.

The main features that distinguish theme parks from other kinds of visitor attractions are:

1) A single pay-one-price admission;
2) Charge;
3) The fact that they are mostly artificially created;
4) The requirement of high capital investments.

Theme parks attempt to create an atmosphere of another place and time, and usually emphasize one dominant theme around which architecture, landscape, rides, shows, food services, costumed personnel, retailing are 636 orchestrated. In this definition, the concept of themes is crucial to the operation of the parks, with rides, entertainment, and food all used to create several different environments. Since the end of World War II, the number and range of theme parks available to consumers has multiplied dramatically. The rise of car-ownership has increased mobility and allowed people to visit more isolated parks in their own countries that were previously inaccessible. Rising affluence has increased the amount of free time. Also, longer weekends and increased paid holidays have helped to stimulate the expansion in theme park visits. Furthermore, the growth of tourism in the past fifty years and the recognition of the economic benefits of tourism have led to the growth of purpose-built attractions, such as theme parks, specifically designed to attract tourists, and to encourage them to spend their money. Disney was the first to introduce a special and new style of parks around a number of themes or unifying ideas to sanitize the amusement park for the middle classes. The modern-day techniques for reproducing landscape, buildings, and arte facts can create a reality in theme parks that has been previously the preserve of film and theatre. Through changes in transportation technology and social attitudes, downtown industrial and residential land has become redundant. This strong consumer demand has resulted in the development of many parks. These parks are not only growing rapidly in size and importance, but also are investing substantial amounts in new entertainment and facilities, and extending their services into relatively unexplored areas such as catering and accommodation (Raluca & Gina) (Anonymous).

B. Research Objectives

1) To understand different operations research models and methodology used in theme parks.
2) To understand and elaborate the impact of visitor flow on store profits within theme parks
3) To find how visitor flow can be directed to be equally spread through the park instead of being concentrated in selected areas.
4) To elaborate the ways in which wait times can be managed for different rides.
5) To outline how operations research works in theme parks.

C. Research Methodology

In order to discover some meaningful information related to the research following methods have been used:

1) Quantitative methods, i.e., existing data from research papers for measuring, ranking, categorizing, identifying patterns and making generalizations. Through this we aimed at producing generalizable knowledge about the application of Operations Research at various Theme Parks.
2) Also, a deep study was done to understand and elaborate the impact of visitor flow on store profits within theme parks
3) Statistical techniques were used to analyse the data retrieved and helped to find out how visitor flow can be directed to be equally spread through the park instead of being concentrated in selected areas and the ways in which wait times can be managed for different rides.

II. LITERATURE REVIEW

Today, not only do ticket sales make money for the theme parks but profits also come from merchandise sales from shops located in the park. Using regression analysis, we can find out how visitor flows can affect profits for these stores. Analysis from Ahmadi & Rajaram (2202), taking example of Universal Studios Hollywood, shows that the total store profits are strongly impacted by visitor flow levels. However, the total store profits are negatively correlated with the estimated number of visitors in areas 2 and 3 (i.e., at the bottom section and backlot tour). On the other hand, they are positively correlated for all other areas. This is because stores in areas 2 and 3 contribute a smaller share to total store profits than other stores (Ahmadi & Rajaram, 2002). The same theory can also be applied on amusement parks in India, such as Adlab's Imagica or Essel World.

