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Mine Blast Algorithm

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Abstract*: Optimization is technique by which we can do our work in most efficient way as possible. This can be achieved by reducing no. of calculations in particular algorithm or reducing work done in any of the task. Mine blast algorithm is a new optimization algorithm which is population based algorithm for solving constrained engineering problems. Computational effort that is number of evaluating functions are less and the results of the computations are perfect. More than fifteen constrained problems are solved by Mine blast algorithm and results are more accurate. An introduction and detail about the algorithm as well as one application which is using mine blast for optimum results is also described in detail. The name of the application is speed reducer problem in which the mine blast algorithm is used to get the optimal results of the parameters which are optimal if we get as less value as we can. This result is compared with various other algorithms and hence mine blast algorithm proved to be most efficient in giving optimal results.

I. INTRODUCTION

Mine Blast Algorithm is an optimization algorithm that is used to solve many constrained engineering problems. over the period of time many algorithms had been introduced but this algorithms is proven to give the better results then the other algorithms. This algorithm is novel population –based algorithm. Many algorithms had came that uses on the gradient information for the evaluation, less information leads to inaccurate results and more of the function evaluation. The target of optimization technique is to reduce time, computations, inaccuracy, parameters on which algorithms are based upon.

In this algorithm the concept of mine blast explosion is used.

The main concept is that when the mine blast in real world its shrapnel pieces are spread in different direction with different speed and time and the next is exploded when the shrapnel collide with next mine within a specified area. The initial population is produced when the first mine is blasted. Lets assume a situation in which there is a mine field in which there are so many mines plotted under the ground and to clean up the mine field is the main purpose. One optimal point is taken in the starting where the first mine is blasted and the shrapnel of that mine will lead to blast the other mines proceeding in this direction we will get next optimal point. The first optimal point from where the maximum causalities caused is denoted as X* and the causalities caused are defined by min and max function (f(x)) per X* . Bombs of different sizes and powers are pointed under the ground .When a mine bomb is exploded many of its shrapnel pieces causes the causalities which are calculated as the direction and distance of each shrapnel is different. One shrapnel can cause many causalities that indicates the explosive power of that bomb. These will lead to the clearance of the mine field. The solution domain is field divided into the grids.

II. RELATED WORK

Mine Blast Algorithm provides the accuracy in results and leads to less function evaluations and the work is done in a specified domain.

Algorithm have an initial point is the starting where the first mine is blasted known as the initial point or first shot point.

It is denoted as the Xf0.

f is number of first shot points(1,2,3,4…) and it is a user defined parameter.

The population is generated by the first shot explosion which is denoted as the initial population(N_{pop}) and that is number of shrapnel(N_s).In this algorithm have lower and upper bound values which are provided in the problem. Now, the first shot point is calculated by the Equation (1):

X_0=LB + rand * (UB-LB)

Where X_0,LB and UB are first shot point, lower bound, upper bound and rand is uniformly distributed random number between 0 and 1.

Now, the Equation (2):

X={X_m}, m=1,2,3….N_d

N_d is search space dimension which is equal to number of independent variables. Now, the location of another mine bomb is given by Equation(3):

$X^f_{n+1}=X^f_{e(n+1)}+\exp\left(-\sqrt{\frac{m^f_{n+1}}{d^f_{n+1}}}\right)X^f_n,$ n=0,1,2,3…. (3)

D is distance, m is distance. now the location of exploding bomb is given by Equation(4):

$X^f_{e(n+1)}=d^f_n \times \text{rand} \times \cos(\Theta)$, n= 0,1,2…….. (4)

D is the distance to find next optimal point, theta is angle of the shrapnel pieces and is calculated as 360/Ns. The distance and the direction of the shrapnel is calculated by Equation(5) and Equation(6):

$d^f_{n+1}=\sqrt{\left(X^f_{n+1}-X^f_n\right)^2+\left(F^f_{n+1}-F^f_n\right)^2}$ n=0,1,2,3 ..(5)

$m^f_{n+1}=\frac{F^f_{n+1}+F^f_n}{X^f_{n+1}-X^f_n}$, n=0,1,2,3……….(6)

