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Optimization of a Portfolio of Indian Companies Using WDO, GA and ALO

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Abstract: This papers presents optimization of a portfolio consisting of stocks of Indian companies. The optimization has been done using three nature inspired computing techniques- Genetic Algorithm (GA), Wind Driven Optimization (WDO), Ant Lion Optimization (ALO). Overall ALO shows better results compared to other techniques.
Keywords: Finance, Portfolio optimization, wind driven optimization, antlion optimization, genetic algorithm.

I. INTRODUCTION

A fundamental principle of investments is diversification, where investors diversify their investments into different types of assets. Instead of investing their entire wealth in a single or a few assets, investors wants to hold well-diversified portfolios. Portfolio diversification minimizes investors' exposure to risks, and maximizes returns on portfolios. Since it is rarely desirable to invest the entire funds of an individual or an institution in a single security, it is essential that every security be viewed in a portfolio context. Thus it seems logical that the expected return of a portfolio should depend on the expected return of each of the security contained in the portfolio. A lot of research work has been done on portfolio optimization and these days many nature inspired techniques are also being surveyed [1-19].

II. TOOLS AND TECHNIQUES

For a portfolio with a vector of portfolio returns *r*, and a covariance matrix *C*, and the fitness function can be formulated as follows:

Maximize $r^T w - w^T K w$ *(1)*

Subject to following constraints:

$\Sigma_i w_i = 1$ *(2)*

$w >= 0$ and $w < 1$ *(3)*

where w_i is the proportion of the total capital invested in stock *i*, r^T is the average return of each stock , and *C* is the covariance matrix. It has to be noted that the first term $r^T w$ denotes the 'return' of portfolio, whereas second term $w^T C w$ denotes 'risk'. The minus sign is used before 'risk' because risk needs to be minimized.

The equation (1) maximizes return (= $r^T w$) and minimizes the risk (= $w^T C w$) of the portfolio. The equations (2) and equation (3) correspond to our constraints that sum of all investments is one unit and all investments are positive.

In this work, Optimal Portfolio is designed using three techniques i.e. Genetic Algorithm, Wind Driven Optimization and Antlion optimization.

GA is inspired by natural process of evolution present in living organisms invented by Holland. It has been applied to various optimization problems. GA is inspired by natural process of evolution present in living organisms invented by Holland. It has been applied to various optimization problems [20].

The Wind Driven Optimization (WDO) technique is one of the latest nature inspired optimization technique [21]. The inspiration for WDO comes from atmospheric motion in which the trajectory of an infinitesimally small air parcel can be described via Newton's law of motion. The different regions of earth's surface experience varying amount of solar energy based on the location on earth. Thus temperature can fluctuate significantly among different region. Areas with high temperatures have rising warm air, and areas with low temperatures have sinking cold air, which causes the air density to decrease in high temperature areas and to increase in low temperature areas. Thus temperature differences lead to variations in air density and air pressure at different locations. Thus these differences in air pressure cause air pressure to move from high pressure regions to low pressure regions. This is the basis of this technique. The investor is interested in how much money he should invest in each stock in a portfolio so as to get maximum returns.

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Ant lion optimization is a new stochastic nature inspired computing technique – Antlion Algorithm (ALO). Antlion optimization (ALO) is a bio-inspired optimization algorithm proposed by [22]. It mimics the hunting mechanism of antlions in nature. The Antlions are a group of species of insect in the family of My rmeleontidae. They are sometimes referred to as doodle bugs because of the strange marks they leave in sand. These have very unique hunting behaviour and ALO is based on this. An Antlion larvae digs a funnel shaped pit in sand by moving along a circular path and throwing out sand with its massive jaw. The larvae hide underneath the bottom of cone after digging the trap. It sits and waits for ant to be trapped in the pit. The ant can easily get trapped in pit as edge of cone is very sharp. The Antlion tries to catch the ant that is in the trap. The ant tries to escape but Antlion throws sand such that ant comes towards the bottom of pit. When caught, it consumes the ant and throws the leftovers out of the pit. Again, it becomes ready for the next hunt.