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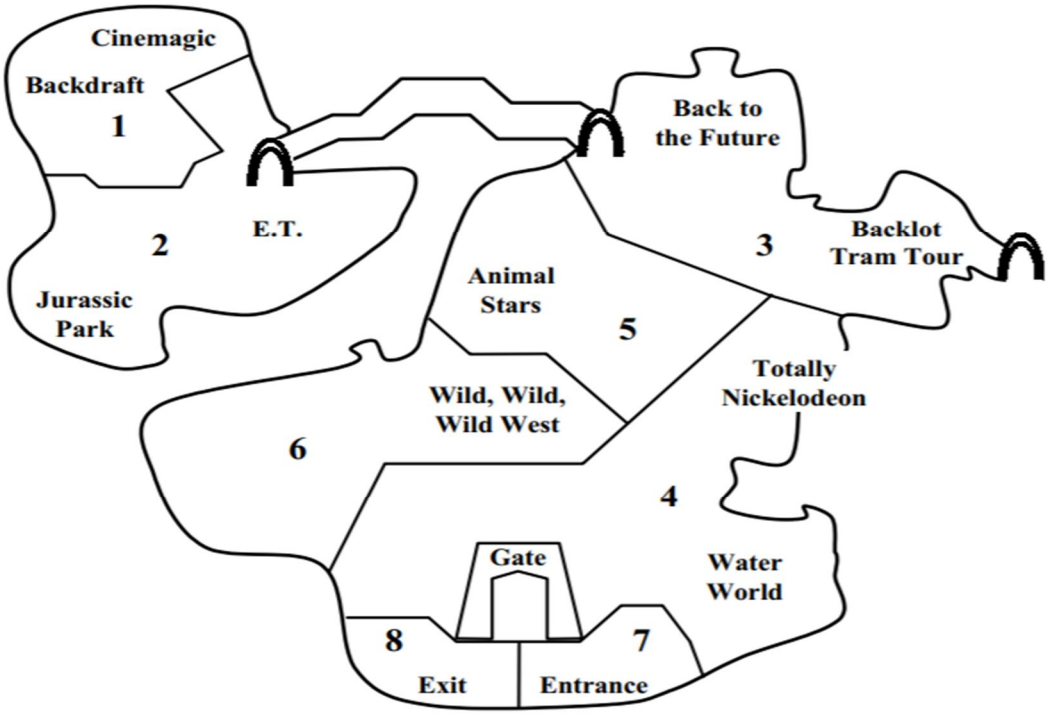

Fig: Layout of Universal Studios Hollywood.

Rajaram also makes use of linear regression to make a model to analyse how capacity and schedules are affected by visitors flows and how they can be linked to maximise store profits. Analysis of store profits can help find stores which are not making as much profit as others and what are problems that they facing which is leading to this. Also, using regression, the paper gives a flow management model which not only helps in scheduling of rides with respect to visitor flow but also helps in deciding the capacity and whether it needs to be changed by either increasing (decreasing) the number of carts or the workforce which is assigned for operating the rides. The objective function of all these analyses is to maximise profits, by optimizing the use of capacity and scheduling (Rajaram, 2000).

Ahmadi in another paper, 1997, has given models to how capacity can be managed during different times of the day and different seasons. He developed a tour design model, which gave different touring routes for the entire park. This allowed visitors to be equally distributed around the park, avoiding concentration in one area, which would not only reduce profits of stores in other areas but also impact wait times, with wait times being very high in areas of high concentration and vice versa (Masson & Wang, 1990).

One of the most important factors for customers in theme parks in the waiting time for rides. Nowadays, many theme parks have started having boards in queue areas showing the estimated wait time for that particular ride. The wait time is always shown in respect of the last person standing in queue. The calculation of wait time is useful because wait time has a bearing on customer satisfaction (Xu, 2013) (Wells, 1989) and if the management think that wait time is becoming too much then they can increase the capacity of the ride, which will have no bearing on ride time (Ahmadi, Managing Capacity and Flow at Theme Parks, 1997) while reducing wait time at the same time.

The total cycle time (CT) for each car would be

$CT = T(R) + T(L) + T(U)$

Where,

$T(R)$ = Total Ride time

$T(L)$ = Total Loading time

$T(U)$ = Total Unloading time

However, the next ride will start not at the end of the CT but after the minimum time required between start of two cars (Tibben-Lembke, 2007). In case a ride only has a single car in operation at a given point of time, the waiting time for the next few people in

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line would be equal to the cycle time of the ride. Cycle time because only once have all passengers been unloaded that the loading can start for the people in queue next.