F is the function value for the X. To check the exploration that is the range of the area or space smaller and larger

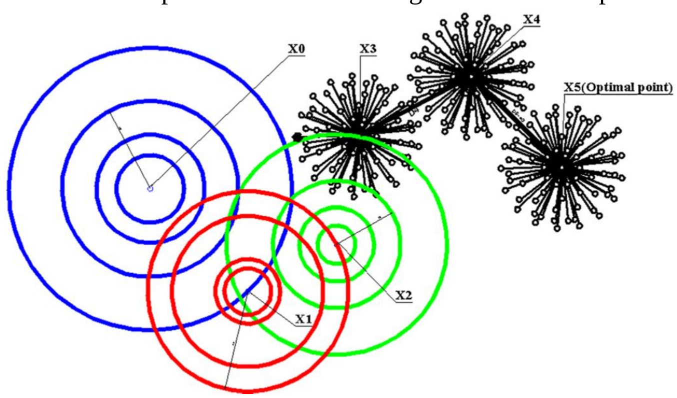

Fig 1: Exploration area of mines when the mines are blasted.

distances the exploration factor(u) is used. The condition on the exploration factor is checked as:
If(u>k)
Exploration(Equation(7) and(8)
Else
Exploration(Equation(4)(6) and(9)
End

K is iteration number index. for the solution space the Equation(7)and (8):

$d^f_{n+1}=d^f_n \times (|randn|)^2$, n=0,1,2…….. (7)

$X^f_{e(n+1)}=d^f_{n+1}\times \cos(\Theta)$, n=0,1,2 … (8)

For the more accurate and rapid search we need to decrease the area is calculated by the Equation(9):

$d^f_n=\frac{d^f_{n-1}}{\exp(\frac{k}{\alpha})}$, n=1,2,3…. (9)

These were the parameters and the equations used in this algorithm. the functions of every equation is given below:
Equation(1): First shot point value.
Equation(2):current location of mine bomb
Equation(3):location of another mine
Equation(4):location of another mine to be used in previous equation
Equation(5):distance of shrapnel
Equation(6):direction of shrapnel pieces
Equation(7):new distance can be smaller or larger
Equation(8):new location of another mine bomb

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Equation(9):reduced distance.

In the figure no.1 we can see that there are two processes are searching the solution and in first process iterations are being done to get the optimal solution whereas in the second process the focus is set on optimal points. The area is measured according to the optimal point and the exploration is carried out accordingly.

Now we will discuss the constraint handling and termination criteria:

(i)Constraint Handling:

There are some rules based on which the results are derived, these are:

Rule1: over any infeasible solution, feasible solution is preferred.

Rule2: if there is small violation in any infeasible solution then it is considered as feasible solution.

Rule3: if there are two feasible solutions then the solution having better objective function value is taken.

Rule 4: if there are two infeasible solutions then the solution with smaller sum of constraints is preferred

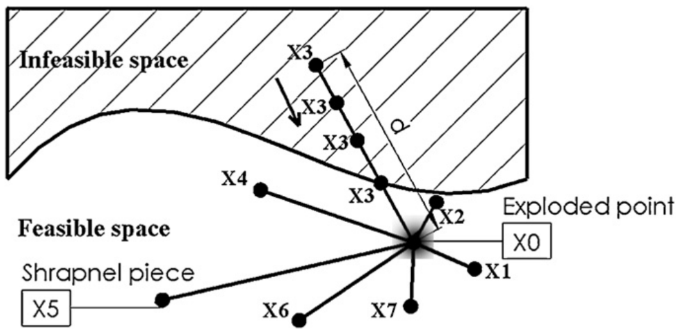

Fig 2: feasible and infeasible area for constraint handling.

The algorithm is terminated when we get the best results are calculated. We can get the best results in this algorithm when the following conditions are true:

a. Maximum number of iterations.

b. Less cpu time.

c. (e) defined as tolerance between the last two results and it should be less.

