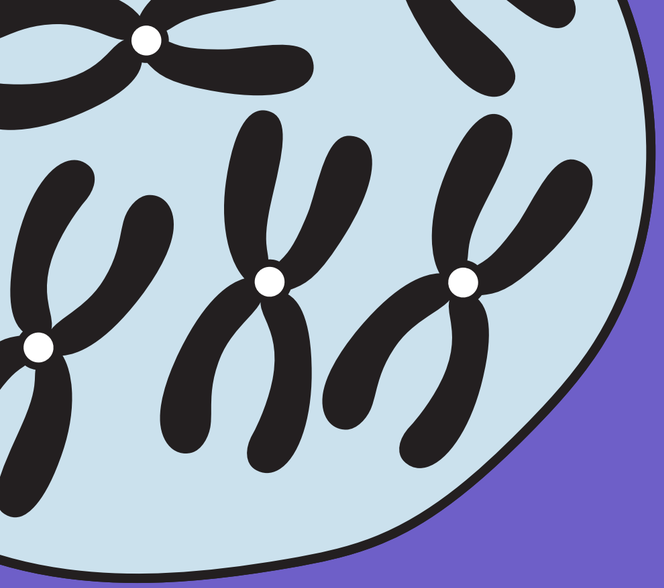
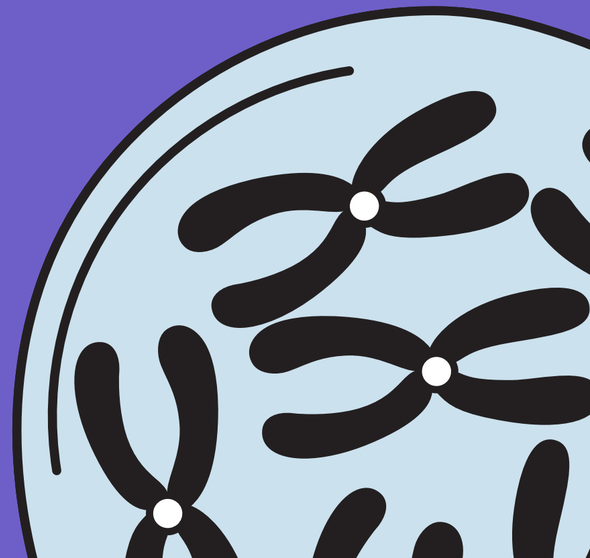


GENETIC ALGORITHM

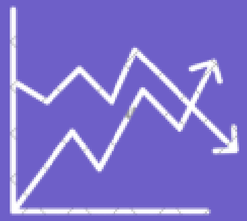
A Genetic Algorithm (GA) Approach to the Portfolio Design Based on Market Movements and Asset Valuations

Asma BEN-ZINE
Leaticia AIDOUNE



Introduction to Portfolio Optimization

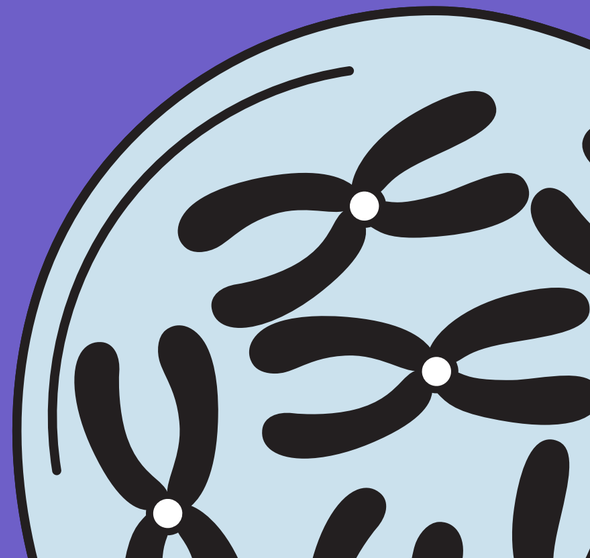
Challenges



Unpredictability: Future prices are uncertain due to countless variables (e.g., geopolitical events, pandemics).

Noise: Irrelevant or misleading price fluctuations caused by irrational trading, rumors, or liquidity gaps (not reflecting true value).

Socio-economic factors: Interest rates, inflation, policy changes.



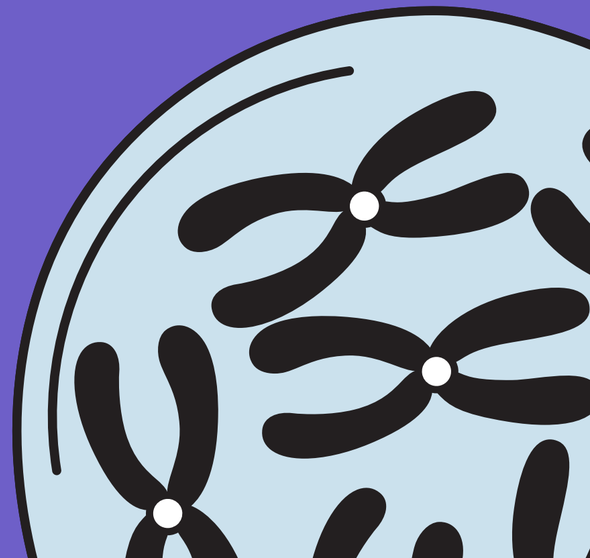
Introduction to Portfolio Optimization

Traditional approaches

Modern Portfolio Theory

	Portfolio 1	Portfolio 2
Return	12%	14%
Risk	10%	10%

A practical method for selecting Investments in order to maximize their overall returns within an acceptable level of risk