Now to calculate wait time for a ride the formula would be:

For rides with multiple cars operational at a given time:

T(W) = [T(S) * (number of people in queue/capacity of each car)^] – time elapsed since start of CT of previous car

For rides with a single car operational at a given time:

T(W) = CT * (number of people in queue/capacity of each car^) - time elapsed since start of CT of previous round

Where,

T(W) = Total wait time

T(S) = Time required between two cars (for safety purposes)

^ *where the figure is rounded off to the next whole number*

For example, there's a ride, operating multiple cars at once, called 'Alibaba' in the amusement park Imagica, let's assume it has capacity of 50 people per car and there are 3 cars in total. Taking the approximate times as follows:

T(C) = 6 minutes

T(S) = 2 minutes

Suppose the ride starts at 10:00 am. The first 50 people will be let in immediately. the next 50 at T(S) which is 2 minutes, at 10:02 on Car 2, the next 50 at 10:04 on Car 3. When it's time for the next 50 to be seated, at 10:06, Car 1 would have been back after completing its cycle time.

Now suppose a person enters the queue at 10:01 and is the 141st person in line at time of entering. The wait time for him would be

WT = [T(S) * (number of people/capacity per car) ^] - time elapsed since last ride

^*multiplied with T(S) after rounding off the next whole number*

So,

WT = [2 * (141/50)] - 1

WT = [2 * 3] - 1

WT = 6 - 1 = 5 minutes

As we know from the above illustration that he would be accommodated on Car 1 at 10:06, the same can also be proved as follows:

10:06 - 10:01 = 5 minutes

Now for a single car ride, another example from Imagica is the ride 'Scream Machine, the approximate timings were as follows:

T(L) = 1 minute

T(R) = 4 minutes

T(U) = 0.5 minutes

Therefore, CT = 5.5 minutes

Assuming ride capacity being 80 people

Using the same example above, with the formula for single car rides, the person entering the queue at 10:01 would have to wait:

WT = [CT * (number of people/capacity per car)^] - time elapsed since start of CT of last previous round

WT = [5.5 * (141/80)] - 1

WT = [5.5 * 2] - 1

WT = 11 - 1 = 10 minutes

As said before, that changing of capacity has no effect on cycle time, hence, calculation of wait time does not only have benefits for amusement park goers to make decisions, but it also gives insight to the operators as the weather increase/decrease capacity to have the queues moving at a brisk pace without having any idle time.

The above wait time is calculated on the basis of the last person standing in time. However, if the numerator is less than the denominator then the wait time would be T(S) and CT for multiple car rides and single car rides, respectively.

In recent times, major amusement park chains, such as Disney and Universal Studios are realising the increasing problems caused by long queues (Nip, 2014). The tackle this solution they are getting priority systems in place in the form of fast track queues. This allows the customers to enter the ride from a priority queue by paying a small (and sometimes even high) premium for the ticket (Milman, 2001). Not only do these systems bring extra profits for the parks but they are also being used to gather data for analysis which will help improve visitor flow models and provide personalised services. In the paper Priority Systems at Theme Parks from the Perspective of Managers and Customers, there is a regression analysis of customers' attitudes towards priority systems and if it impacts their purchase of a priority pass (Hernandez-Maskivker & Ryan, 2016). The purchase of a priority pass depends on the

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perceptions of the customer, it has everything to do with what the customer thinks about such systems. A customer is more likely buy such a pass if he feels that its time saving, while those who think it's a waste of money and wouldn't help much are less likely to buy one. The research done till now doesn't show that there is anything else which can influence customers on this subject.

Theme Parks also make use of revenue management practices which is basically charging different prices to different days, such as weekdays and weekends and can create different packages as well, such as all rides inclusive, kids inclusive, or a pass like FASTPASS by Universal Studios which provides different queue for such pass holders which is generally shorter.

Some theme parks like Disney, their success heavily depends on providing customers with consistently pleasant and at the same time enthralling experiences, crowded theme parks and long waiting times pose a very serious threat to the park. One of Disney's most critical innovations, the FASTPASS, addresses to this dilemma.

Disney's FASTPASS is a virtual queuing system. FASTPASS allows customers to hold a spot in line for a popular and busy ride, but instead of physically waiting in line, they can enjoy other attractions during their wait and come back as soon as their turn comes at zero additional cost. This allows Disney to smoothen out the demand for the most popular rides over the course of the day (Albert, 2013) (Trefis Team, 2015).

