Real-World Applications of Genetic Programming in Financial Trading

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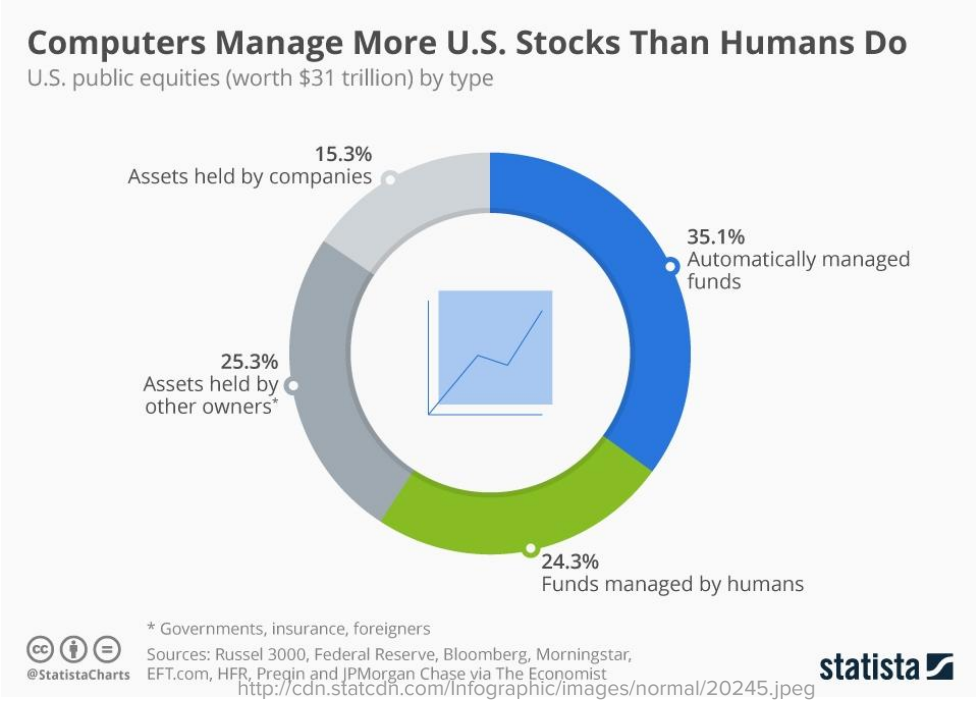
Introduction

- What is investing?
  - Using money to buy an asset, then selling the asset later for a different value (ideally higher)
- Goal is to minimize risk, maximize return
- Estimated 50-60% of trades in US market are automatically executed by computers



Outline

- Background
- Generating Trading Rules using STGP
- Conclusion

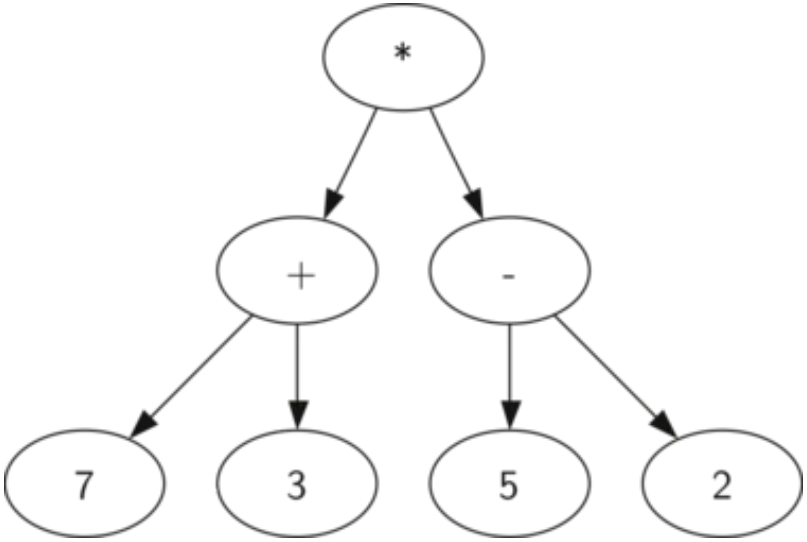
Background

What is Genetic Programming (GP)?

- Sub-field of artificial intelligence (AI)
- Theoretical until 1980’s
- Goal is to solve a given problem
    - In this case, achieve best financial return
- Useful when traditional methods cannot find patterns
    - Financial models usually have many variables

Visualizing GP

- Visualized using syntax trees
- Captures order in which function components execute
- Output is root node, functions are internal nodes, terminal arguments are leaf nodes
- Easily visualises how functions change between generations



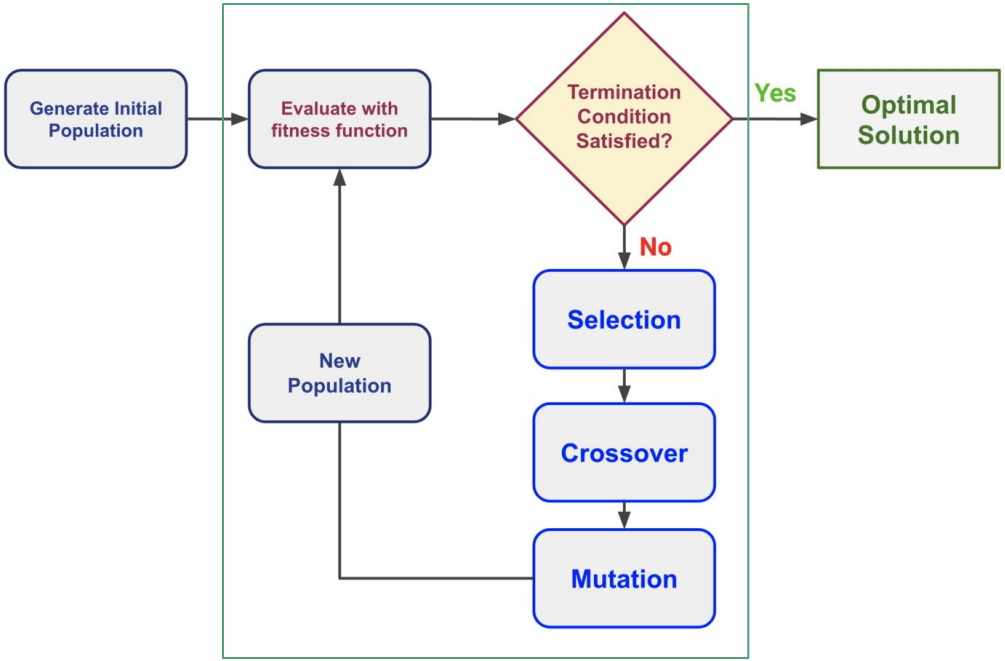
(7 + 3) * (5 - 2)

https://runestone.academy/ns/books/published/pythonds/_images/meParse.png

Generation Example

- Population
  - Set of functions to be evaluated
- Fitness function
  - Evaluates how close each function is to optimal one
- GP Operations
  - Selection: carries over best functions based on fitness
  - Generate new child functions
- New population/generation
  - Excludes worst functions to keep same population size (functions die)

Generation Cycle



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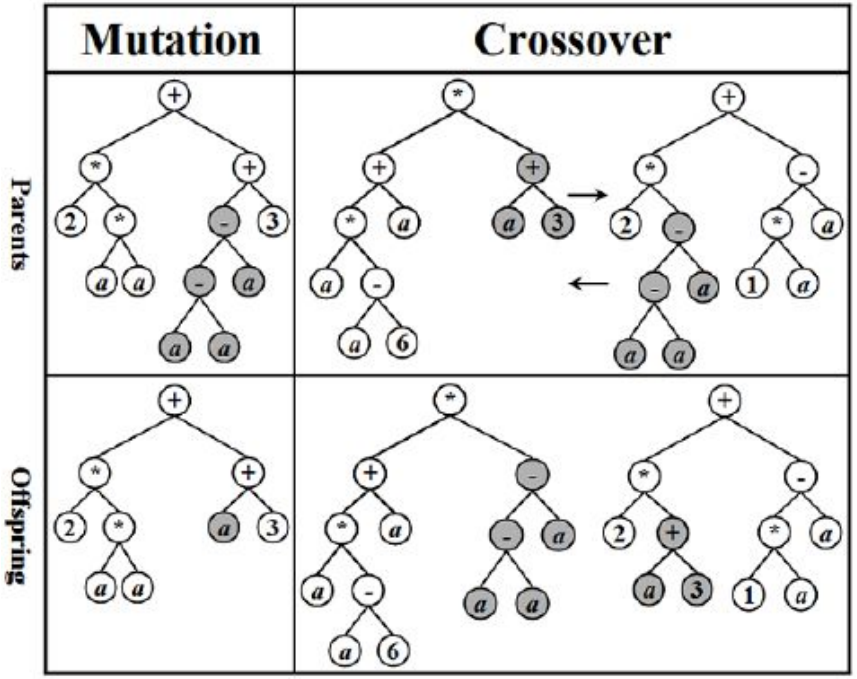
GP Operations

- Crossover: uses two parent functions and swaps at split
- Mutation: chooses variables at random and alters them, then becomes child function



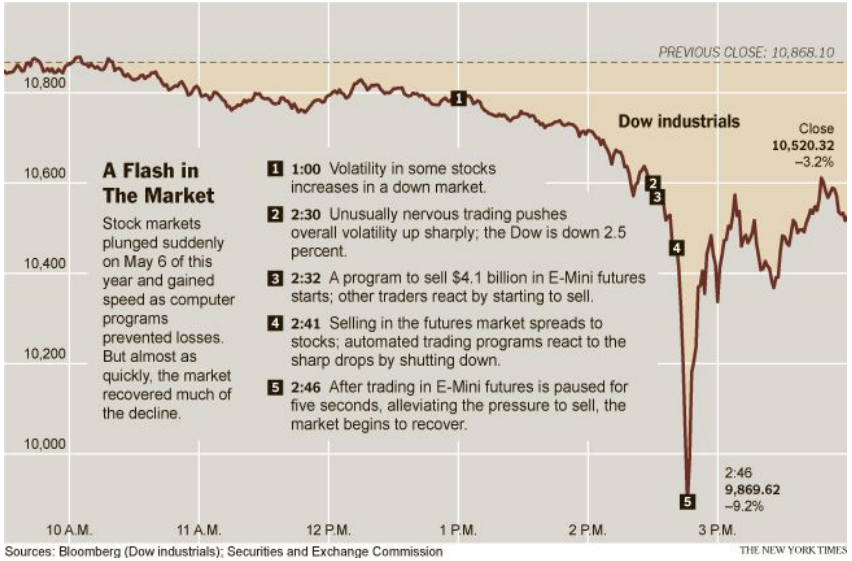
https://www.researchgate.net/profile/Masao-Fukushima/publication/228791048/figure/fig3/AS:300801248514057@1448728014792/Mutation-and-crossover-operations-in-GP.png

In/Out-of-Sample

- In-Sample
  - Existing data
  - Split between training and testing
  - Still useful for finding patterns
- Out-of-Sample
  - Not part of sample
  - Measure effectiveness of model against new information
  - Performance can be worse than in-sample

Automated Financial Trading

- Quicker pattern analysis
- No emotion
- Also susceptible to computer error
  - 2010 Flash Crash
  - Domino Effect

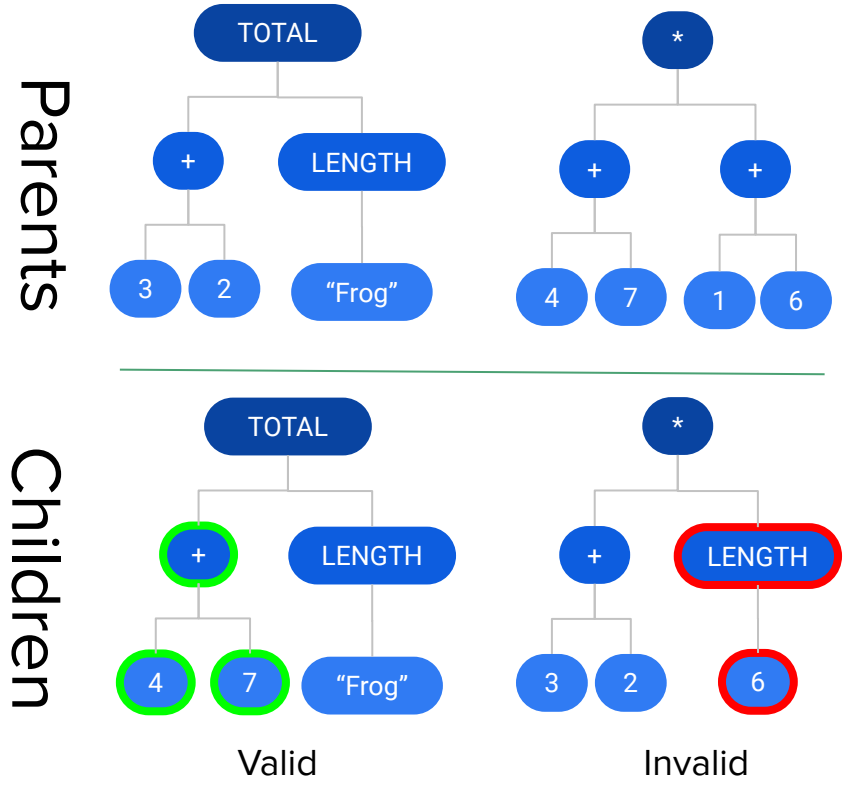


http://graphics8.nytimes.com/images/2010/10/02/business/flash-crash-dow/flash-crash-dow-popup.png

Generating Trading Rules using STGP

Strongly Typed Genetic Programming (STGP)

- Data types of every argument and type returned are specified beforehand
- Mutation and crossover are different due to type requirements
- Smaller search space



Generating Trading Rules from STGP

- Authored by Michell and Kristjanpoller [3]
- Generate unique trade rules
  - Buy, Sell, Hold Signals
- Goal to beat US market indexes
- 40 Generations, population size of 60
  - Previous evidence showed higher values do not improve results

Proposed STGP Model

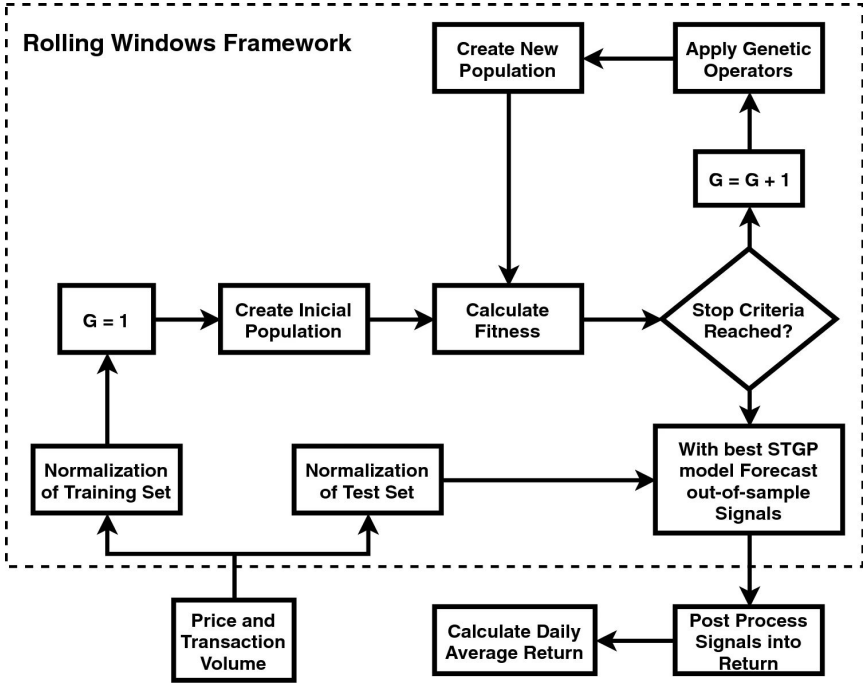
- Use daily US Fed fund rate
  - Considered risk-free
- If return is greater, buy
- If return is less than zero, sell
- Otherwise do not trade
- 0.1% transaction cost

$$\text{Target}_{i,t} = \begin{cases} 1 & \text{if } r_{i,t} > r_{f_t} \quad \forall t \in T,\ \forall i \in N, \\ -1 & \text{if } r_{i,t} < 0 \quad \forall t \in T,\ \forall i \in N, \\ 0 & 0 \leq r_{i,t} \leq r_{f_t} \quad \forall t \in T,\ \forall i \in N, \end{cases}$$

where T is the length of the analyzed period, N is the total number of stocks analyzed, $r_{i,t}$ is the return of stock i at time t

Testing Period

- Rolling window
  - 252 days (one financial year) training
  - 10 days prediction (two financial weeks)
- January, 2003 - November, 2015
  - Contains entire 2008 financial crisis



Model Results

- Outperformed all benchmarks
- Buy and hold (B&H) strategy
  - 90 most traded stocks for period
  - 61% of stocks in STGP portfolio outperform despite transaction cost
- Used Standard GP model from 1999
  - Population of 500
  - Ran for 50 generations, or until no improvement for 25
- Best forecast horizon was 22 days ahead
- STGP Model chose best rule 50% of the time (expected 33%)

Benchmark	STGP Model Improvement (%)
US Fed Rate	435.16
DJA	65.08
S&P500	51.46
B&H	17.74
Standard GP	407.32

Conclusion

What does this all mean?

- Usage of computers in trading can be expected to increase
  - Benefits outweigh drawbacks due to competition
- Research has shown GP to be effective in improving returns
- Acceptance by major financial institutions
  - Must thoroughly validate model before usage
- Black box methods
- 7,690 Google Scholar results since 2021 for “genetic programming finance”

Acknowledgements

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Questions?

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