STOCK PORTFOLIO OPTIMISATION

Using Genetic Algorithm

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CONTENTS

INTRODUCTION

We aim to build the optimal investment portfolio according to a defined set of assets. This involves finding the maximization of an objective function.

PROBLEM STATEMENT

Portfolio optimization involves selecting N financial assets and determining weight values for each based on historical returns. The objective is to find these weight values that maximize returns and minimize risk simultaneously.

SOME RELATED TERMS...

Portfolio

Collection of financial assets and investment tools that are held by an individual, a financial institution, or an investment firm

Historical Returns

Refers to the past rate of return and performance of an investment or asset

Risk-Free Rate of Return

The theoretical rate of return of an investment with zero risk or zero chance of loss

Standard Deviation

The statistic that measures the dispersion of a dataset relative to its mean

SOME RELATED TERMS...

Here are some other terms that are used in implementing our required optimisation

Sharpe Ratio, S

S = (μ – r)/σ

μ: Mean portfolio return

r: Risk free rate (0.0697)

σ: Standard deviation of portfolio return

Covariance

$$cov_{x,y} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{N}$$

Mean

$$R_P = \sum_{i=1}^{n} (w_i) \times (R_i)$$

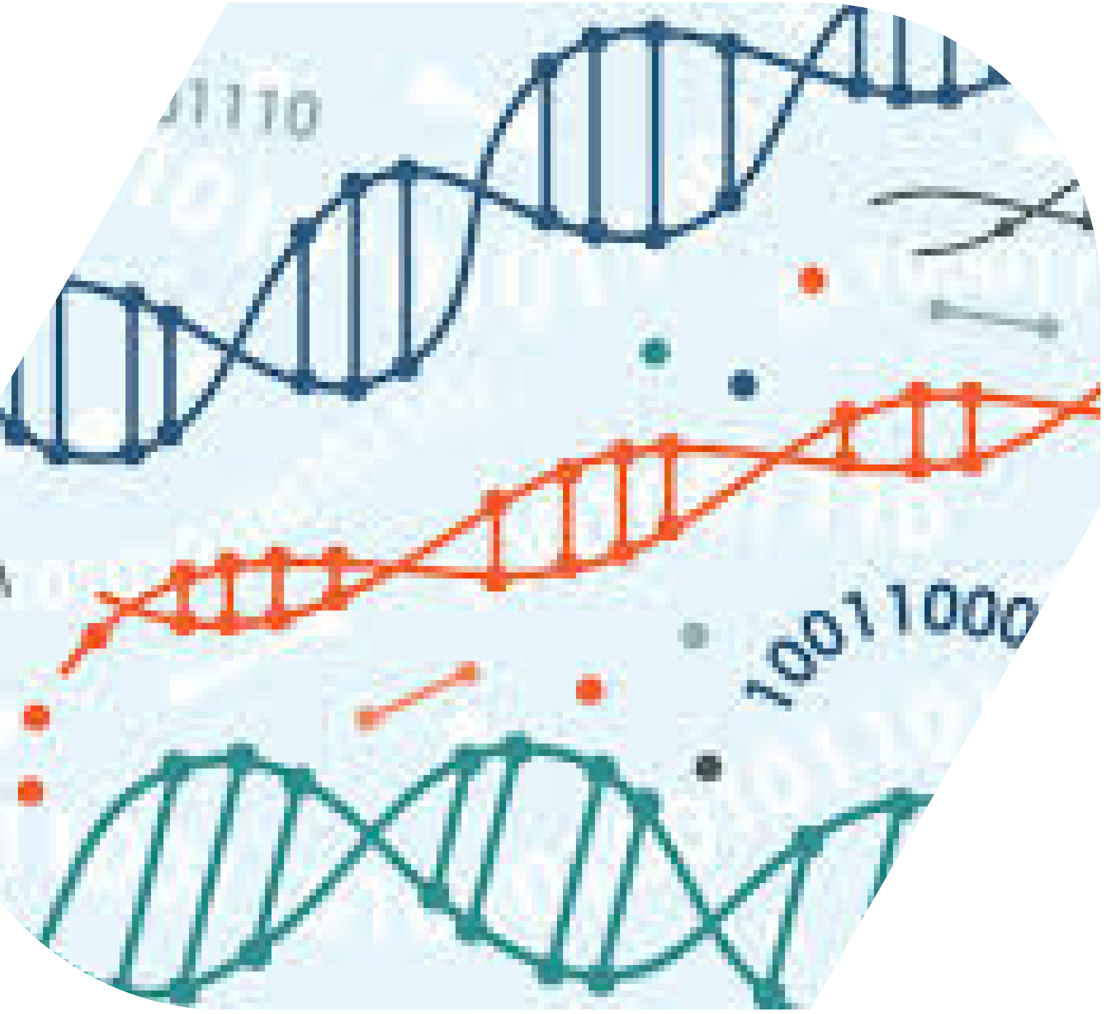
Standard Deviation

$$\sigma_p = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\rho_{1,2}\sigma_1\sigma_2}$$

$$\sigma_p = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2Cov_{1,2}}$$

WHY GENETIC ALGORITHM?

Why did we choose Genetic Algorithm for Portfolio Optimisation?



Nature of Search Spaces

Able to deal with computationally complex problems. Can predict returns and risks for a vast set of assets and time periods.

Type of Search Spaces

Can deal with discrete or continuous search spaces.

Evolutionary Algorithm

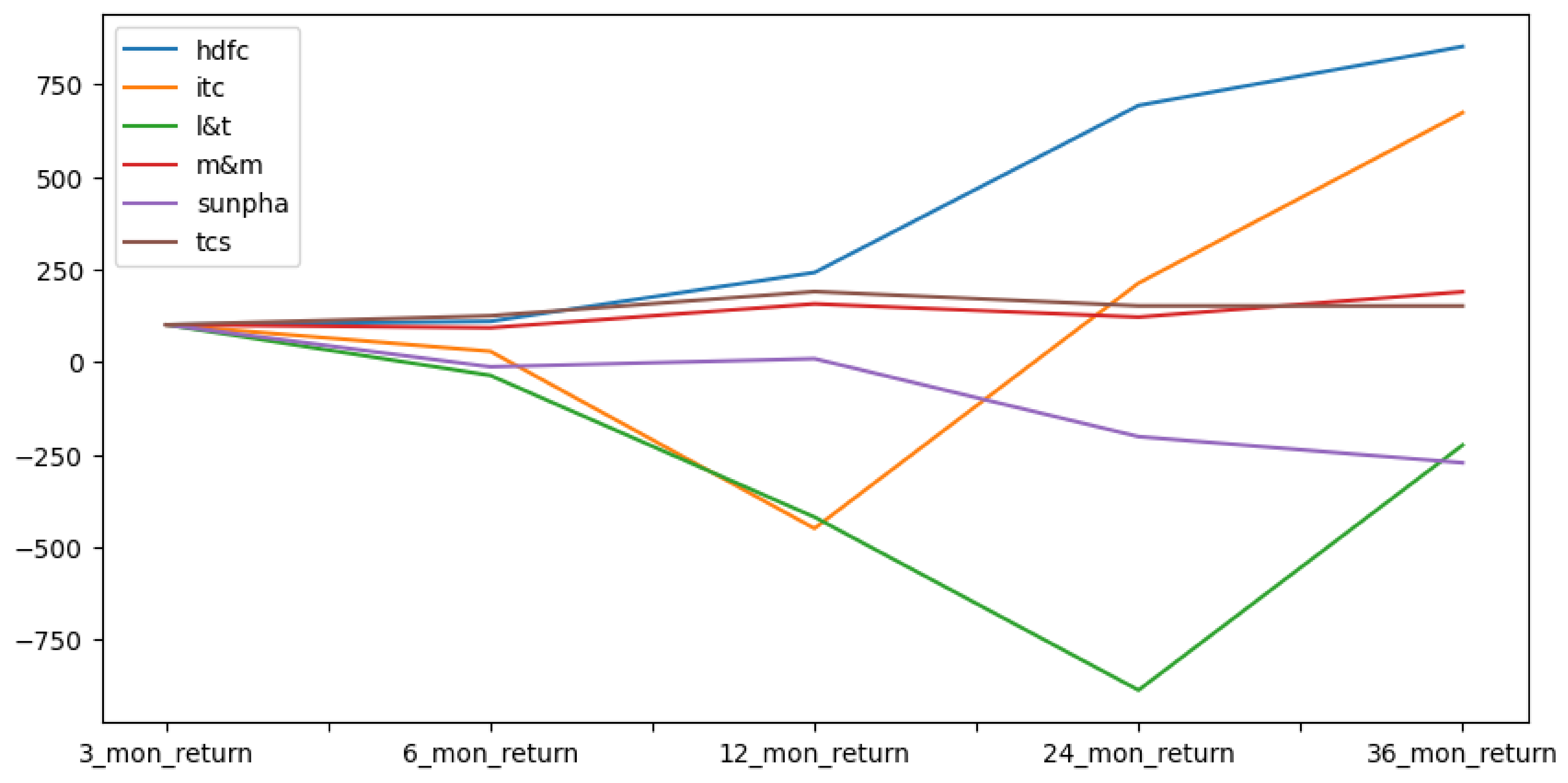
Generates near optimal solution using stochastic search methods, involves concepts of Genetics and Evolution. Perfect for Portfolio Optimisation when we aim to optimise the returns and risks.