Introduction to Portfolio Optimization

Traditional approaches

Sharpe Ratio

The Sharpe Ratio measures how much excess return a portfolio earns for each unit of risk, compared to a risk-free asset.

$$\text{Sharpe Ratio} = \frac{r_p - r_f}{\sigma_p}$$

Where:

r_f = Risk-Free Rate

r_p = Rate of Return of Stock/ Portfolio

σ_p = Standard Deviation of Stock / Portfolio

$R_f = 3\%$

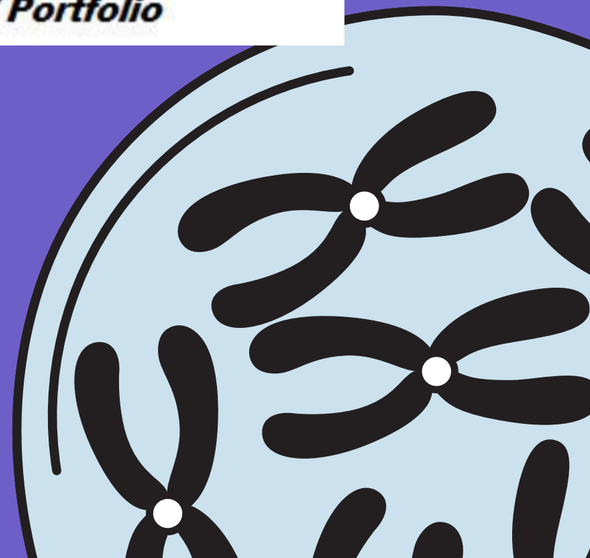
	Portfolio 1	Portfolio 2
Return	10%	12%
Risk	14%	16%

Portfolio 1

$$\text{Sharpe Ratio} = \frac{10\% - 3\%}{14\%} = 0.5$$

Portfolio 2

$$\text{Sharpe Ratio} = \frac{12\% - 3\%}{16\%} = 0.56$$



Introduction to Portfolio Optimization

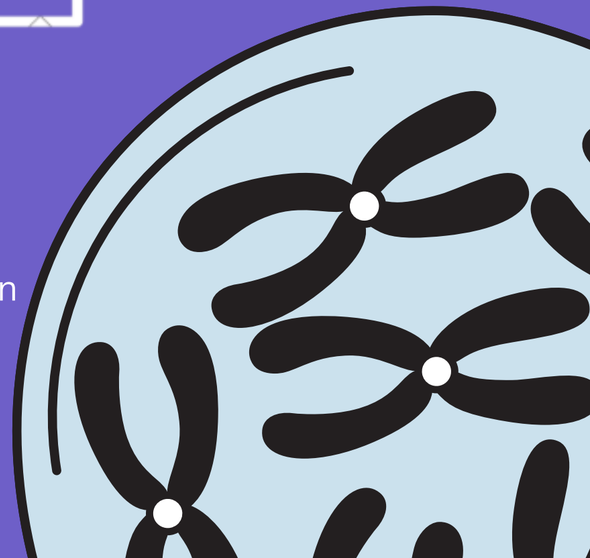
Limitations

High computational complexity ($O(n^2)$ for MPT).

$cov(x,y)$

Covariance ignores multi-asset interactions (e.g., 3+ stocks).

Ignores asset valuation (e.g., CAPM)



Introduction to Portfolio Optimization

Traditional approaches

Fund Standardization

- Cuts complexity ($O(n^2) \rightarrow O(1)$).
- Captures all asset interactions (not just pairs).
- Uses simple +/- for fast risk calculation.

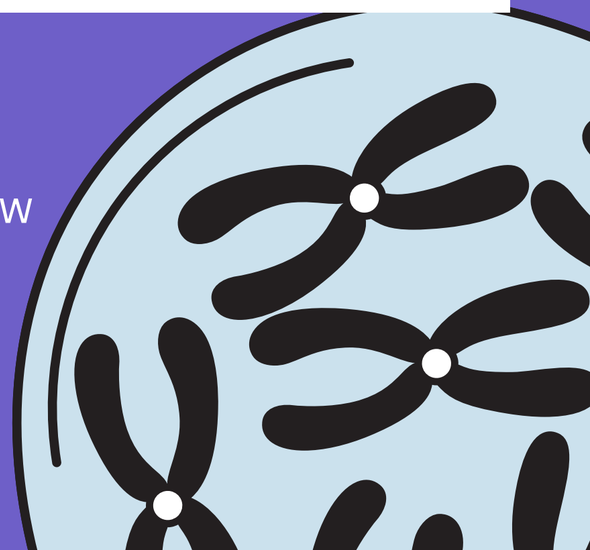
Fund Metric Formula:

$$\text{Fund Value} = \text{Return} - \text{Fees} - \text{Tax} + \text{Remaining Budget}$$

Portfolio Risk :

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{j \neq i} w_i w_j \sigma_{ij}$$

- $\sum w_i^2 \sigma_i^2$ → Risk of each asset, adjusted by how much you invest in it (individual variance).
- $\sum\sum w_i w_j \sigma_{ij}$ → How assets move together (covariance between each pair).