Weights are calculated of Indian companies stocks using the nature inspired computing techniques i.e. wind driven optimization and Ant lion optimization. Again weights are calculated of the various stocks of companies listed on Indian Stock Exchange, using Genetic Algorithm. The returns are calculated monthly at .01,.015,.02,.025,.03. Total 50 stocks have been considered on the basis of market capitalization.

III.ANALYSIS ON THE BASIS OF GENETIC ALGORITHM

1) The analysis is carried for different time periods. When investment is done for two years in stocks of Indian Companies, using GA technique, it is found that as the size of the portfolio increases , the return also increases. When investment is done in 15 stocks at .01 expected return, the actual return is .0102 and risk is .0510, and at .015 expected return, the actual return comes to .0156 and risk increases to .0511. When investment is made in 0.02 expected return, the actual return is 0.0237 but the risk is same i.e. 0.0511. So this technique states rather than .0102% return, investor should take 0.0237 return at almost same level of risk. Again at 0.025 actual return, there is marginal insignificant increase in risk i.e.0.0516. At 0.03 actual return, risk is 0.0526. So the fundamental principle applies here that more the risk, more the return.

2) When funds are committed for four years in 15 stocks portfolio, at expected return 0.01, the actual return comes 0.0113 and risk is 0.0427. At 0.015 expected return, the risk is same i.e. 0.0427 and actual return increases to 0.0183. So this technique suggests to individual as well as to portfolio investors to take advantage of higher actual return i.e. 0.0183 at same level of risk i.e. 0.0427. At 0.02 actual return, the risk is 0.0430. At 0.025 actual return, the risk is 0.0456 and at 0.03 actual return, the risk comes to 0.0546. This technique has shown that as the actual return is increasing, risk is also increasing.

3) When funds are committed for 6 years in the portfolio of 15, 30 and 50 stocks in all the three cases, the technique has shown that as the risk increases, the return is also increasing. In the portfolio of 15 stocks at 0.01 expected return, the actual return comes to be 0.014 and risk is .0411. At 0.018 actual return, risk is same i.e. 0.0411. So here the technique suggests to investors to take an advantage of higher return i.e. 0.020 at the same level of risk i.e. 0.0411. But if an aggressive investor wants to maximize more return i.e. 0.025 or 0.03, then one has to face more risk also i.e. 0.0444 and 0.0552 respectively.

4) When investment is diversified from 15 stocks to 30 stocks at expected return .01, actual return increases from 0.0102 to 0.012 and risk reduces from 0.0510 to 0.0438. At expected return 0.015, actual return increases from 0.0156 to 0.017 and risk again reduces from 0.0511 to 0.0430. At expected return 0.025, although the actual return is same in case of portfolio of 30 stocks i.e 0.025 but the risk reduces from 0.0516 to 0.0470. Again at the same level of actual return 0.030, the risk reduces from 0.0526 to 0.0468 by diversification. When portfolio of 50 stocks is made then also as comparative to 30 stocks, actual return is increasing and risk is decreasing . Like at 0.01 expected return in the portfolio of 30 stocks, the actual return is .014 and risk is .0356. In case of expected return .015, the actual return is .017 and risk .0430 and in case of 50 stocks, the actual return increases to 0.018 and risk reduces to 0.0299 in the same case. So in 2 years case, GA technique suggests to get maximum return at 0.03 as the risk is minimum than all the other cases.

5) When funds are committed for four years and diversification increases from 15 stocks to 30 stocks, the actual return start increasing or remains same but the risk starts diminishing. Again when the level of diversification increases to 50 stocks the actual return remains same or increases but risk reduces upto 0.02 expected return. After this level, risk starts increasing. Like at expected return 0.015, actual return is .0183,0.016 and then 0.016 and risk is 0.0427,0.0382 and 0.0323 in the portfolio of 15,30 and 50 stocks respectively and at 0.02 expected return, the actual return is same in all the three portfolios but risk is decreasing i.e. 0.0430 in case of 15 stocks, 0.0390 in case of 30 stocks and 0.0364 in case of 30 stocks and 0.0364 in case of 50 stocks. But in case where expected return is at 0.025, the actual return is same in all the three cases but risk is 0.0456,0.0429 and 0.0450 in case of portfolio of 15 ,30 and 50 stocks respectively. Again at .03 expected return, the actual return is same in all the three cases but risk is 0.0546, 0.0455 and 0.0521 in 15,30 and 50 stocks respectively. So , this technique suggests to risk