INPUT

Monthly Closing Stock values of HDFC, ITC, L&T, M&M, Sun Pharma and TCS from June 2015 to June 2018.

OUTPUT

Portfolio of stocks with maximum returns and minimum risk, along with weights allocated to each stock.



Graph plotted between historical returns of the stocks vs periodically closing values.

GENETIC ALGORITHM APPROACH

- All the data is combined into one dataframe.
- Historical returns for 3, 6, 12, 24, and 36 months are generated as fractions for each stock.
  - Calculated as the difference between recent and old stock prices divided by old stock price
- Gene: A fraction of the total capital assigned to the stock - also called weight.
  - Real Encoding

- Chromosome: Set of genes, i.e., 1D array of weights of each stock
    - The sum of each chromosome must be 1.
- Fitness function: Sharpe ratio (S) is a measure for quantifying the performance of the portfolio, which works on “Maximisation of return(mean) and minimization of risk(variance) simultaneously.”
- Select Canonical Population: Select the chromosomes with the highest returns as determined by the fitness function.
    - Canonical Selection Method

- Mutation: Randomly, we choose two numbers between 0 and 5 and swap those elements.
- Crossover: Linear crossover

$$\text{Offspring A} = \alpha * \text{Parent1} + (1 - \alpha) * \text{Parent2}$$

$$\text{Offspring B} = (1 - \alpha) * \text{Parent1} + \alpha * \text{Parent2}$$

- Next Generation: Building a new generation of chromosomes by selecting, crossover, and mutation depending on probability.
- Iteration: Iterate the entire process until we reach a desired return or fixed number.