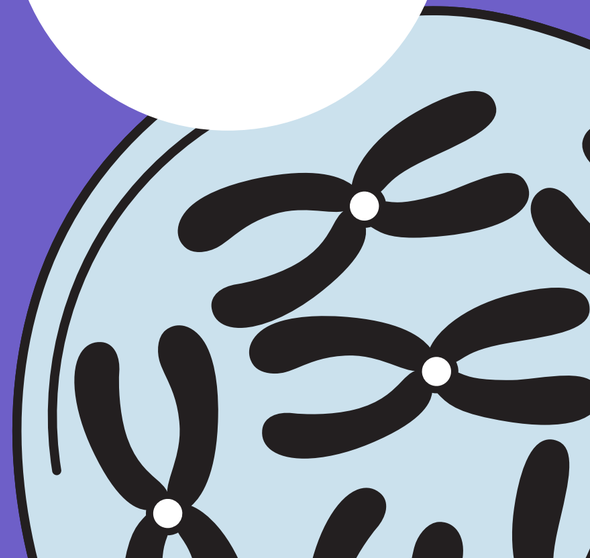


Key Concepts

Momentum Strategy

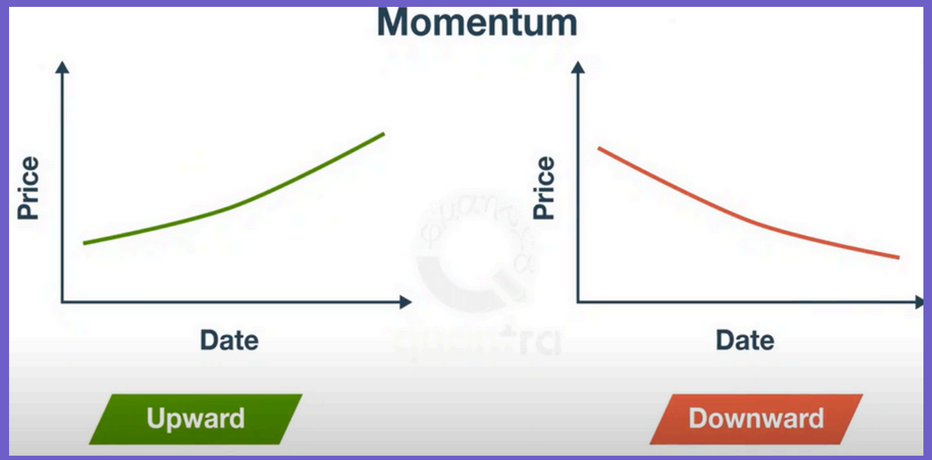
CAPM (Capital Asset Pricing Model)

Genetic Algorithm (GA)



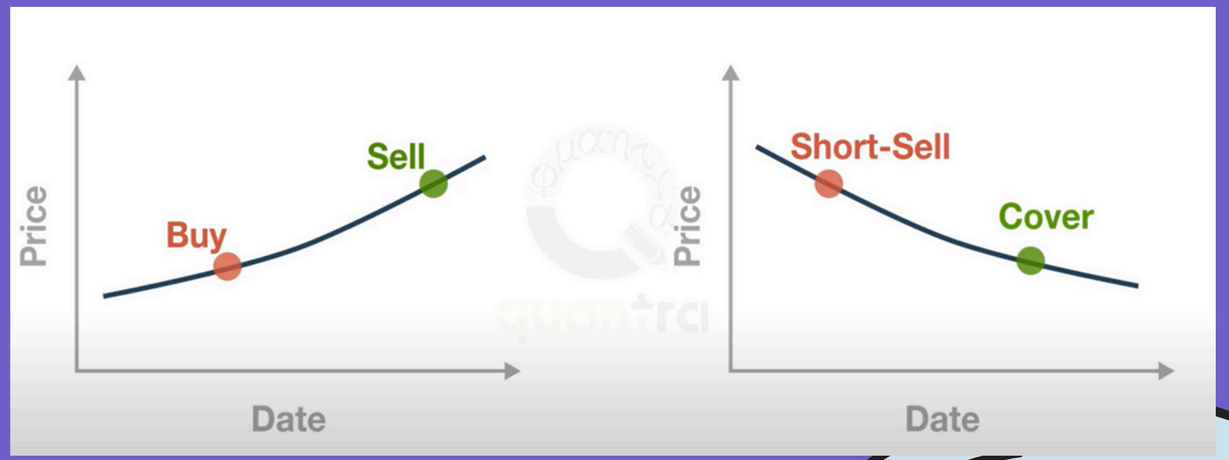
Momentum Strategy

Definition :