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averters to invest in the portfolio of 30 stocks to get the actual return of 0.025 and 0.03 as minimum risk is found here in this case. But to get the expected return of 0.01, 0.015 and 0.02, it is suggested to invest in the portfolio of 50 stocks as risk is minimized here.

6) When investment is made for 6 years and diversification increases from 15 stocks to 30 stocks and again from 30 stocks to 50 stocks, the actual return start increasing or remains same but the risk starts diminishing. At 0.01 expected return, the actual return is 0.013,0.01 and 0.013 and risk is 0.0411, 0.0387 and 0.0322 in case of 15,30 and 50 stocks respectively. It means risk starts diminishing as the diversification level increases. Again at 0.015 expected return, the actual return is increasing 0.016, 0.019 and 0.018 but the risk but the risk starts decreasing i.e.0.0411, 0.0385 and 0.0327 in case of 15, 30 and 50 stocks respectively. At 0.02 expected return ,the actual return is almost same i.e.0.02 but the risk level goes down i.e. 0.0411 (15 stocks), 0.0388 (30 stocks) and 0.0335 (50 stocks).At 0.025 expected return, the risk again diminishes, i.e. 0.0444, 0.0408 and 0.0396 in case of 15, 30 and 50 stocks respectively. At expected return 0.03, the actual return remains same in all the three cases but the risk is 0.0552 in case of 15 stocks, 0.0445 in case of 30 stocks and 0.0541 in case of 50 stocks. In this case, the risk increases in case of 50 stocks. So this technique suggests to risk averters to invest where actual return is 0.025 and risk is minimum i.e. 0.0396.

IV. ANALYSIS ON THE BASIS OF ANT LION ALGORITHM

1) When funds are committed for 2 years in 15 stocks in Indian Companies using Ant Lion Algorithm technique, at .01 expected return, the actual return comes 0.013 and risk 0.0510. At 0.015 expected return, actual return comes 0.017 and risk 0.0513. At 0.02 expected return, the actual return is 0.0207 and risk is 0.0522. At 0.025 expected return, actual return is 0.025 and risk is 0.0536. At 0.03 expected return , actual return is 0.037 and risk is 0.0555. As the actual return is increasing , risk is also increasing. As the actual return is increasing , risk is also increasing. So, the aggressive investors can take advantage of this situation to get higher returns.

2) When investment is made for four years in Indian companies stocks; at the expected return 0.01, the actual return is 0.012 and risk is 0.0427. At expected return 0.015, the actual return is 0.018 risk increases to 0.0428.At .02 expected return, actual return comes to .0216 and risk increases to .0433. At 0.025 expected return, the actual return is 0.025 and risk is 0.0441. At 0.03 expected return ,the actual return is 0.03 and risk is 0.0453. This technique also shows that as the return is increasing, risk is also increasing. Even if investment is made in 30 stocks,there also as the actual return is increasing i.e. 0.012, 0.017 0.021 0.025 0.03, the risk is also increasing i.e. 0.0367,0.0368, 0.0372, 0.0387 respectively. When funds are committed in 50 stocks, actual return is increasing i.e. 0.013, 0.0165, 0.0219, 0.027, 0.0326 and risk is also increasing i.e.0.0292, 0.0297, 0.0323, 0.0363, 0.0424 respectively. So the aggressive investors who want high return must invest in the portfolio of 50 stocks to get the actual return of 0.0326 at 0.0424 risk.