Steps of MBA:

Step 1: we have to choose the initial parameters N_s, u, a and maximum number of iterations, where a is reduced distanced.

Step 2: the condition of exploration that is (u<k) is checked.

Step 3: now if the condition is satisfied then the equation no. (7) & (8) are applied to calculate the distance of shrapnel. otherwise go to step 10.

Step 4: the direction of the shrapnel is calculated according to Equation no (6).

Step 5: now, the shrapnel pieces are to be generated and their improved location is also calculated using Equation no.(3).

Step 6: for the generated shrapnel pieces the constraints are checked.

Step 7: Temporal solution is saved which best shrapnel piece.

Step 8: Then condition is checked that is if shrapnel piece have lower function value the best temporal solution?

Step 9: Now if the condition is true then the best temporal solution is exchanged with position of shrapnel piece.

Step 10: Now the location and distance of the shrapnel pieces is calculated by using equation (4), (5) and return to step 4.

Step 11: The distance of the shrapnel pieces is reduced by using equation (9).

Step 12: In the final step the termination criterion is checked, if the termination criterion is satisfied then the algorithm is stopped otherwise return to Step 2.

III. APPLCATION

Mine blast algorithm is used in various applications regarding the optimization of truss structure, width factor etc. this algorithm is proven to give better results as compared to the other optimizations like TRGA,GA,EC etc. Here we will discuss the application named Golinski's speed reducer problem deals with the optimization during the design of a gearbox. The objective of the problem is to minimize the weight of the speed reducer (alternately, its volume) while maintaining the maximum efficiency of rotational speed of the two shafts. The speed reducer consists of a gear and pinion and respective shafts. There are 7 design variables and two subsystems for this problem, gears and shafts. Stress, geometric and deflection are the various constraints involved. The weight of the speed reducer includes both the weight of the gears as well as the weight of the shafts.

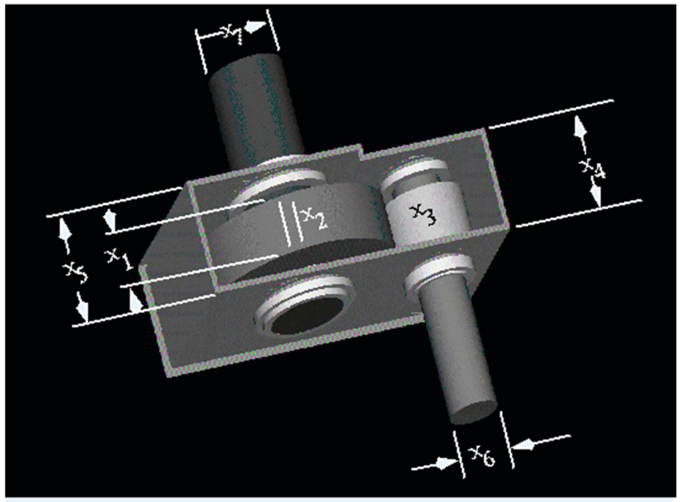

Fig 3. Cylindrical fin heat sink.

IV. PROBLEM DEFINATION

The objective of Golinski's Speed Reducer problem is to find the minimum of a gear box volume *f* (and, hence, its minimum weight), subject to several constraints. There are seven design variables, *x1 - x7*, which represent

x1 width of the gear face, cm

x2 teeth module, cm

x3 number of pinion teeth

x4 shaft 1 length between bearings, cm

x5 shaft 2 length between bearings, cm

x6 diameter of shaft 1, cm

x7 diameter of shaft 2, cm

Mathematically, the problem is specified as follows:
minimize *f*, given by:

$$f=c_{f1}x_1x_2^2(c_{f2}x_3^2 + c_{f3}x_3 - c_{f4}) - c_{f5}\,(x_6^2 + x_7^2)x_1 + c_{f6}(x_6^3 + x_7^3) + c_{f1}\,(x_4x_6^2 + x_5x_7^2\,)$$

where the constants are:
c_{f1}=0.7854, c_{f2}= 3.333, c_{f3}=14.9334, c_{f4}=43.0934, c_{f5}=1.5079, c_{f6}=7.477
and the seven variables with their lower and upper limits are
$2.6\leq x_1\leq 3.6$, $0.7\leq x_2\leq 0.8$, $17\leq x_3\leq 28$, $7.3\leq x_4\leq 8.3$,
$7.3\leq x_5\leq 8.3$, $2.9\leq x_6\leq 3.9$, $5.0\leq x_7\leq 5.5$