At each attraction, a certain number of seats are set aside for FASTPASSes every day. The number of FASTPASSes available is then evenly divided into five-minute time intervals. As customers obtain FASTPASSes throughout the day, time intervals are exhausted, pushing back the return time window (Ali, 2015) .

Operations Research also helps Theme Parks in project planning, such as where to locate the park; how many ticket booths, turn styles, and strollers will be needed; planning train lines between locations how to select the mix of attractions and lay them out in a defined way; how much merchandise space to set aside; deciding the routes of parade; how to handle the "wastes" that happen when a show gets over; how to locate your favourite; how to plan backstage areas to coordinate pretty complex shows; and locate and run hotel services (Lillestol, Timothy, & Goodman, 2015).

FORECASTING SERVES AS the analytical foundation for operations planning at the theme Parks. It all starts with the forecast of park attendance, which lays out the expected attendance at each park. These predictions are strongly considerable when setting park hours and performing other strategic planning. In addition to this, data mining is used to understand what vacation packages are most appealing and enticing to different types of guests. This analysis, coupled with optimization models, allows the company's Web site and the call centre agents to present offers that provide a more customized and pleasurable vacation planning experience (Buczkowski & Chu, 2012)

Linear programming (LP) is a mathematical technique which is used by Theme Parks to optimize limited resource allocation for the achievement of decision-making goals.

The technique is mainly used for profit maximization or cost minimization issues and gives both the objective function and the constraints condition in linear forms. Data envelopment analysis DEA is a linear programming technique to maximize the ratio of output weighted sum to input weighted total under the constraints condition that the ratio should not exceed 1 while each input factor and output factor's weighted values exceeds 0.

To find the relative efficiencies of the DMUs, DEA is conducted using the installation area, the installation cost, and annual repair cost of the attraction as input factors and the number of annual users and customer satisfaction as output factors. Of the input factors, the installation area and installation cost are fixed costs while the annual repair cost is a variable cost. The number of annual users, which is one of the output factors, represents how frequently the attraction was used each year and thus includes considerations of the waiting time.

Using all the data collected further calculation are done (Kim & Kim, 2016) (Buczkowski & Chu, 2012).

III. FINDINGS

A. Higher visitor flow has a positive correlation with increase in store profits.

B. Visitor flow when well spread across the park leads to higher store profits and when concentrated in selected areas leads to decrease in profits of store.

C. Wait time has a direct impact on customer satisfaction. Hence it is important to use methods to decrease the wait time whenever necessary or otherwise.

D. Forecasting give predictions which are strongly considerable when setting park hours and performing other strategic planning which ultimately provide a more customized and pleasurable experience.

E. Using Linear Programming we can maximize profits and minimise costs.

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IV. CONCLUSION

Handling visitors has a direct bearing on the overall profitability. It is always preferable to have a well distributed visitor flow rather than concentration in select areas. This is shown to have a positive correlation with merchandise sales in parks. A well distributed flow also helps reduce wait time for ride which is essential as it has a direct bearing on customer satisfaction.

Efficient management at theme parks will lead to lower and desirable waiting time and optimal utilisation of the park's services, facilities and products. There might be wastage of efforts and resources which might result in reduced profits if the management sciences are not properly used. There are various factors and constraints to be considered in different theme parks. Theme parks in Japan have seen more tolerance in visitors regarding the queue time compared to the theme parks in the US. With the help of Operations Research, the management can understand the theme park analytics through forecasting, simulation etc. Through various models of Operations research, these parks can gain exclusive profits and efficiency in operations.

Forecasting is a very good analytical foundation for operations planning at the theme parks. Regression techniques have been used to optimise the wait time for different rides since this has a direct correlation with customer satisfaction.

Hence, Operations Research is intensely helpful in various day to day as well as sporadic activities inside a theme park. From the minute the customer enters till the time they leave and even after that, OR is in use.

