iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** VII **Month of publication:** July 2024

DOI: https://doi.org/10.22214/ijraset.2024.63621

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

Portfolio Optimization Strategies for the Common Investor

Harshitha S[1], Dr. R. Muthu Meenakshi[2]
Department of Computer Science and Applications, Reva University

Abstract: ***Financial Analytics is a key field to making investment decisions and has been developed only recently. It involves analytical thinking, computational knowledge and creative thinking about investment strategies. There are many ways to invest money. Some people invest them in Gold, some in real estate, some create a fixed deposit, some in the stock market. Some people diversify their money into different sectors of the market and invest to get an optimal profit by understanding the market. This kind of investment is called portfolio management. Unlike gambling, understanding of the portfolio and its management can actively minimize the risks associated with investment. In the proposed research we tried to study the different strategies of investing in the different sectors and building a portfolio, with the express aim of creating optimal diversified portfolios. Our methods include optimizing the weights of different investment instruments in different sectors, with implementations carried out in Python and using time-series Python libraries. We have focussed on three different investment strategies in particular: (1) Genetic algorithms help us to divide the portfolio (chromosome) into the genes (sectors) and understand it in a better way. Exploiting the existing algorithms for optimizing fitness functions in genetic algorithms, we have implemented one strategy for optimizing portfolios; (2) Efficient frontier analysis from Markowitz theory helps in investing and creating our own portfolio. We developed some of the strategies that help in displaying portfolio allocation and efficient frontier graphs; (3) We have also implemented a new criterion in vogue in the financial markets today, the "Kelly Criterion" preferred by many investors all over the world. We used real time financial stock data to validate and test our functions. All the strategies developed are modular and we also show a proof-of-concept web interface for one of the developed strategies. It is hoped that our work enables investors in making better decisions about where to park their money and converting their wealth into high-yield portfolios.***

Keywords: Portfolio Management, Genetic Algorithms, Efficient Frontier Analysis, Markowitz Theory, Kelly Criterion, Optimal Portfolios

I. INTRODUCTION

As one of the quotes in finance says higher the risk greater the reward. Stock market majorly deals with risk and reward. To maintain both in equilibrium many theories and mathematical operations are developed. To invest, people choose many other fields than portfolio management as they feel that it is so risky. Proper analysis and readiness check over the sectors in the portfolio should be done before investing in it. Good analysis and research give a good portfolio, hence giving good reward with less risk. As said, there are many ways to value a portfolio.

One can use financial ratios to know the trends of the sectors in the portfolio, simple Balance sheet analysis can give good insight over a portfolio, trend of the market, tips from the stockbrokers.

Recent day's data science also plays a key role in analysing the portfolio. There are many machine learning models that are used to validate the portfolio weights and calculate trends. Auto regression model and ARIMA Model are some of the machine learning models that help in constructing a mathematical model over time series data of a portfolio. CNN, Logistic regression, Neural networks are also used to back test the data. Therefore, with the whole discussion we can conclude that the stock market (portfolio) needs analysis and that is optimal portfolio strategies under Financial Analytics.

A while ago investment in the stocks and portfolio maintenance was done through stockbrokers. People used to invest in the stock market by using tips given by big shots of the market. Later, Finance evolved as a subject with greater research and potentiality and creativity. Nowadays, data science extended its roots to analyse time series data which is, Stock market data. With the knowledge of python and testing Machine learning models over this time series data gave good insights. Financial tech companies used this as a major turning point and established their own financial ideas. As a matter of confidentiality their research won't be able to get to the public. Therefore, people want these big financial companies to build their portfolios and maintain it. As we are growing rapidly in terms of the computational methods as well.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

The portfolios can also be optimized by the computational methods of finding the financial ratios as well as the weights to be optimized. This motivates us to find some strategies to optimize the weights that can be invested by the investor to get the optimal portfolio allocations according to investor preferences or We can also create an opportunity for the investor to choose the optimal allocation from the experts as well by formulating some criteria.

There are many financial concepts that should be considered to understand the portfolio and its management. Some of the statistical techniques are also used in finance to validate a stock as well as a portfolio. Techniques like regression, correlation has its own place in financial analytics. As all we know correlation helps in knowing how the data points behave with respect to each other, dealing them with time series data can give some good insights. Basic techniques like Standard deviation which we call in finance as volatility and Mean are also used. Volatility calculates the risk by considering the log standard deviation of close. Expected Returns also plays an important role in the analysis of a stock or a portfolio which can be a good or bad one. These concepts can be taken into consideration for the analysis of the portfolio and can be used in further.

There are many financial ratios and portfolios that are in existence. In the world of finance, portfolio can be defined as a basket of investments made by the user. User has a freedom to create his own financial concept and financial ratio according to their portfolios. With the observations and research people create their own financial strategy to invest in the market. In the same efficient frontier is generally calculated by using Sharpe ratio for optimal allocation for a portfolio. But as finance provides freedom, people can use any of the advanced ratios and if they find that good returns are expected through the method, they can follow the method which can yield some good profit according to their portfolios.

Sharpe and Sortino ratios have their own place in the creation of an optimal portfolio, as they indicate the performance of a fund or stock. In this research, we used various measures to determine the optimal portfolio for different investment strategies, which can be applied in real-life scenarios since we utilized real-time data to calculate the optimum profit. Essentially, this research focused primarily on the weight allocation of the funds within the portfolio and its weighted permutations based on user preferences.

II. METHODOLOGY

The main objective of this research is to study and automate various financial models of strategies, algorithms and functions that help in trading and investing wisely with their portfolios, with a view to the market returns and to Obtain an overview of the world of finance to be better poised to develop the next-generation analytics toolkit with some advanced computation which is user friendly.

With this as our main objective and to create useful strategies which will help the user and the investor to know the optimal portfolio among the given weights which are allocated to the portfolio as we know for integrative financial analytics which helps the user to analyse the stock and the portfolio weights which he can invest. Functions that are developed are seen to be modular and maximum of the functions has their inputs as ticker value of that company or organization, start date and end date for a strategy and the allocated weights as its inputs for a strategy as well. Our main AIM is to back test these strategies with the real time financial data so that it comes in handy for the people in real time investments.