3) When funds are committed for 6 years in Indian companies stocks at expected return 0.01, risk is 0.0411. At expected return 0.017 risk is same i.e.0.0411. For an investor, it is better to invest in the portfolio of 15 stocks at expected return of 0.015 rather then 0.01 as risk is same in both the cases. At an expected return 0.02, actual return comes 0.0221, risk is 0.0414.At expected return 0.025 , actual return arrives to 0.0259, whereas risk increases to 0.0437.At expected return 0.03 actual return comes 0.0310 at 0.0515 risk. In this time period also, this technique has shown as the return is increasing , risk is also increasing.

4) When funds are diversified from portfolio of 15 stocks to portfolio of 30 stocks and again from portfolio of 30 stocks to portfolio of 50 stocks, the actual return increases or remains same but the risk is reducing to a great extent. At 0.01 expected return , in case of portfolio of 15 stocks, the actual return is 0.013 and risk is 0.0510.At the same expected return when investment is diversified in the portfolio of 30 stocks, the actual return comes to 0.012 and risk diminishes to 0.0413 and when for the same expected return , investment is diversified in the portfolio of 50 stocks, the actual return comes to 0.013 and the risk is 0.0282.This technique suggests here that increase in diversification reduces the risk to a great extent .

5) When investment is diversified in the portfolio of 15 stocks to 30 stocks and then from 30 stocks to the portfolio of 50 stocks, the actual return remain same or increases but the risk stars decreasing. At expected return 0.01, the actual return is 0.012 and risk is 0.0427(While investing in the portfolio 15 stocks) , actual return comes to 0.012 and risk 0.0367 (While investing in the portfolio of 30 stocks) actual return comes 0.013 and risk is 0.0292 (While investing in the portfolio of 50 stocks) At expected return 0.015 though actual return is decreasing while doing diversification i.e.0.018, 0.017, 0.0165 but diversification reduces the risk i.e 0.0428, 0.0368 and 0.0297 in case of portfolio of 15 stocks, 30 stocks and 50 stocks respectively. At 0.02 expected return , actual return is 0.0207 and risk is 0.0522 (while investing in the portfolio of 15 stocks) , actual return is 0.0234 and risk is 0.0422 (while investing in the portfolio of 30 stocks), actual return is 0.02 and risk is 0.0310 (while investing in the portfolio

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of 50 stocks).At expected return 0.03 ,actual return comes 0.037 and risk 0.0555 in case of portfolio of 15 stocks. When funds are diversified to portfolio of 30 stocks at expected return 0.03, actual return comes to 0.0316 and risk 0.0448. Again, when funds are more diversified to 50 stocks, at expected return 0.03, actual return comes to 0.036 and risk 0.0378. This technique suggest the risk averters to take advantage of this optimum point where risk is minimized and return is better then other opportunities i.e actual return 0.036 at risk 0.0378 or actual return 0.02 and risk 0.0310 while investing in the portfolio of 50 stocks .

6) When investment is diversified from the portfolio from 15 stocks to 30 stocks and again from the portfolio from 30 stocks to 50 stocks, the actual return is increasing and risk is diminishing . At expected return 0.01, actual return comes 0.01 and risk0.0411 (while investing in the portfolio of 15 stocks). Actual return comes again 0.01 and risk 0.0380(while investing in the portfolio of 30 stocks) and actual return is 0.014 and risk 0.03(while investing in the portfolio of 50 stocks). At an expected return 0.015, actual return comes 0.017 and risk 0.0411 (portfolio of 15 stocks), 0.017 actual return and 0.380 risk (in case of portfolio of 30 stocks), actual return 0.018 and risk 0.0303 (in case of portfolio of 50 stocks). Risk is almost same in both the cases of expected return 0.01 and 0.015, so here the technique suggest to get higher actual return of 0.018 at 0.0303 risk. In case of expected return 0.02, actual return is 0.0221 (15 stocks), 0.022 (30 stocks) and 0.0234 actual return in the portfolio of 50 stocks but the risk is minimum 0.0323, in the portfolio of 50 stocks .At expected return of 0.025 the actual return is 0.0259 and risk is 0.0437 (in the portfolio of 15 stocks)while diversifying the investment in the portfolio of 30 stocks, the actual return is 0.0251 and risk 0.0392 and when funds are more diversified in the portfolio of 50 stocks, the actual return is 0.027 and risk 0.0353. At expected return 0.03 , though actual return is increasing but risk is decreasing i.e. 0.0310 actual return and risk 0.0515 (in case of portfolio of 15 stock) 0.0314 actual return and risk 0.0430 (in case of portfolio 30 stocks) and actual return 0.032 and risk 0.0395 (in case of portfolio of 50 stocks). ALO technique suggests to risk averters to take the advantage of diversification by minimizing the risk and maximizing the return.