The constraints can be characterized by

g1 upper bound on the bending stress of the gear tooth

g2 upper bound on the contact stress of the gear tooth *g3, g4* upper bounds on the transverse deflection of shafts 1, 2

g5, g6 upper bounds on the stresses in shafts 1, 2

g7-g23 dimensional restrictions based on space and experience

g24, g25 dimensional requirements for shafts based on experience

V. RESULTS

The speed reducer problem is used in many other types of applications and is one of the standard benchmark problems in structural optimization. Although many metaheuristic algorithms have been developed to solve this problem, these methods cannot guarantee global optimality of the solution. However, numerous break points are utilized in the linearization process for reaching an approximate global solution with a low error, and much CPU time is required to solve the reformulated model. Therefore, this study also adopts the range reduction technique to enhance the computational efficiency. Compared with metaheuristic methods, this study guarantees the global optimality of the solution. Compared with other deterministic methods, this study obtains a better solution with a lower error in constraint.

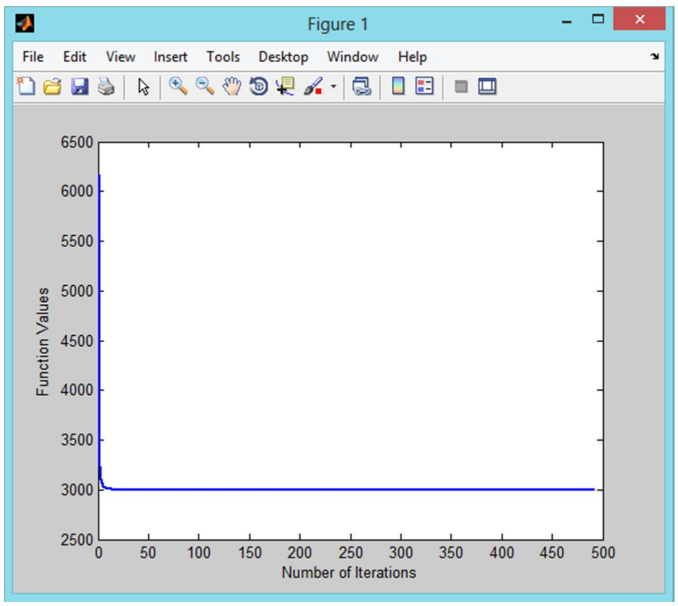

Table 2: shows the number of iterations and the corresponding function values.

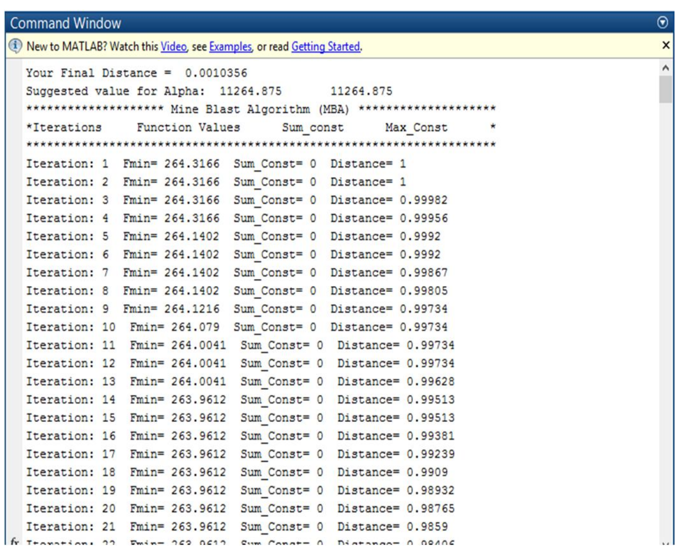

Fig 4: implementation of the mine blast algorithm in matlab.