Glimpse of objectives

1) Given a certain risk appetite, what Portfolio selection / allocation will yield maximum returns from a given set of permutations.
2) Calculating the returns of the investment according to the weights and optimizing the portfolio allocation.
3) Efficient frontier analysis with Sharpe ratio, risk and the returns of the weights
4) Analysis of the weights and its permutations with the help of genetic algorithms and optimizing the weights based on the fitness value.
5) Implementation of the most diverse set of sector allocations which would help in optimizing with genetic algorithm, Markowitz portfolio theory, Kelly Criterion
6) Development of a user web interface to show the optimized weighted portfolio to invest using Gradio.

A. Literature Survey

There are many packages that are available in python. But there are very few packages that contribute towards finance and its analysis and the understanding of the known and unknown terms of the finance which would help in the optimization part of a portfolio. List of packages that are available and functions in them that contribute towards financial analysis are listed below. Note: Not every package and function are listed here:

TABLE I
PACKAGE

Package Name	Functions Available
Numpy	Pmt, ipmt, ppmt, rate, mirr, Irr
SciPy	This package helps Numpy package with some of itsstatistical functions
Pandas	Helps in handling financial data
Yahoo Finance	Download the data. No need for any API key. An open source.
Pyfolio	Gives simple and complete tear sheets
Pygad	Genetic algorithm package used to find the optimal valuewith the help of the fitness value generated with the inputs.
Matplot lib	This package helps us to draw the graphs and its representation types helps us to interpret the data as well.
itertools	This is a library used to find the permutations of a givenset of values of a list.
Gradio	This is a package used to draw a simple user interface fora machine learning algorithm with the help of python.
Statsmodels	This package is used for the statistical purpose of thefinance where we can find some values of a fund.
matplotlib	To plot the graphs and scatter plots
plotly	used in dash to represent the scatter plots in web interface
Numpy	Pmt,ipmt,ppmt,rate,mirr,Irr
Scipy	This package helps Numpy package with some of itsstatistical functions
Pandas	Helps in handling financial data

B. Proposed System and Architecture

The proposed system and architecture for this research paper involves a comprehensive approach to financial analysis and portfolio optimization. The process begins with the collection of time series data for stock market movements, which is downloaded from sources such as Yahoo Finance. If required, the downloaded data is pre-processed to ensure it is in a suitable format for further analysis.

The researchers utilize Python packages, such as pandas, to work with the financial data. The underlying mathematical formulas for the financial concepts under study are investigated and understood, forming the foundation for the analysis. The code is designed in a modular fashion, with each financial concept implemented in a separate function, ensuring a structured and maintainable approach.

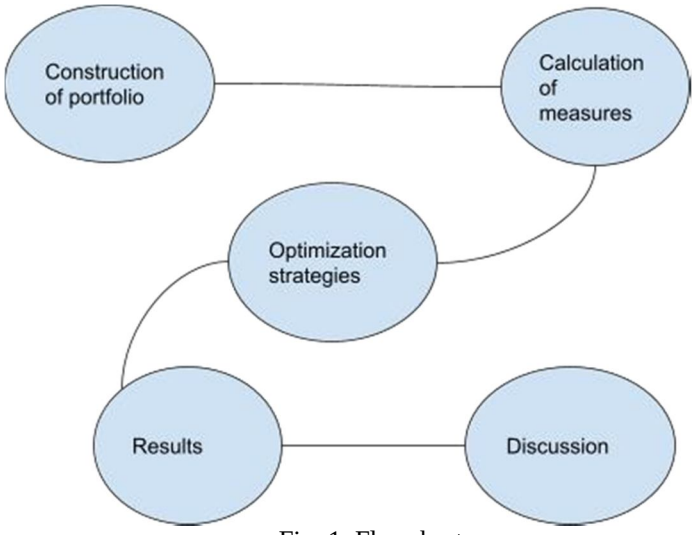


Fig. 1 Flowchart

The system automates the process of generating tear sheets for financial strategies, allowing for efficient and consistent reporting. Plots are generated, if required, to visualize the financial data and analysis, providing valuable insights to the researchers.

The researchers enumerate various financial portfolios and ratios from different sources and implement them in the system. The portfolio construction process considers the weights allocated to different sectors and the sectors included in the portfolio, ensuring a well-diversified approach. The calculation of financial measures is performed using statistical methods or Python libraries, providing a robust and reliable analysis. Three optimization strategies are implemented: Genetic Algorithm, Markowitz Portfolio Theory, and Kelly Criterion, each offering a unique perspective on portfolio optimization.

Finally, the portfolio is visualized using the Matplotlib library, and the graphs are interpreted to draw conclusions. This comprehensive approach, leveraging the power of Python and its robust financial data analysis capabilities, aims to provide a robust and automated system for financial analysis and portfolio optimization.

C. Dataset Description

Stock market data is a time series data. It gets updated with time frequently. This data consists of 6 columns such as High, Low, Open, Close, Adjusted Close and Volume. Rows in this data completely depend on the user as it completely depends upon the date and time we chose. We can download daily, monthly, quarterly and yearly data depending upon the user interest and analysis he/she wishes to perform over. The data is completely numerical. There are many ways to download real time stock data. Some of the packages like yahoo finance, Quandl, Google finance API helps to download the data. Or else we can download the data from the web manually. To provide ease with downloading the data with time we used yahoo finance. Data is downloaded using yahoo finance as it is open source, and no special API Key is needed. Yahoo finance provides stock price data of many companies using ticker values of that company/organization. The data_download functions help the user to download the data by just entering the ticker value of that company/organization, start date and end date. Users can download the most recent data and historical data too with this function. Here is a screenshot of the stock market time series data.