V. ANALYSIS ON THE BASIS OF WIND DRIVEN OPTIMIZATION

1) When investment is made for 2 years in Indian companies stocks according to WDO technique, at expected return0.01 actual return comes 0.012 and risk comes 0.0510. When at the expected return 0.015, actual return comes again 0.015 and risk 0.0513. So, as the return is increasing, risk is also increasing .At expected return 0.025, when actual return comes to 0.0273 and risk increases to 0.0536. At an expected return 0.03, actual return comes to 0.0307 and risk increases to 0.0555.This technique also believes in the fundamental truth that to get the higher return , investor has to face high risk also.

2) When funds are Committed for 4 years at expected return 0.01, the actual return comes to 0.01 at risk 0.0427.When expected return is 0.015, the actual return comes to 0.018 and risk 0.0426.As the actual return is increasing risk is increasing side by side. At expected return 0.025, actual return is 0.026 and risk 0.0449. At expected return 0.03, the actual return comes 0.031 and risk 0.0469.As the actual return is increasing, risk is increasing. This technique suggests to investors, to get higher return one has to take higher risk.

3) When investment is made for 6 years according to WDO technique, at every expected return, the actual return is increases or remain same , but the risk increases with increase in actual return. When actual return is 0.01, the risk is 0.0412. At expected return 0.015, the actual return comes to 0.015 and risk increases to 0.0414.Again at 0.02 expected return , the actual return comes to 0.0234 and risk 0.0419.This shows as the return is increasing, risk is also increasing. Again at expected return 0.025, actual return comes 0.0259 and risk 0.0437 and at 0.03 expected return, the actual return comes 0.0322, the risk rose to 0.0549. As the level of return is increasing , risk is also increasing.

4) When investment is diversified from 15 stocks to 30 stocks and again from 30 stocks to 50 stocks, return remain same or increases but risk start diminishing. At Expected return 0.01, actual return comes 0.012 and risk 0.0510.When funds are diversified to 30 stocks, actual return comes 0.01 and risk reduced to 0.0416. When again funds are more diversified to 50 stocks actual return comes 0.01 and risk 0.0288.As the diversification take place , risk is reducing. At 0.015 expected return, actual return remain same in all the three cases i.e 0.015 but risk is reducing i.e 0.0513 (for portfolio of 15 stocks) 0.0422 (for portfolio of 30 stocks), 0.0310 (for portfolio of 50 stocks).At 0.02 expected, actual return comes 0.024 and risk 0.0522(in case of portfolio of 15 stocks), actual return is 0.0234 and risk 0.0433 (in case of portfolio of 30 stocks) and 0.0219 actual return and 0.0341 risk in case of portfolio 50 stocks. At expected return 0.025, when investment is made 15 stocks, actual return comes 0.0273 and risk 0.0536, when funds are diversified to 30 stocks, actual return comes 0.0275 and risk 0.0448, again when are more diversified to 50 stocks, actual return comes 0.0256 and risk 0.378.At 0.03 expected return , actual return comes 0.0307 and risk 0.0555 (in case of portfolio o 15 stocks), actual return comes 0.0316 and risk 0.0466 (in case of portfolio of 30

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stocks), actual return comes 0.0319 and risk 0.0422 (in case of portfolio 50 stocks). This technique suggests the investors to reap the benefits of diversification and get higher returns by minimizing risk.