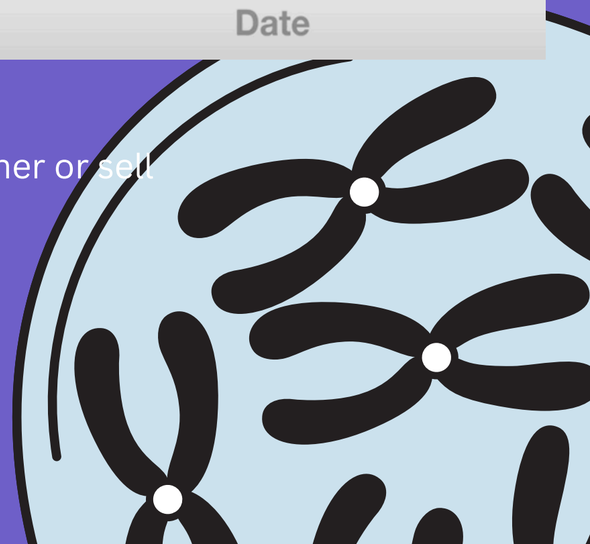


Based on the idea that stocks that performed well in the past tend to continue performing well

Purpose:



The purpose is to buy high and sell higher or sell short to cover lower



Key Concepts

Momentum Strategy

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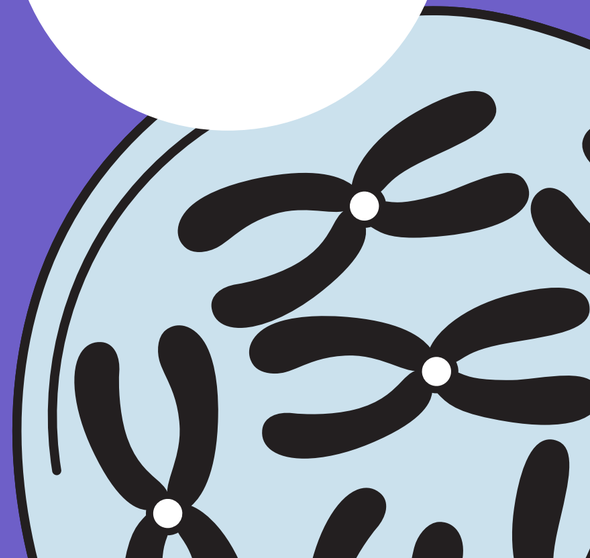


CAPM (Capital Asset Pricing Model)

Formula

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$

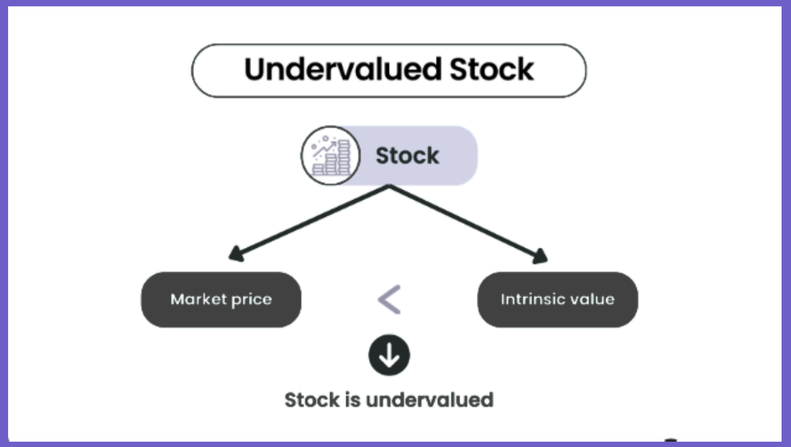
$E(R_i)$ = expected profitability of the financial asset
R_f = risk-free interest rate
β_i = sensitivity
$E(R_m)$ = expected profitability on the market

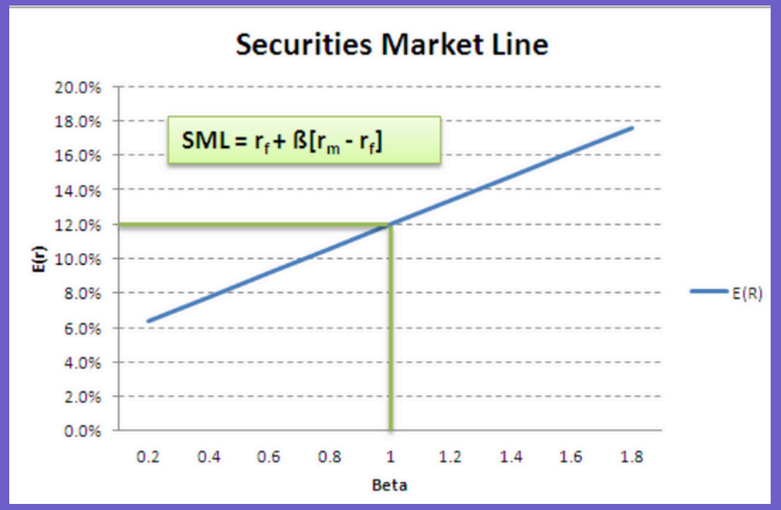
- **β = 1 :** in line
- **β > 1** : more volatile
- **0 < β < 1** :less volatile
- **β < 0** :moves inversely