TABLE III
SAMPLE DATA SET MPT

Date	Open	High	Low	Close*	Adj. close**	Volume
14-Jun-2021	15,7940	15,791.90	15,60650	15744.80	15,744.80	-
11-Jun-2021	15,796.45	15,835.55	15,749.80	15,799.35	15,799.35	3,63,000
10-Jun-2021	15,692.10	15,751.25	15,648.50	15,737.75	15,737.75	2,98,300
09-Jun-2021	15,766.30	15,800.45	15,566.90	15,635.35	15,635.35	4,57,900
08-Jun-2021	15,773.90	15,778.80	15,680.00	15,740.10	15,740.10	3,78,200
07-Jun-2021	15,725.10	15,773.45	15,678.10	15,751.65	15,751.65	3,94,000
04-Jun-2021	15,712.50	15,733.60	15,622.35	15,670.25	15,670.25	4,14,200
25-May-2021	15,291.75	15,293.85	15,163.40	15,208.45	15,208.45	4,41,500

D. Dataset used for genetic Algorithm

As we know that genetic algorithm is an optimization algorithm which is mainly used for the optimization purposes for nonlinear data. We have the data which is non-linear as the data used for the genetic algorithm is that of an array of weights considered in different sectors of the market considered as the weighted allocation of a portfolio. The permutations of those weights are taken as an input for the genetic algorithm.

TABLE IIIII
SAMPLE DATA SET FOR GA

stock 1	stock 2	stock 3	stock 4	stock 5
0.16	0.17	0.18	0.19	0.30
0.16	0.17	0.18	0.3	0.19
0.3	0.16	0.17	0.19	0.18
0.16	0.18	0.19	0.17	0.3

E. Financial Ratios

Financial Ratios play a very important role in analysing the stock of a company. There are many financial ratios that are theoretically discovered. Financial ratios that are developed are listed below. These ratios not only give the report of the fund or the stock but also gives us a glimpse whether we can invest in the fund or not.

1) *Volatility:* A Volatility is a measure of standard deviation over log of returns. In simple words it calculates risk of the stock price. Higher the volatility greater the risk. Volatility is also used in calculating the efficient frontier. Here is the formula of Volatility

$$Volatility = \sqrt{Variance\ of\ log\ returns.}$$

Function name: port_volatility

Inputs taken by this function are organization ticker value, start date and end date.

2) *Sharpe Ratio:* A Sharpe Ratio gives the idea to the investor on the returns of the investment based on the returns of the fund which is related with the volatility of the fund. The Ratio is calculated as the average return of the fund based on the risk-free rate with the unit of risk (Volatility).

Sharpe Ratio = (Return of portfolio-risk free rate)/Standard deviation of the portfolio.

Function name: Sharpe_ratio.

3) *Beta:* A Beta is used for the measurement of the volatility of the fund or stock or a portfolio and can be used to tell whether the stock is volatile to invest in it. If the fund's beta value is less than 1, then it is said to be less volatile which means less risky to invest so as the investor would invest in it.

Beta = (Covariance of individual stock with the entire market)/ (variance of the market)

Beta is also used with the Capital pricing asset model (CAPM) describing the relation between the expected returns and the risk usually with the stocks.

F. Genetic Algorithm

Genetic algorithm is one of the prominent algorithms used in the machine learning concepts for optimization solutions which are intended to give the optimal solutions for the non-linear data.

Genetic Algorithm (GA) is a nature-inspired algorithm that has extensively been used to solve optimization problems. It belongs to the branch of approximation algorithms because it does not guarantee to always find the exact optimal solution; however, it may find a near-optimal solution in a limited time. In this lesson, we will learn the basics of GA in terms of its source of inspiration, general structure, working, and implementation.

Optimization is the process of finding the best solution to a problem. For example, finding the shortest route to the destination, scheduling the hospital staff in the most efficient manner possible, or planning the day's activities to best utilize the available time. To solve the real-world optimization problems, the problems are formulated as mathematical functions and optimization deals with minimizing/maximizing the output of that function to find the best solution. Once the problem is formulated mathematically, an optimization algorithm such as GA is used to find the best solution (optimal solution) to that problem. The optimization process using GA is depicted in the following diagram.

GA involves many kinds of calculations which are needed to optimize the required non-linear data which is our data for the selection of the optimal solution for the portfolio selection. The ratios or functions involved in the optimization process is that there are:

1) *Fitness*: Fitness is a function created to calculate the fitness of the non-linear data using the GA (genetic algorithm) by using a formula which depends upon the output and the desired output.

Fitness = 1/absolute value(output-desired_output)

Function name: fitness_func

Fitness can be defined as the performance metric of the *non-linear data,* which is provided, the higher the fitness value the greater the optimal value for it.

2) *Call back generation:* This function is created in this research project to print the fitness value change over the generations and the number of generations and the last generation which took place to get the desired output for the non-linear data. It also gives the last completed generations (iterations) of the data in the process of optimization.