5) When investment is diversified from 15 stocks to 30 stocks and again from 30 stocks to 50 stocks, return remain same or increases but risk start diminishing. At 0.01 expected return, actual return comes 0.01 and risk 0.0427. When funds are diversified to 30 stocks actual return comes 0.01 and risk 0.0372. Again when funds are more diversified to 50 stocks actual return comes 0.01 and risk 0.0297. This technique suggests here to get the same 0.01 actual return , one must invest in the portfolio of 50 stocks as risk is low as compared to other portfolios. At 0.015 expected return, again risk is decreasing while doing diversification. While investing in the portfolio of 30 stocks the actual return becomes 0.017 and risk 0.0378, from actual return 0.018 and risk 0.0426 while investing in the portfolio in 15 stocks. When funds are more diversified in the portfolio of 50 stocks, actual return increases to 0.019 and risk decreases to 0.0308.At expected return 0.02 the actual return comes 0.022 and 0.0429 (in case of portfolio 15 stocks), actual return comes 0.023 and risk 0.0387 (in case of portfolio of 30 stocks), actual return comes 0.024 and risk 0.0340 (in case of portfolio of 50 stocks). At expected return 0.025, actual return remain same but risk is 0.0449, 0.0400 and 0.0424 in the three portfolios but this technique suggests while diversifying in the portfolio of 50 stocks, risk is 0.0424 which is more than the portfolio of 30 stocks, so, here it is suggested to risk averters to invest in the portfolio of 30 stocks because it has low risk than the other two portfolios. Again at expected return 0.03 actual return is 0.031, 0.032 and 0.035 and risk is 0.0469, 0.0419 and 0.0463 in case of 15, 30 and 50 stocks. In this case also, risk is higher in the portfolio of 50 stocks i.e 0.0463 than the portfolio of 30 stocks, though return is a little bit higher, in case of 50 stocks but for risk averters this technique suggests to invest for an expected return 0.03 in the portfolio of 30 stocks.

6) When investment is diversified from 15 stocks to 30 stocks and again from 30 stocks to 50 stocks, return remain same or increases but risk start diminishing. At 0.01 expected return, the actual return comes 0.01 and risk 0.0412 (in case of portfolio of 15 stocks), actual return comes 0.01 and 0.0383 (in case of portfolio 30 stock) actual return comes 0.012 and risk 0.0303 (in case of portfolio of 50 stocks). So risk is decreasing with diversification. At expected return 0.015, actual return comes 0.015, 0.0156 and 0.017 and risk 0.0414, 0.0387 and 0.0311 for the portfolio of 15, 30 and 50 stocks respectively. At 0.02 expected return the actual return comes 0.022 , 0.023 and 0.022 and risk 0.0419, 0.0392 and 0323 for the portfolio of 15,30,50 stocks respectively. This technique shows that diversification is reducing the risk to a great extent . At 0.025 expected return the actual return is increasing i.e 0.0259, 0.0267 and 0.028 and risk is decreasing to a large extant i.e 0.0437, .0400 and 0.0373 for the three portfolios. At 0.03 expected return the actual return comes 0.0322 and risk 0.0549 (in portfolio of 15 stocks) the actual return return comes 0.0314 and risk 0.0418 (in portfolio of 30 stocks), the actual return comes 0.0345 at risk 0.422 (in portfolio of 50 stocks). Here, again the risk is increasing with return in portfolio of 50 stocks.

VI. CONCLUSIONS

In this study, three techniques are used for finding investment options: Genetic Algorithm, Wind Driven Optimization, AntLion Optimization. Top listed 50 Indian Companies are taken. With the help of these techniques, investment amount is calculated and it points out the stocks which can maximize the return and minimizes the risk. Genetic Algorithm is robust to solve various nonlinear and integer programming problems. It can solve portfolio optimization problems effectively. It has ability to obtain a good solution to solve difficult portfolio optimization problem in an easy manner.

The Wind Driven Optimization technique finds optimal values of w i.e. amount of investment in each stock of the portfolio so that desired goal is achieved. It has been observed that WDO is well capable of finding optimal solution.

Antlion Optimization is a bio- inspired optimization algorithm which is used to maximize return for a particular level of risk to be tolerated by the investor. Return samples are taken by using all the three techniques and it is found that ALO performs better than WDO and GA.

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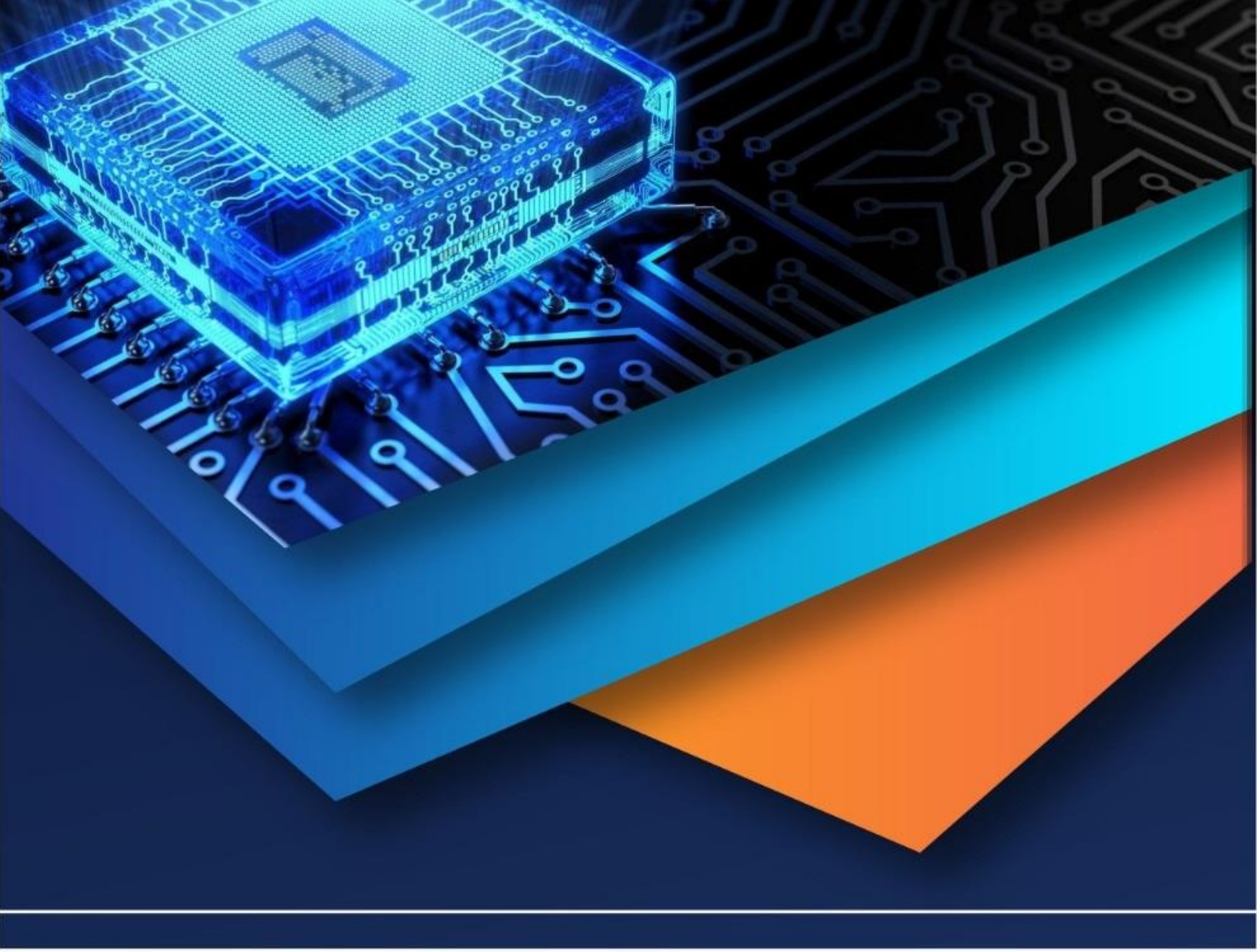

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