Definition :

CAPM (Capital Asset Pricing Model) is a financial model that calculates the theoretically appropriate expected return of an asset based on its systematic risk (beta) relative to the overall market. It answers: 'What return should investors demand for bearing market risk?' R_f

Purpose :



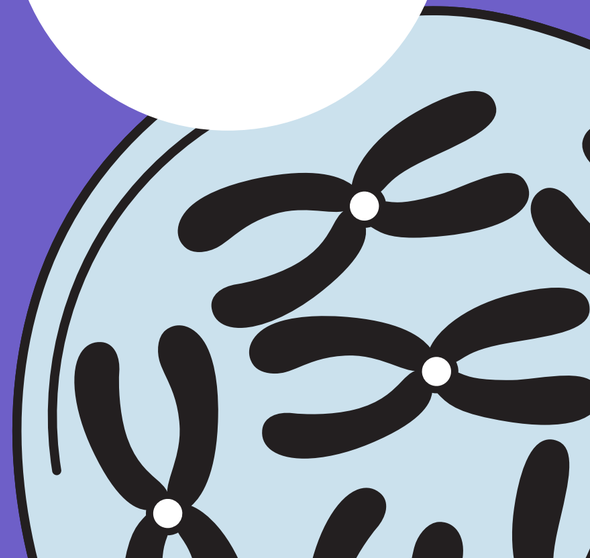


Key Concepts

Momentum Strategy

CAPM (Capital Asset Pricing Model)

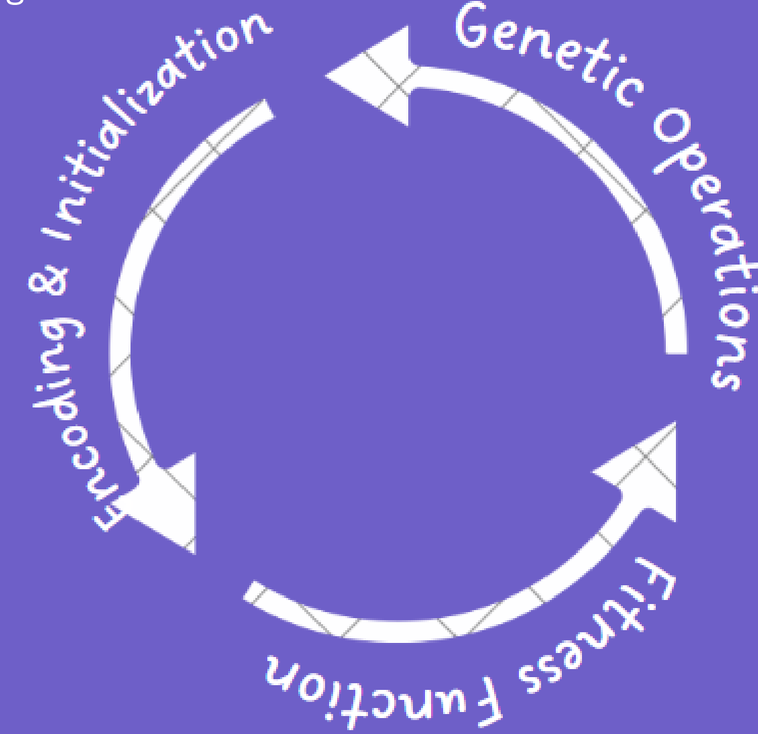
Genetic Algorithm (GA)