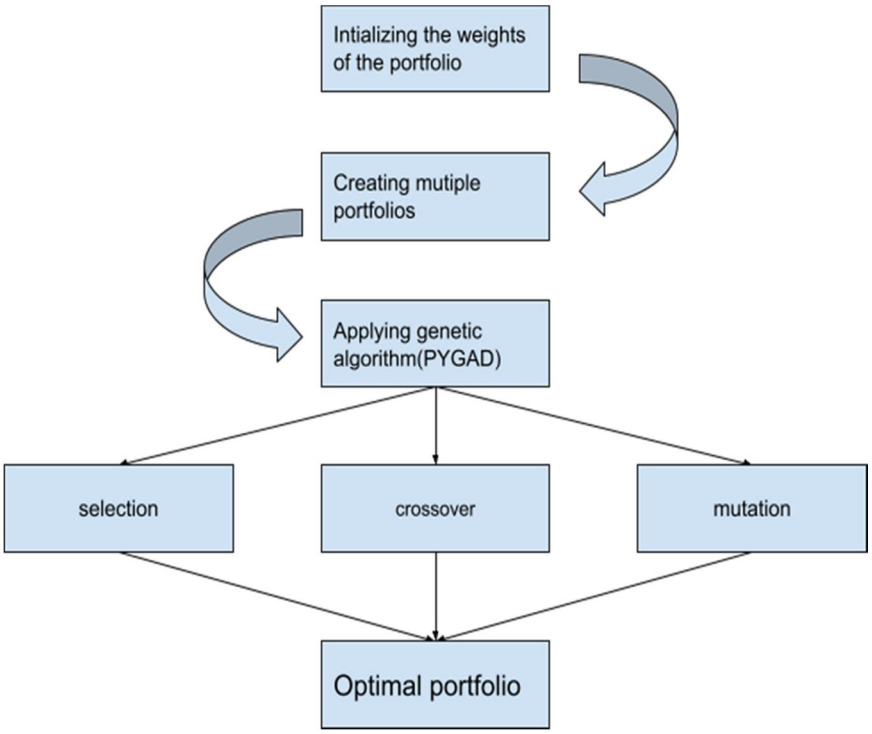


Fig. 2 Flowchart for genetic algorithm

3) *Crossover/mutation:* Crossover and mutation are the two main steps for the genetic algorithm which intends to reproduce the offsprings and use for the calculation of the fitness and then giving the best-off springs as the optimal result for the further process. In this work, as we are working with the package PYGAD for the genetic algorithm we are choosing the single point crossover type and random mutation type with a fixed number of generations.

G. Modern Portfolio theory

This modern portfolio theory is used basically for the investors to choose the investments by accepting the level of risk involved within it to get the maximum profit within a given period. As we all know that each asset has their own risk and reward, some with high risk and low reward and some with low risk and high reward and vice versa.

In this process we can achieve a point where we can attain the optimal value of a fund where we invest the optimal amount to get the optimal profit in a best way possible.

Mainly, This MPT is used to diversify our funds into various sectors according to the optimum level to get the risk lowered and gain the profit. It also states that the risk of a single fund or stock affects the whole portfolio returns as well. As we know a single investment makes a huge change in the portfolio as well. We need to take care of the investment with minimal risk only. MPT involves statistic measures into act such as correlation and variance of the fund or portfolio.

1) *Risk:* Each and every investor who wants to invest in the market maintains and wants to maintain their portfolio with minimum risk involved within it. If we are needed to calculate the acceptable risk of a portfolio we need to calculate by the following formula.,

The general formula is

$$Portfolio\ variance\ = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2Cov_{1,2}$$

Where*:*

w_1 = the portfolio weight of the first asset

w_2 = the portfolio weight of the second asset

σ_1 = the standard deviation of the first asset

σ_2= the standard deviation of the second asset

$Cov_{1,2}$= *the covariance of the two assets, which can thus be expressed as* $p_{(1,2)}w_1w_2$ *where* $p_{(1,2)}$ *is the correlation coefficient between the two assets*

As an investor, everyone wants low risk. We need to follow some tips from great investors, and we can achieve that feat with a serious analysis and with experience where we require enough knowledge about the funds we invest. Every investor needs to invest their money in a diversified manner where we split the money we invest into different sectors and we look forward to the negative correlated funds which are., Govt. ETF (exchange traded funds).
There are risks that we cannot avoid in the meantime of investment but there is a risk which we can avoid which is known as the unsystematic risk. This risk will also get diversified as the investor diversifies the assets in his portfolio.

H. Efficient Frontier

The Portfolio is one of the tools that is used to invest in the stock market. Generally, investment without maintaining a portfolio increases risk for the user. Portfolios are used for diversification. Here, investment is done by a set of good companies. For suppose the amount to be invested is 100. We diversify it by investing it in different companies with some ratio rather than investing all of them in one company(funds). With this risk profile of the user decreases. To calculate this portfolio, we follow Modern Portfolio theory. An extension to this is an efficient frontier. In an efficient frontier we generate so many random portfolios on the same set of companies. In that we choose the best allocation using expected returns and the risk involved. With generated random portfolios we calculate which portfolio gives the optimal returns and the low returns with the risk involved, we mark it as the optimal portfolio. Generally, Sharpe ratio is used in calculating efficient frontier.
In Sharpe ratio we use standard deviation of all the returns, we also calculate the minimum volatility point. Users can choose this when he/she doesn't want to bear risk. Optimal portfolio has some risk but helps in yielding higher returns. So as an outcome of the function we will have optimal portfolio allocation i.e. maximum expected return allocation, minimum volatility allocation and efficient frontier plot. We also have the minimum risk portfolio which has the maximum expected returns with minimum amount of risk involved within it.

Here is the mathematical formula for calculating the expected returns of a portfolio with two assets:

$$E(R_p) = w_1 E(R_1) + w_2 E(R_2)$$

where w1, w2 are the respective weights for the two assets, and $E(R_1)$, $E(R_2)$ are the respective expected returns.

I. Kelly Criterion

This is one of the major revolutionary concepts coming into the finance concept in terms of investment and this in turn is now being used by many investors around the globe such as Warren buffet as well. Kelly Criterion is also a technique which is generally used in gambling and sports. This technique gives the optimal amount to be invested in an asset to get an optimal profit among the given assets. It can determine the amount or the percentage of the bankroll to be invested in a certain bet. This technique would involve a bit more risk where the investor would be ready to invest even his profits in this technique.
This Kelly criterion has 2 components in the formula, those are: the winning and losing probability and the win or loss ratio.

$$Kelly\ \% = W - \left[\frac{(1-W)}{R}\right]$$

where, Kelly % is The Kelly percentage, W is the Winning probability and R is the Win/loss ratio
The functions are developed in the research for calculating the arithmetic and the geometric returns of a fund by inducing the statistics concepts into it.
Function name: expected_arith() and expected_geo()

We tried to find the Kelly criterion fraction by formulating the function by using **NumPy**. As we cannot say whether a fund will return us the positive return after we invest or not, but we can estimate the returns of a fund by using this strategy as well.
We also need to consider the major point in the terms of investing is Diversification., where even the Kelly criterion gives us the huge value, we stick to the diversified portfolio and not invest more than 25% in any of the fund.
We have a package called **pyfolio** which is used to give us a tear sheet (information about the fund) in a very peculiar manner with tables, charts) we get enough information about the fund such as Sharpe ratio, beta, alpha etc.
Kelly criterion is a strategy nowadays growing rapidly. The calculations are done with the use of the winning and losing probability and the win ratio as well. The risk among the investment made are also high comparatively but it can produce more optimal value as the profit as well.