V. LIMITATIONS

A. Lack of technical knowledge about the subject
B. Didn't have access to powerful and digital computers
C. We didn't get a chance to get primary data
D. Also we weren't able to test the model and the formulae
E. Models had limited variables but there can be n number of variables that has an effect on visitor flow and profit. Adding more variables would have made the model more complex for understanding it and for calculations.

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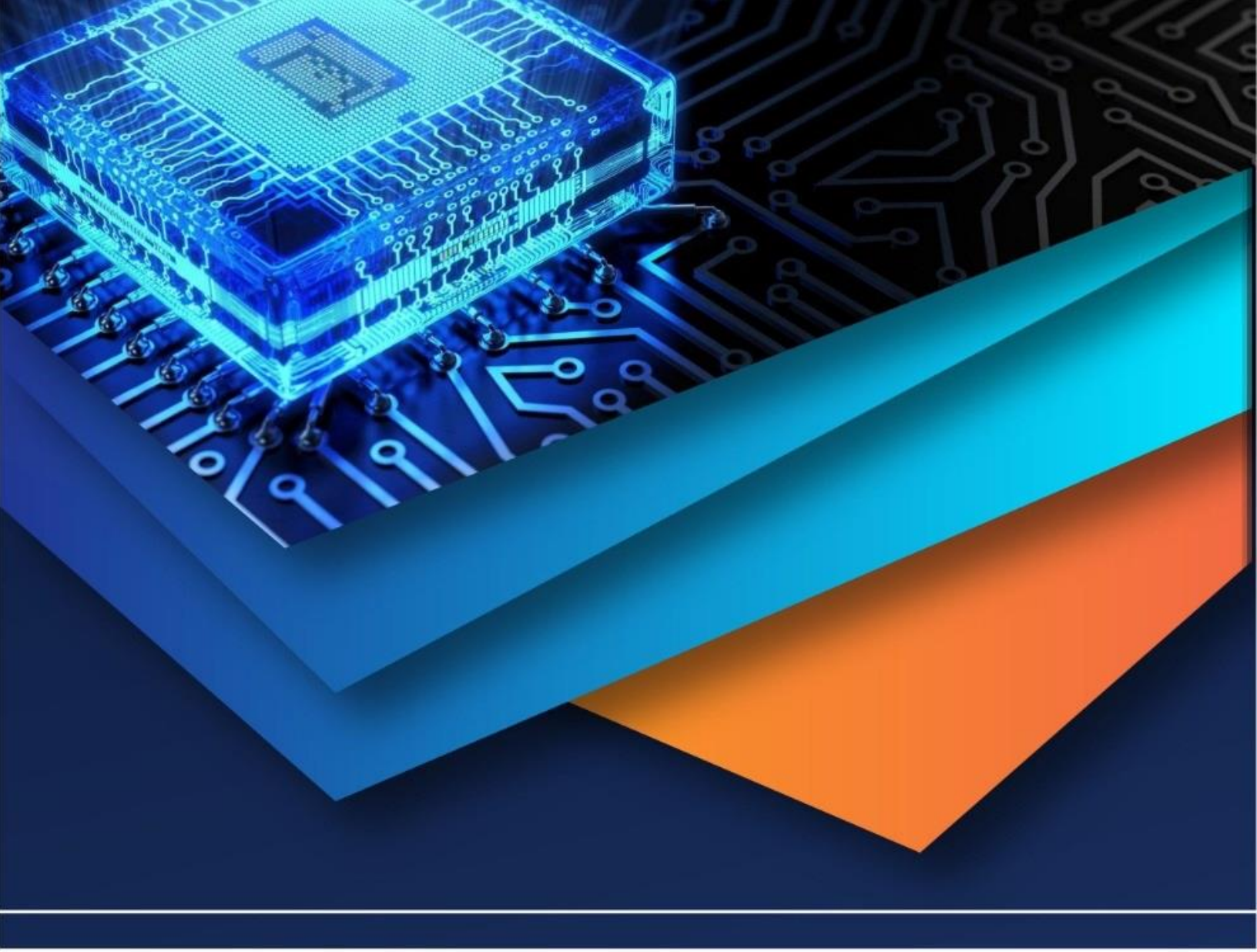

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