RESULTS

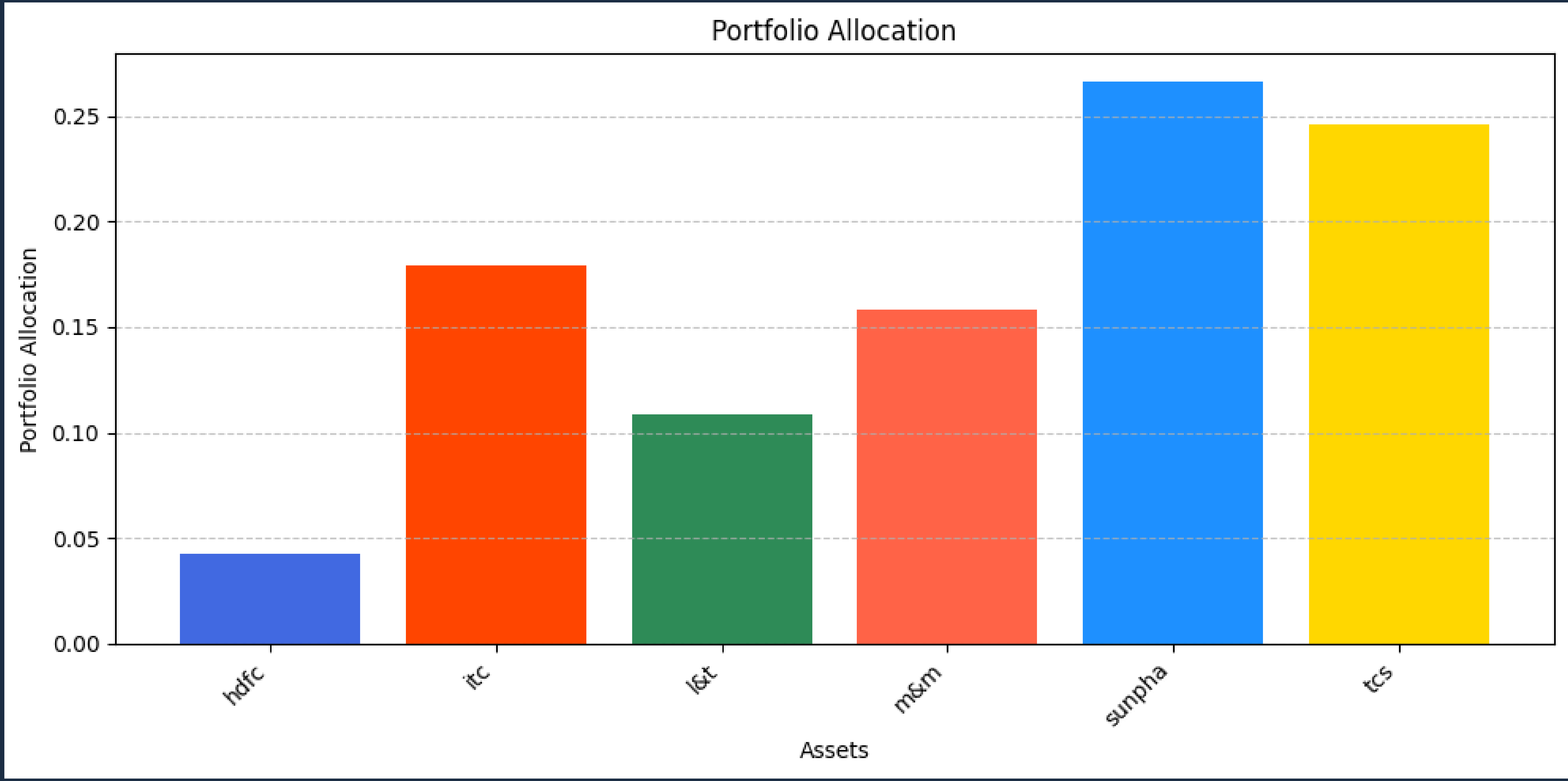
```
print('Portfolio of stocks after all the iterations:\n')
[print(hist_stock_returns.columns[i],':',elite[0][i]) for i in list(range(6))]

print('\nExpected returns of {} with risk of {}\n'.format(Expected_returns,Expected_risk))
```

```
Portfolio of stocks after all the iterations:

hdfc : 0.04089155811489179
itc : 0.2138606972375236
l&t : 0.0685812040707566
m&m : 0.0859695511645474
sunpha : 0.2767771783282046
tcs : 0.313919811084076

Expected returns of 0.16399575732195307 with risk of 0.00043107061036632387
```



Weights assigned to different stocks after the population has converged.

CONCLUSION

The solution converges when the expected returns become greater than 0.3, the expected risk is less than 0.0005, or if the algorithm has completed 40 iterations.

The probability of mutation and crossover change with the course of the algorithm to ensure that there is enough exploration as well as exploitation.

Thus, the genetic algorithm has helped to assign optimized stock weights to the different stocks in the portfolio based on the constraints, that is, to maximize expected returns and to minimize expected risk.

THANK YOU

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