It is very crucial to know the winning and losing probability of the bet or investment that we are about to do as well, which could turn the investment upside down. Kelly Criterion is a pure mathematics-based formula which we use. The results of Kelly can be influenced by many factors such as the input of the winning probability as wrong as well.

J. Dash plotly

Dash is a web framework used to create the graphical user interface in a very creative manner and it helps the user of it to understand the plots in a very interactive manner. plotly is used in dash to create the interface and to represent any kind of graphs in it. We have used the flask for the interface.

III.RESULTS

A. Beta of the Market

Beta value is very much useful in calculating how volatile the stock is. A stock that swings more than the market over time has a beta above 1.0. Function named "beta" is used in calculating. If we calculate the beta value of TCS by this function, we get a value of 0.5887659 which is less than 1. With the definition of beta TCS is less volatile.

B. Volatility

Here are the values of volatility. It is calculated in the time slot Feb 2016 to Feb 2021 for Google. If observed volatility is high in the year 2020-2021 because of the COVID-19 pandemic. Values of volatility have seen a greater change. At this period many companies' stock prices have increased. Stock market had a good growth by 1000 points. But this was all sudden. As we know it takes time in building a stock price. This sudden change makes stock so volatile. Higher the volatility, higher the risk.

TABLE IVV
VOLATILITY SHEET

Date	Open	High	Low	Close	Adj Close	Volume	Log_Ret	Volatility
2016-02-02	784.500	789.8699	764.6500	764.6500	764.6500	6348100	NaN	NaN
2016-02-03	770.219	774.5000	720.5000	726.9500	726.9500	6171000	-0.050561	0.389200
2016-02-04	722.809	727.0000	701.8599	708.0100	708.0100	5168700	-0.026399	0.391879

C. Genetic Algorithm

As we know that the genetic algorithm is suitable for giving the optimal values for the non-linear data. Here In this research the genetic algorithm gives the optimal portfolio among the portfolios which are taken as an input by calculating the fitness value of each permuted portfolio. In this process we give the mutation and crossover rate as 50% and then we fix the number of generations as 50 generations and calculate the fitness value.

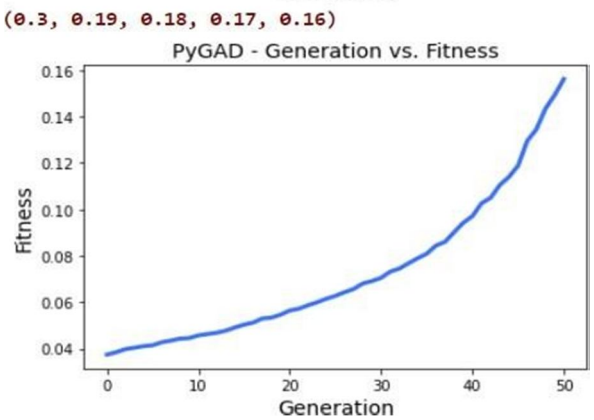


Fig. 2 Genetic Algorithm Graph

For the above graph we have the portfolio for [0.3,0.19,0.18,0.17,0.16] as one of the portfolios.

Parameters of the best solution: [31.6772003 19.5027197 22.11389524 18.008087720.90518262]
Fitness value of the best solution = 0.15613733968489Index of the best solution: 44
Predicted output based on the best solution: 23.59538210386984Best fitness value reached after 50 generations.
For the above graph we have the portfolio for [0.3,0.19,0.18,0.17,0.16] as one of the portfolios.
We take [0.16,0.17,0.18,0.19,0.3] as the standard portfolio where we invest 80,85,90,95 percentages into the first four sectors and then consider the last as a safe fund and invest the remaining amount into it. The above graph illustrates the relation between fitness and the number of generations. As we can see that the trend is going high, we can illustrate that the number of generations can be directly proportional to the fitness value.
We get 120 permutations of the standard portfolio, and we conduct the genetic algorithm for all the 120 portfolios and consider the portfolio having the highest fitness value as the optimal portfolio to invest as below.,

TABLE VV
GA PORTFOLIOS DICTIONARY

Portfolios	Fitness value
(0.16, 0.17, 0.18, 0.19, 0.3):	0.12360074889819636,
(0.16, 0.17, 0.19, 0.18, 0.3):	0.16136679243496593,
(0.16, 0.17, 0.19, 0.3, 0.18):	0.12337582498411084,
(0.16, 0.17, 0.3, 0.18, 0.19):	0.13022824340502442,
(0.16, 0.17, 0.3, 0.19, 0.18):	0.14584840273405006

From the above figure, here are some of the portfolios with their fitness values, we need to select the portfolio with the highest fitness value.

```
optimal portfolio from dictionary: (0.16, 0.18, 0.19, 0.17, 0.3)
```

D. Modern portfolio theory
We here in MPT, we know that we deal with the prices of every stock or fund we invest. We use **yfinance** library to extract the data to use it in the MPT to formulate the efficient portfolio using efficient frontier.

1) Extraction of data using the yfinance and creating a data frame of prices.
2) Calculating the portfolio returns and plotting the graphs.