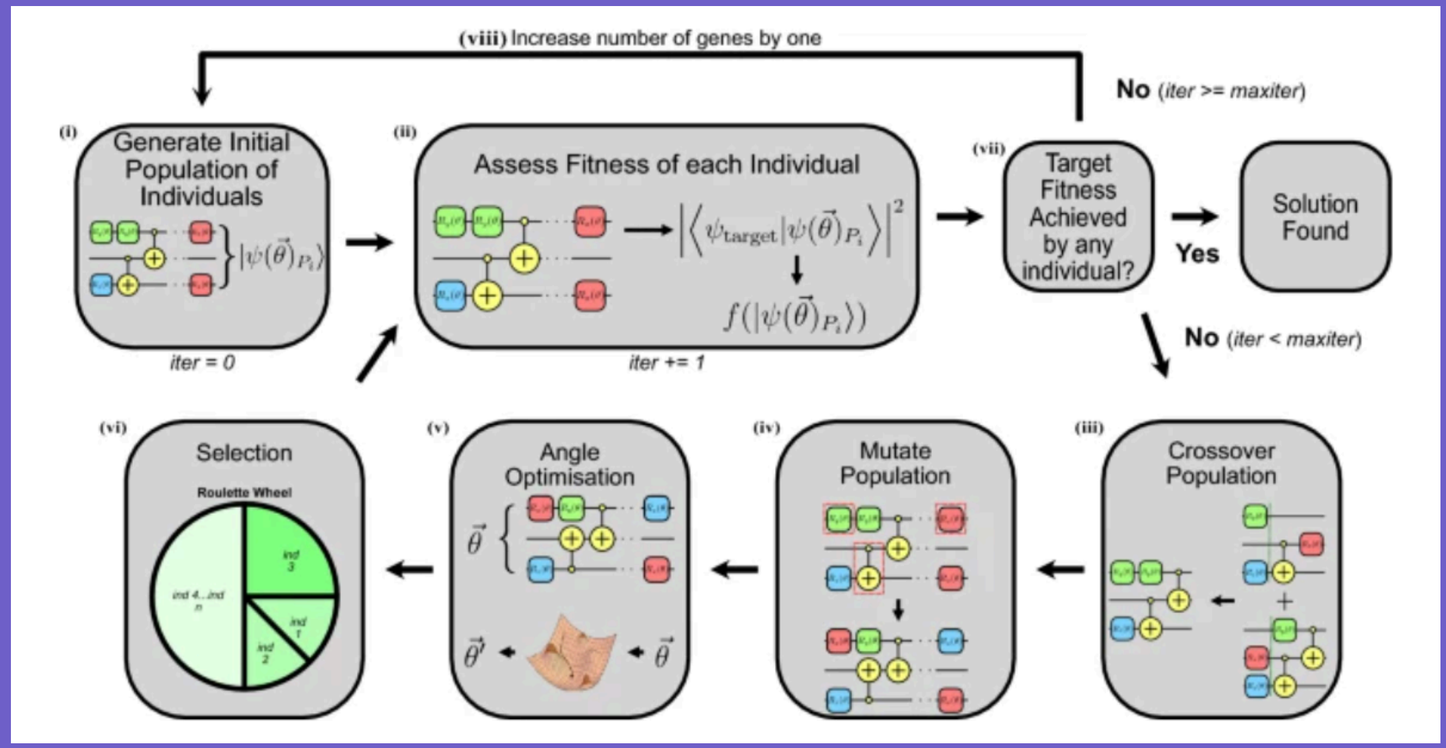


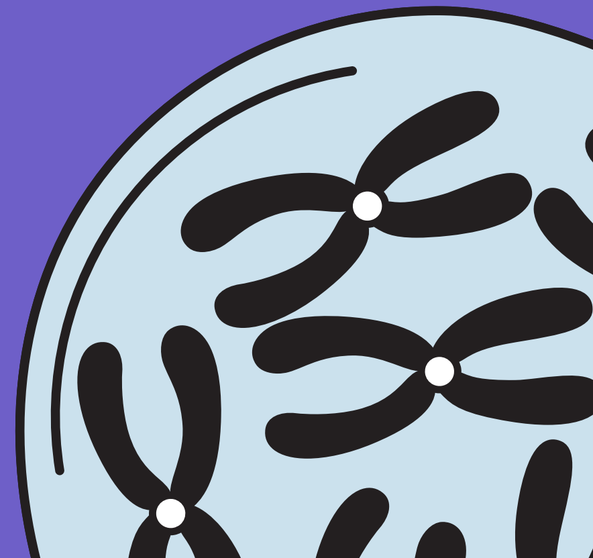
Genetic Algorithm (GA)

Definition :

A bio-inspired optimization technique that imitates natural selection to solve complex problems. It evolves a population of candidate solutions (e.g., portfolios) over generation







Genetic Algorithm (GA)

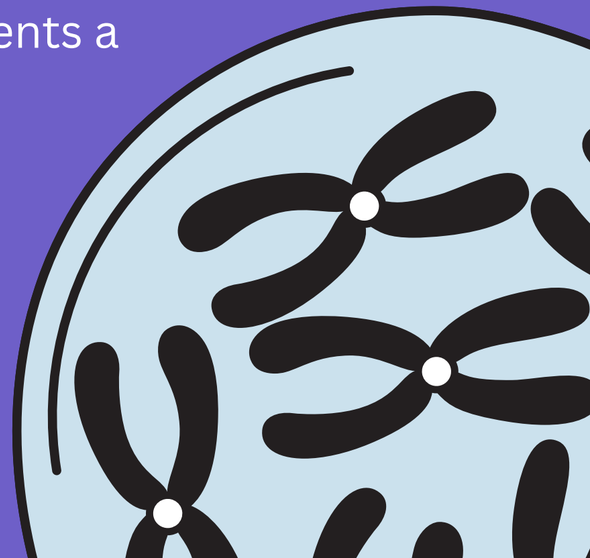
Encoding & Initialization

Chromosome A	10110010110011100101
Chromosome B	11111110000000011111

Chromosomes are string of 1s and 0s and each position in the chromosome represents a particular characteristic of the solution.

During initialization, a population of these chromosomes is randomly generated to represent diverse potential portfolios.

1 = Stock included
0 = Stock excluded



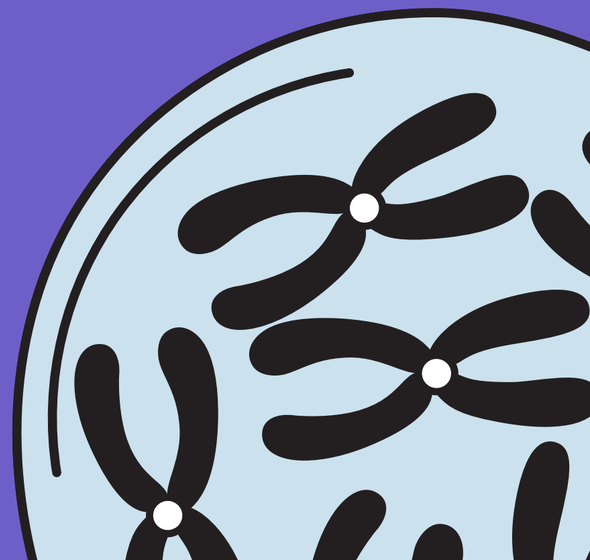
Genetic Algorithm (GA)

Fitness Function

Definition :

The fitness function is the core evaluation metric in a genetic algorithm (GA) that quantifies how well a candidate solution (e.g., a portfolio) performs against the desired objectives by evaluating and filtering assets based on their risk-adjusted returns, valuation gaps, and cost efficiency.

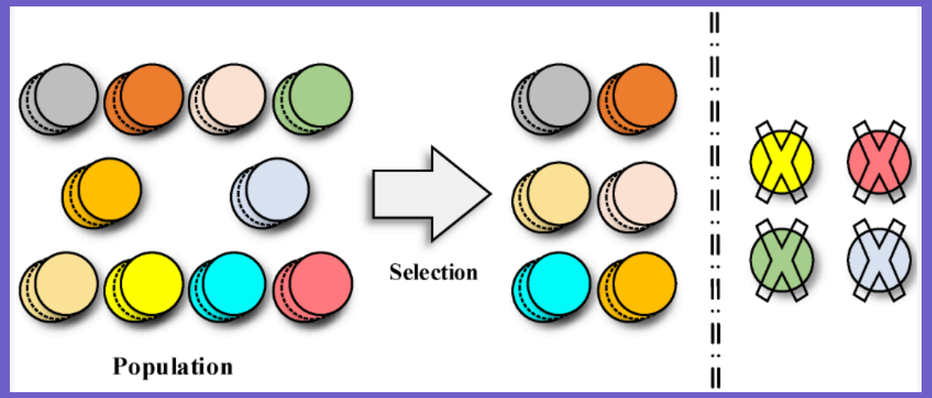
The fitness function evaluates portfolios by combining **CAPM** , **Sharpe Ratio** (risk-adjusted returns), **momentum trends**, and **volatility** measures, while penalizing for transaction costs to guide optimal asset selection.



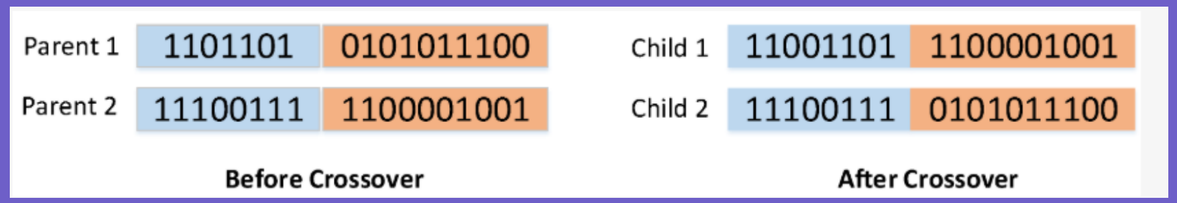
Genetic Algorithm (GA)

Genetic Operations

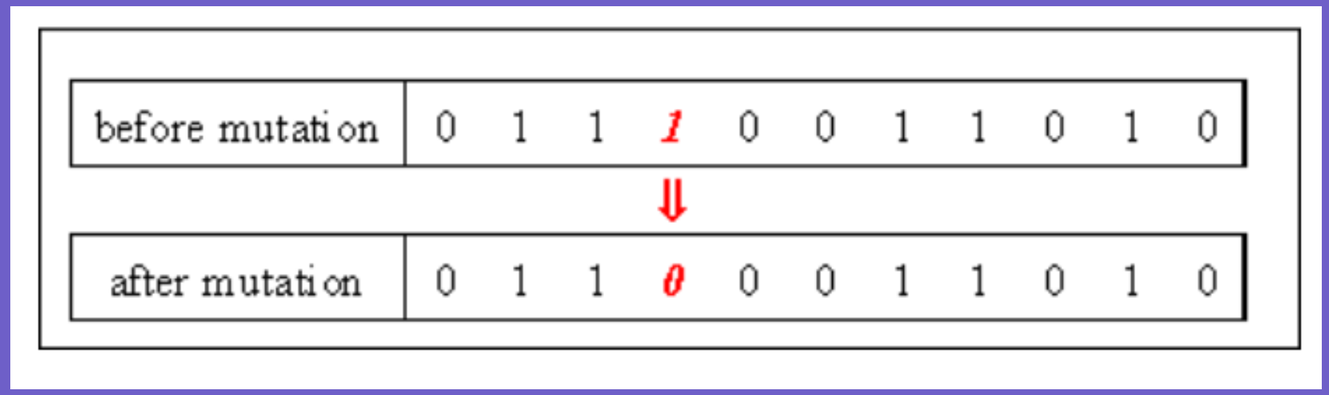
Selection :

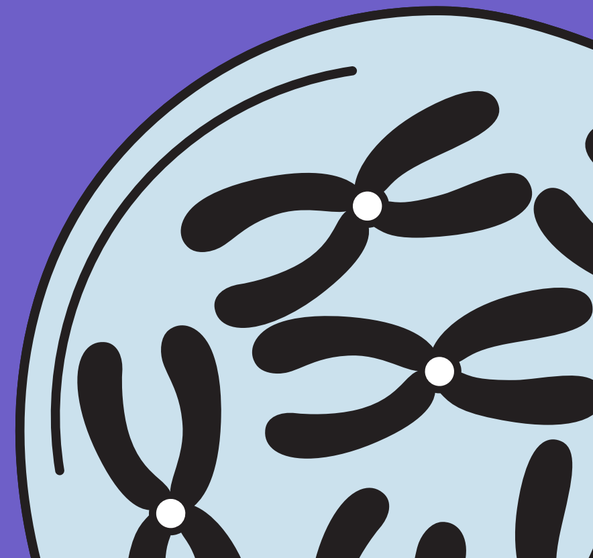


Crossover :



Mutation :





Key Concepts

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CAPM (Capital Asset Pricing Model)

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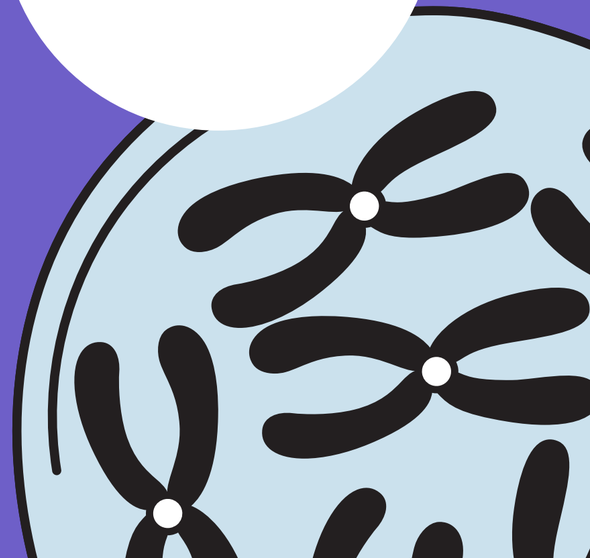


Experimental Setup

GA Settings:

- 1% mutation
- 100% crossover

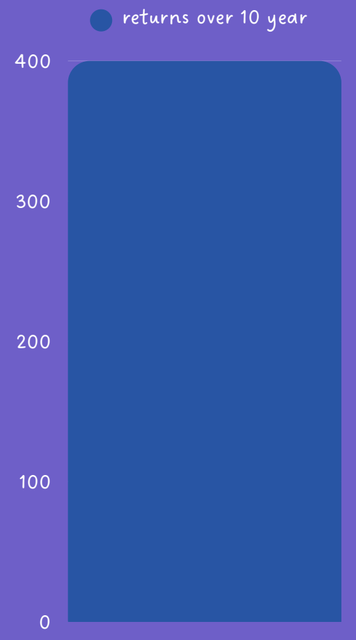
Costs: 0.015% fees, 0.3% taxes

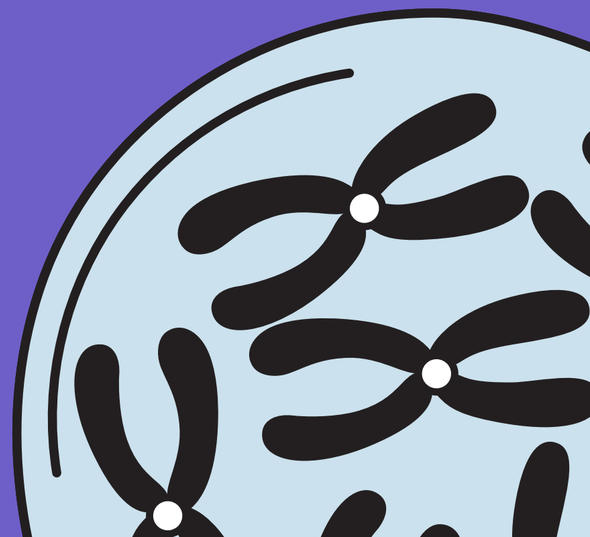
KOSPI200 S&P500

2008-2018

Results

Beating indexes and momentum-only strategies. Shorter (1-month) analysis worked best, with S&P500 needing more GA generations (300 vs. 150 for KOSPI).





CAPM (finding undervalued stocks) + Momentum (tracking trends) + GA (optimizing the mix)

Future Work & Conclusion

Future Research :

- Real-time testing for practical market usability
- Enhance CAPM with Fama-French Factor Models
- Integrate market volatility indexes
- Add macroeconomic indicators for recession prediction

Conclusion :

The CAPM+ strategy offers a strong balance between risk and return, outperforming both index funds and momentum-only methods, especially short-term. It proves robust across multiple markets (KOSPI200, S&P500) and works without expert knowledge, though it can’t fully protect against systemic crises.

+300%
Bull Market Performance

-10%
Crisis Resilience