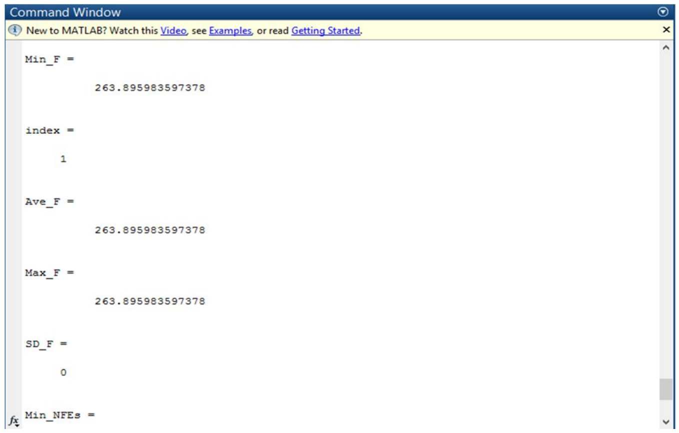

Fig 5:Showing the values of the functions.

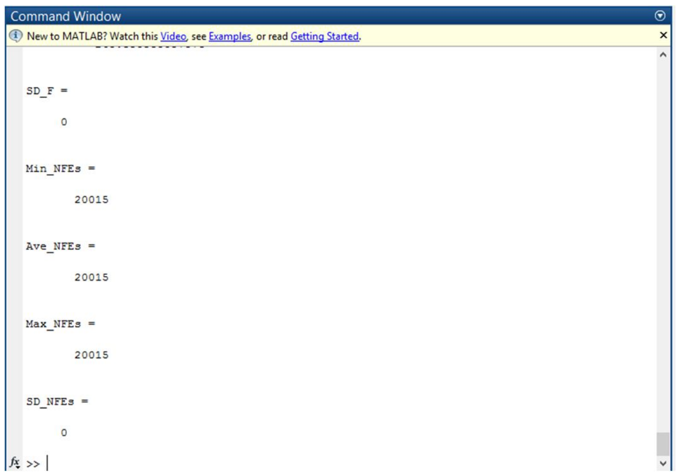

Fig:6: Showing the values of various functions of number of function evaluation.

Hence the mine blast proved to give most efficient results in this application. As compared to other algorithm most optimum results are given by the mine blast algorithm.

VI. FUTURE SCOPE

A. Specified Domain

The exploration area can improved by making the particular domain for the search and efficient results. The exploration factor (u) having the random variable rand, it can be double so that the more area is covered under the search. It will offer the greater extent for research. When the mine bomb is blasted the shrapnel spread in many directions and reaching to the next optimal point so therefore there are more than one path to reach to the optimal point so the both the distances should be calculated and the distance having the minimum value is chosen to reach to that point and the algorithm's exploration area can be much improved in this manner making the algorithm more accurate.

B. Improve Positioning

The prediction of other mines can be done as the when the distance between two mines are calculated. The distance of other mine can be predicted. The position of the optimal points can be chosen more wisely therefore decreasing the difference and increasing the accuracy of the algorithm as it an optimization algorithm aiming at minimizing the results that is being used in the applications. The optimization means to decrease the work load and get the most optimum results as it can therefore if we improve the positioning of optimal points then the calculations will become easy and the will give more accurate and optimum results for various applications.

VII. CONCLUSION

This paper presents the method and procedure of mine blast algorithm. The algorithm have very less number of function evaluation and the accuracy is more in the results. The basic concept of the algorithm is explosion of the mines in mine field and the main aim is to clear the mine field. Many iterations are carried out in this algorithm so as to get accurate and efficient results. The algorithm consists of 12 steps in which various equations are used which are easy to execute. more than fifteen constrained optimization and engineering problems are being solved and the results obtained by them gives better solutions than other optimizers terms of number of function evaluation(computational cost)and objective function for every problem. The quality of solution and computational efficiency obtained by Mine Blast Algorithm depends on the nature and complexity of underlined problem and is true for most meta heuristic methods.

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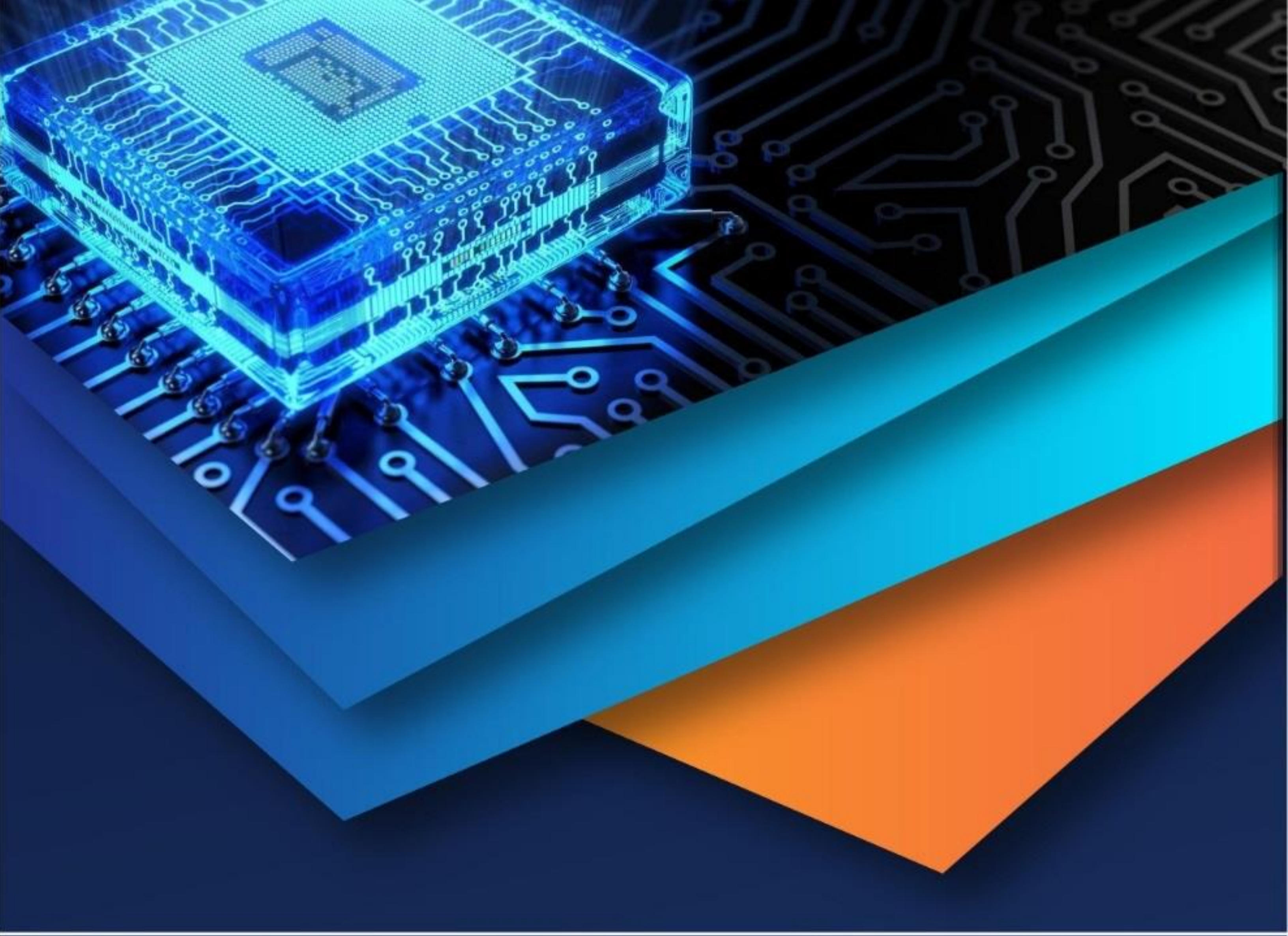

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