Date	0P0000XVTH.BO	EIPIX	GC=F	VNQ	equity
2021-11-16	-0.000112	-0.004359	-0.006698	-0.006610	-0.002079
2021-11-17	0.000363	-0.006254	0.008686	0.003099	-0.011064
2021-11-18	0.000706	-0.005035	-0.004653	0.000182	-0.013593
2021-11-19	0.000000	-0.006958	-0.005266	-0.005905	-1.000000
2021-11-22	0.001068	0.003822	-0.024417	-0.004935	inf
...	...	...	...	...	...
2022-04-26	0.000205	-0.005122	0.004331	-0.016441	0.001708
2022-04-27	0.000829	0.004577	-0.008152	-0.006594	0.002117
2022-04-28	-0.000672	0.017654	0.001485	0.018416	0.008642
2022-04-29	-0.000039	-0.030778	0.010907	-0.045897	-0.003023
2022-05-02	-0.000146	-0.003464	-0.024878	-0.024149	-0.004525

Fig. 4 MPT portfolio returns

3) Calculating the volatility and expected returns of the portfolio which are permutations of the standard portfolio and creating the data frame inclusively.

4) Plotting the graph with respect to the expected returns and the volatility of the portfolios.

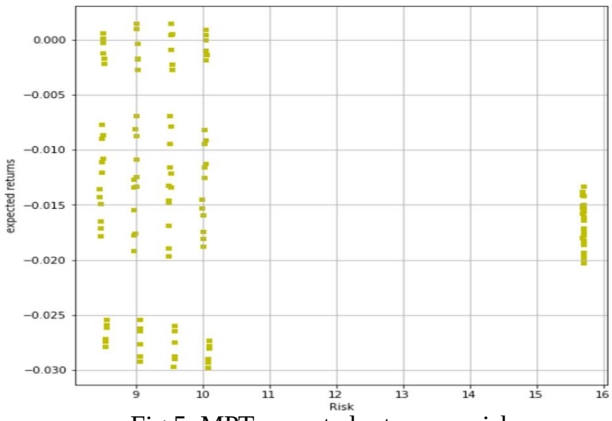


Fig.5 MPT expected returns vs risk

5) From the above portfolios calculating the minimum volatile portfolio and optimal portfolio with volatility. by taking the consideration of the expected returns and the volatility of the portfolios only.

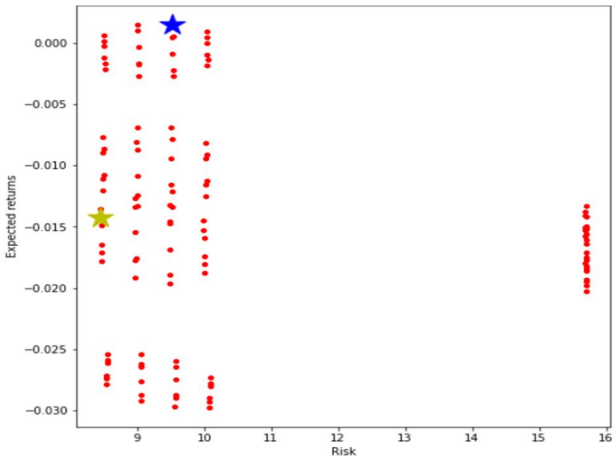


Fig.6 MPT expected returns vs risk with optimal and minimum portfolios

E. Efficient Frontier

Optimal allocation and minimum volatility of 100% for four organizations. We consider five securities to try out the portfolio allocation. They are TCS, ONGC, Kotak bank in equity, Gold as a security, Vanguard as the real estate fund, Axis dynamic fund direct plan(0P0000XVTH.BO) as the bond funds, EIPIX (income and growth fund) as a mutual fund. We used maximum returns with the optimal risk to calculate the optimal portfolio in this case.

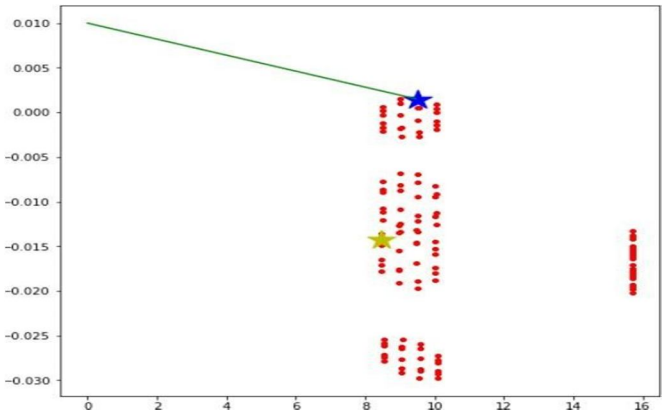


Fig.7 Summary of Efficient Frontier

From fig 4.6 We can observe that the blue star is the optimal risk portfolio whereas the yellow star indicates the minimum volatile portfolio from the above. The line which is called the capital allocation line indicates the optimal fund allocation.

TABLE V
SUMMARY OF MINIMUM VOLATILE PORTFOLIO

Returns	-0.014284
Volatility	8.455779
0P0000XVTH.BOweight	0.300000
EIPIX weight	0.180000
GC=F weight	0.190000
VNQ weight	0.170000
equity weight	0.160000

TABLE VI
SUMMARY OF OPTIMAL PORTFOLIO

Returns	0.001461
Volatility	9.524577
0P0000XVTH.BOweight	0.170000
EIPIX weight	0.300000
GC=F weight	0.190000
VNQ weight	0.160000
equity weight	0.180000

Using the Efficient frontier as discussed in the objectives two goals can be achieved. One to calculate the risk when returns are fixed and calculating the returns when risk is fixed.

TABLE VII
FUNCTIONS USED IN MPT

Function name	**Use**
returns_port	used to find the returns of portfolios
variance_port	used to find the variance of portfolio
optimal_risky_port	to know the optimal portfolio weights

F. Kelly Criterion

To calculate the Kelly fraction, I have developed the function using yfinance and pyfolio which gives us good insights about the funds. formulating a function to get the returns in arithmetic and geometric form as well. with the use of a pyfolio we get a tear sheet with a lot of information about the fund or stock we are about to invest.

Let us have a look at the tear sheet of TCS stock.

Fig.8 Tear sheet of TCS.NS. Top, cumulative returns in a year; below, rolling Sharpe ratio over six months for the same stock.

After the calculation of the portfolio returns and the formulation of finding the Kelly values and the optimal fraction of the fund, we get the following values as the capital that can be invested in the fund irrespective of the portfolio we construct. The given below is the information regarding the stock TCS.NS fund from the portfolio we chose.

TABLE VIII
Kelly values of the funds in the portfolio in terms of arithmetic and geometric

annual returns	14.8%
cumulative returns	52.9%
annual volatility	16.2%
sharpe ratio	0.93
calmar ratio	0.81
stability	0.77
max drawdown	18.2%
omega ratio	1.19
sortino ratio	1.33
skew	-0.22
kurtosis	5.87
tail ratio	0.90
daily value at risk	-2.0%

Funds	Arithmetic	Geometric
GC=F	76.862	4.603
KOTAKBANK.NS	29.438	2.754
ONGC.NS	24.277	1.309
RELIANCE.NS	29.092	3.586
TCS.NS	40.665	4.130

From fig 4.9 we can obtain the Kelly value that we get in arithmetic and geometric forms in the portfolio, but we can also observe that the value we get for tcs in geometric form is 31.56% we need to consider it in a careful manner by choosing the capital to invest as we are also considering the diversification procedure as well.

TABLE IX
KELLY OPTIMAL FRACTION OF THE FUNDS IN PORTFOLIO

GC=F	0.34
KOTAKBANK.NS	0.15
ONGC.NS	0.05
RELIANCE.NS	0.20
TCS.NS	0.26

The above portfolio consists of 5 funds which are Gold, Kotak bank, ONGC, Reliance and TCS as a portfolio and the fractions are the amount of the investment that needs to be done by the investor taking the Kelly criterion as the formula as well.

TABLE X
FUNCTIONS USED IN KELLY CRITERION

Function name	Use
expected_arith()	expected value in arithmetic form
expected_geom()	expected value in geometric form
kelly_fraction()	kelly value of the fund
worst_loss()	to know if the loss is worst
bound_loss()	to know the minimal loss
f_plots()	to plot the optimal fraction and the kelly fraction
optimal_frac()	to know the optimal value of the fund to be invested

G. Dash plotly

The plotly is a library which introduces the interactive method for the representation of the graphs. In the proposed research we have used the dash library and flask for the creation of the graphical user interface for MPT (Modern Portfolio Theory). Where symbols are the ticker codes of the stocks or the funds which the investor needs to invest and the amount of the portfolio or the weights of the portfolio will be the nest input.

Fig.9 Tickers and the weights.

These inputs are given and finding out the optimal and the minimum volatile portfolio is being done in the backend and the results are:

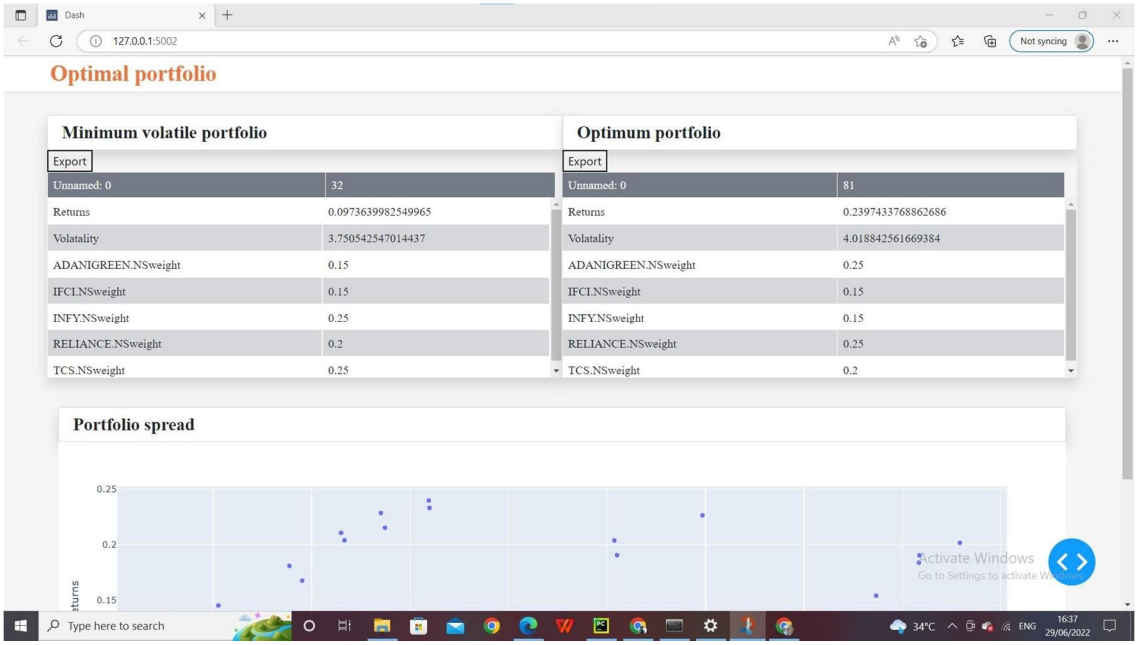


Fig.10 graphical user interface for MPT.

IV. CONCLUSIONS

The Stock market mainly has two rules

1) Do not lose your money

2) Do not forget the 1st point.

With the help of the technical and computational knowledge we can attach proofs to the decisions we make and that is financial analytics. Financial Analytics has good scope. There are many ways to understand a portfolio. It can be through mere observations or by experts' advice or by using some mathematical formula. In this research we tested the genetic algorithm with different weights and were able to get results based on the weights of the portfolio considered as the gene in its term.

We also tested the Modern portfolio theory using the efficient frontier with expected returns and risk of the funds, which also provided us with an optimal value of portfolios considered with it. But there are many mathematical formulas and strategies to find the optimal values or the portfolios such as Calmar ratio, Treynor ratio that can help in optimizing the efficient frontier even better. This whole sum of functions is modular, so in future any functions that are to be added into this package becomes easy. We also used the Kelly Criterion for a stock to see its optimum weight that can be invested by lowering the risk and gaining the optimal profit. The future work would supposedly be the selection of the optimal portfolio gained from the strategies and help the investor to invest money efficiently.

REFERENCES

[1] Oliphant, T.E., 2006. A guide to NumPy, Trelgol Publishing USA.

[2] Markowitz, Harry. “Portfolio Selection.” The Journal of Finance, vol. 7, no. 1, 1952, pp. 77–91. doi: 10.1111/j.1540-6261.1952.tb01525.x

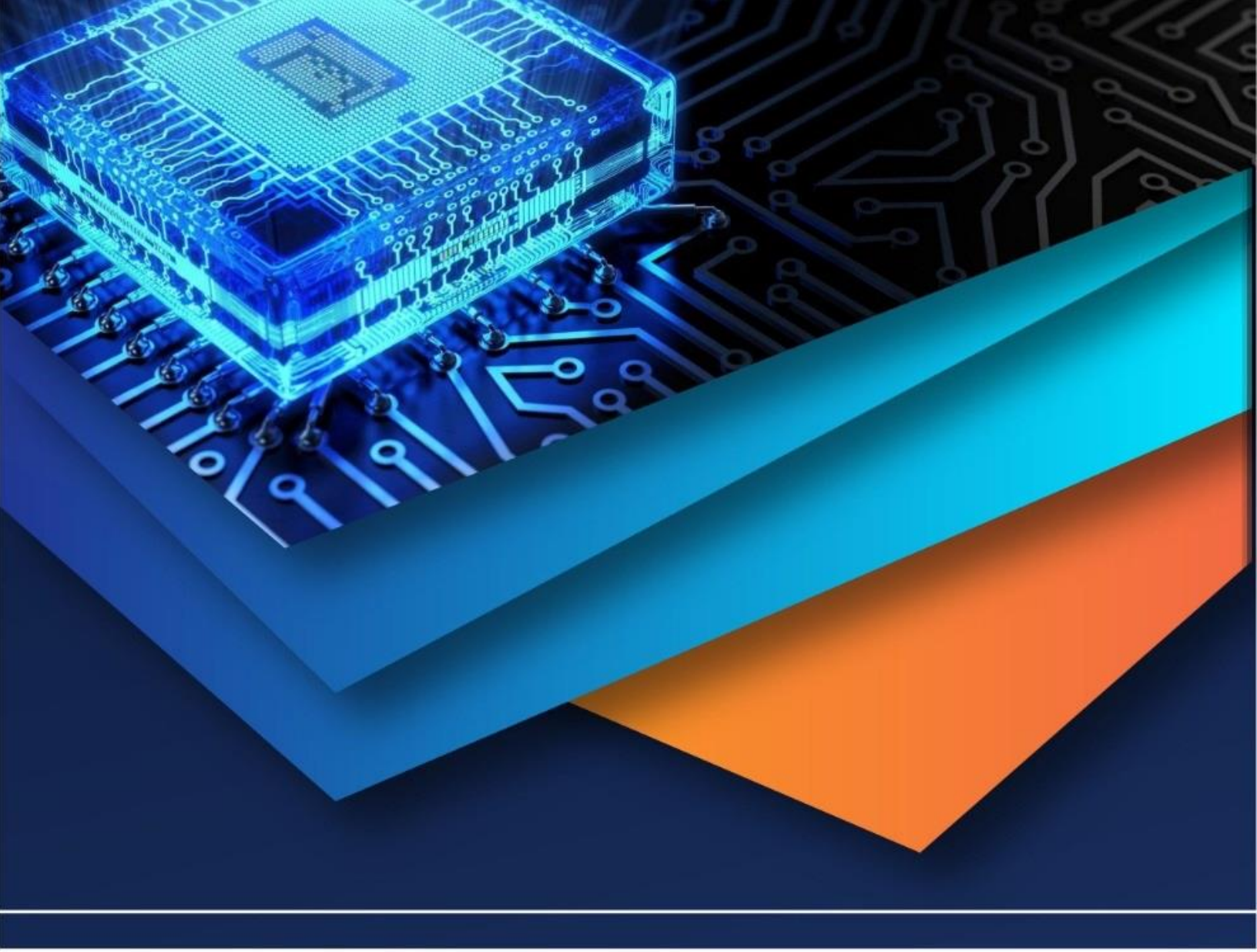
[3] Carta, Andrea and Claudio Conversano. “Practical Implementation of the Kelly Criterion: Optimal Growth Rate, Number of Trades, and Rebalancing Frequency for Equity Portfolios.” *Frontiers in Applied Mathematics and Statistics* (2020).

[4] Edward O. Thorp, 2011."The Kelly Criterion in Blackjack Sports Betting, and the Stock Market," World Scientific Book Chapters, in: Leonard C MacLean & Edward O Thorp & William T Ziemba (ed.), THE KELLY CAPITAL GROWTH INVESTMENT CRITERION THEORY and PRACTICE, chapter 54, pages 789-832, World Scientific Publishing Co. Pte. Ltd.

[5] Estrada, Javier. (2009). “Geometric Mean Maximization: An Overlooked Portfolio Approach?” The Journal of Investing. 19. 10.2139/ssrn.1421232.

[6] Kelly, John L. “A new interpretation of information rate.” *IRE Trans. Inf. Theory* 2 (1956): 185-189.

[7] Kyong Joo Oh, Tae Yoon Kim, Sung-Hwan Min, Hyoung Yong Lee, Portfolio algorithm based on portfolio beta using genetic algorithm, Expert Systems with Applications, Volume 30, Issue 3, 2006, Pages 527-534, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2005.10.010.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY