Developing a Control System to achieve a Profitable Strategy in the crypto market

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Outline

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Introduction and Problem Statement

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Methodology and System Development

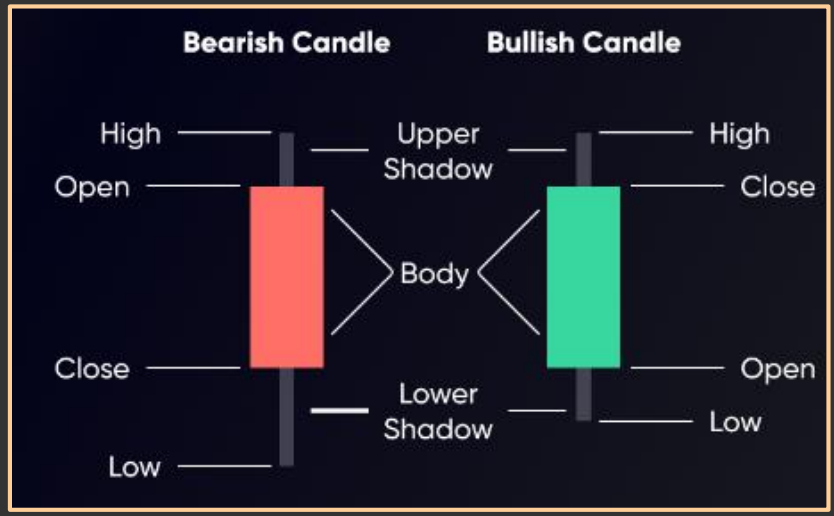
03
Enhancing System Performance

04
Results and Conclusion

Trading Concepts

Candles and Charts

- Color
- OHLC
- Timeframe



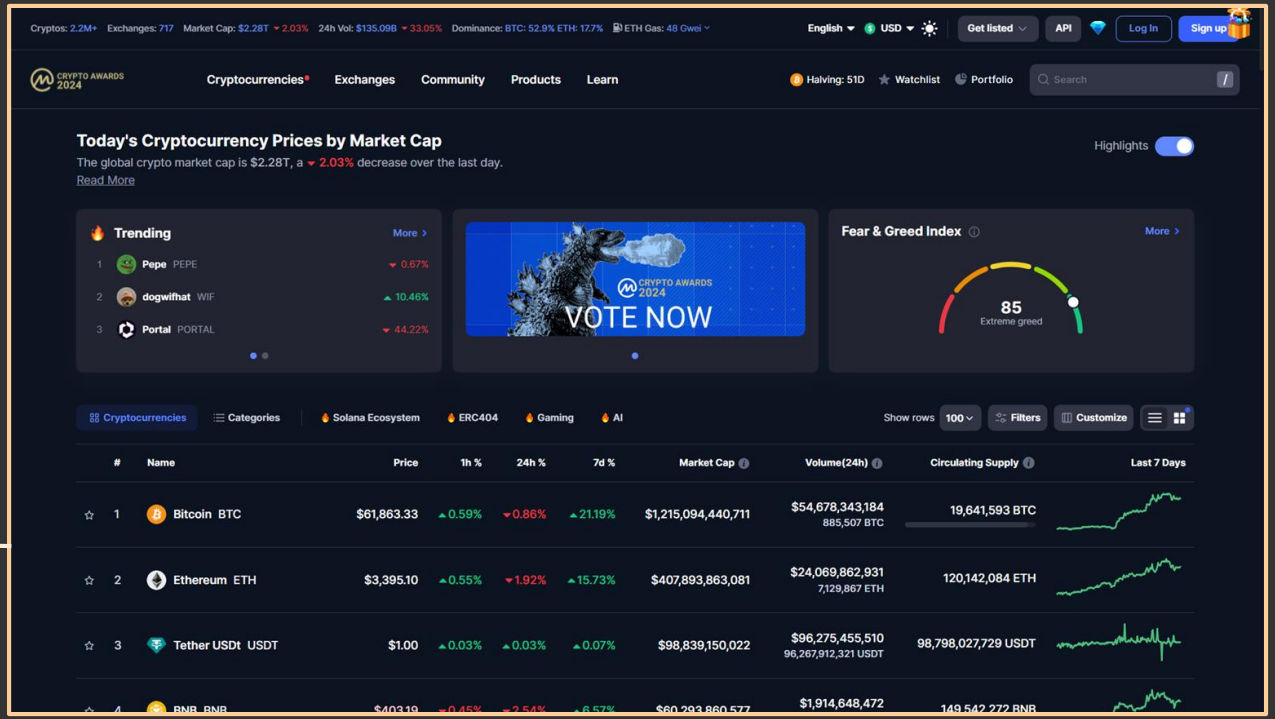
Cryptocurrency Market

- Coin Market Cap
- Tradingview
- Binance

+340M

Monthly Visitors

Largest market aggregator and price tracking platform



Cryptocurrency Market

- Coin Market Cap
- Tradingview
- Binance

+50M

Traders and Investors

Charting Platform

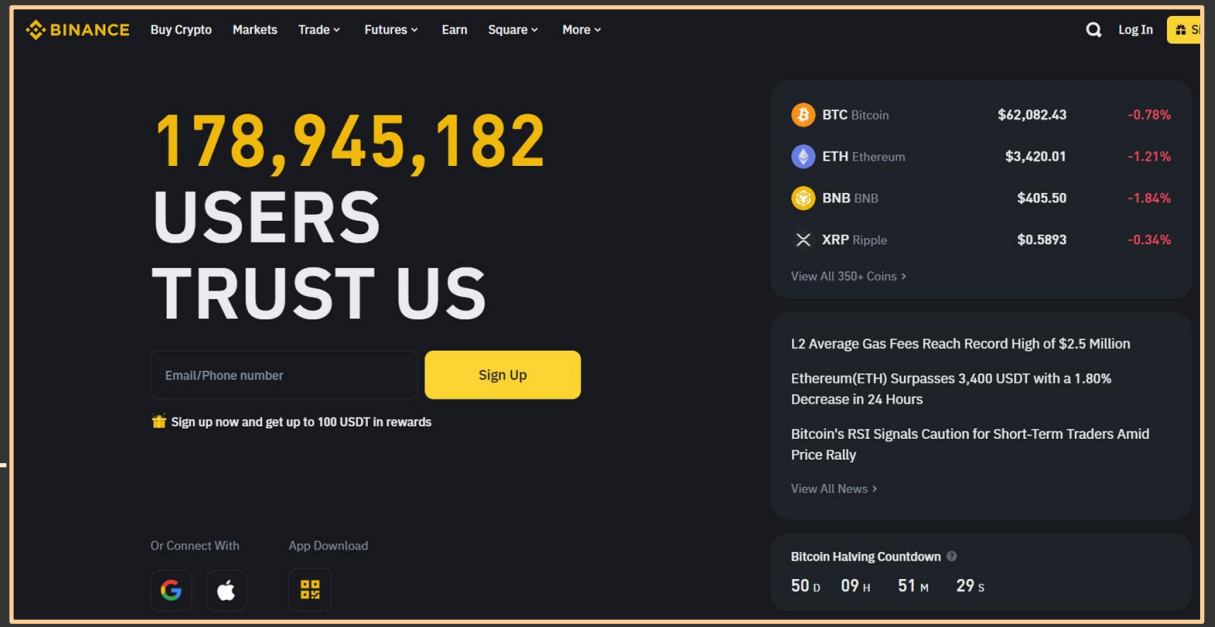
Cryptocurrency Market

- Coin Market Cap
- Tradingview
- Binance

$76 billion

Daily trading volume

World’s largest crypto exchange



Literature Review

01

Price Prediction

Predicting the exact price of a coin

02

Price Direction Prediction

Binary classification of candles

03

Control Based

Use of PI and LQR

Methodology

System Design

Defining system modules

Minimizing the cost function

Using control methods

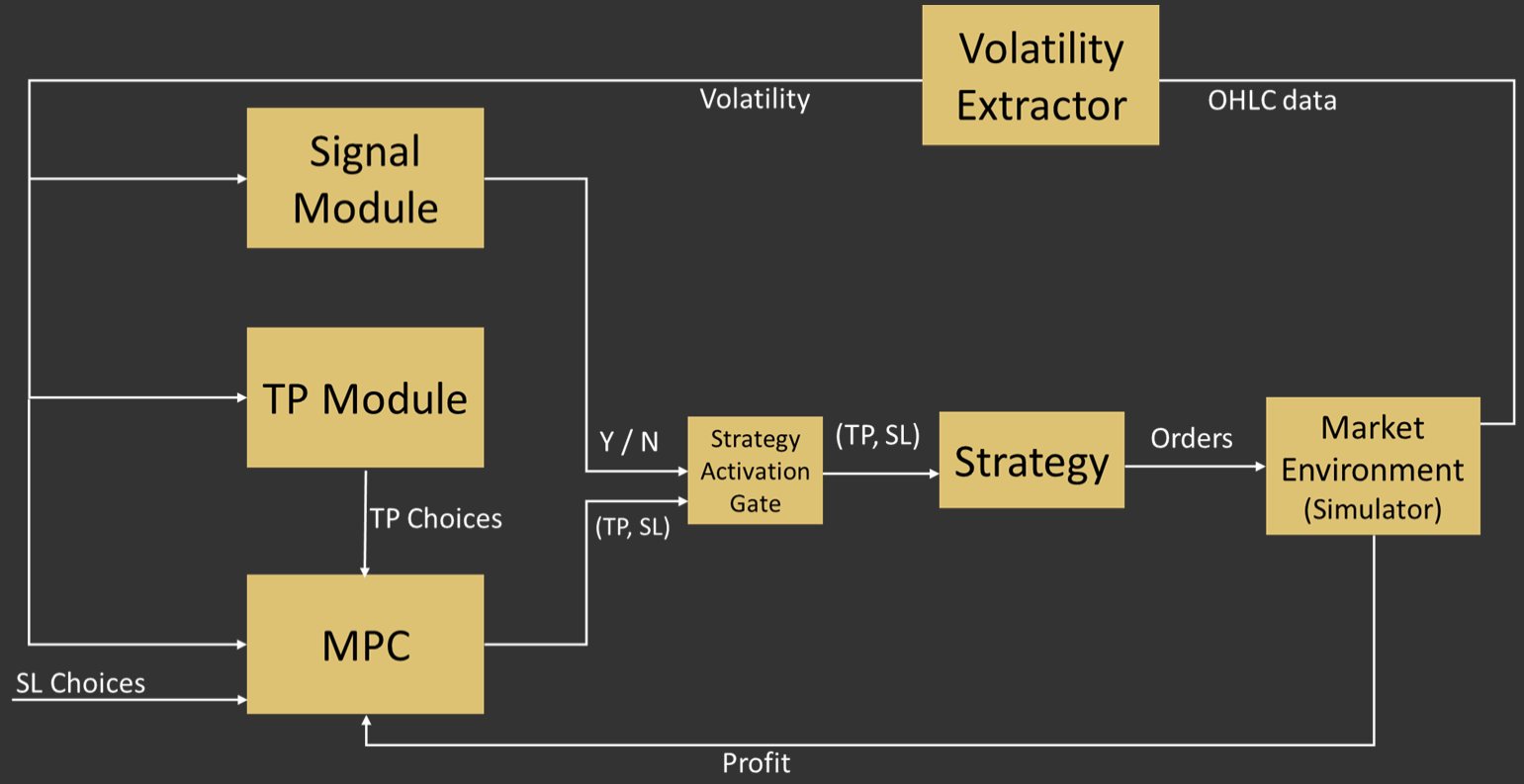
Equation Determination

System identification methods

Validating results

Comparing with previous results

System Schematic

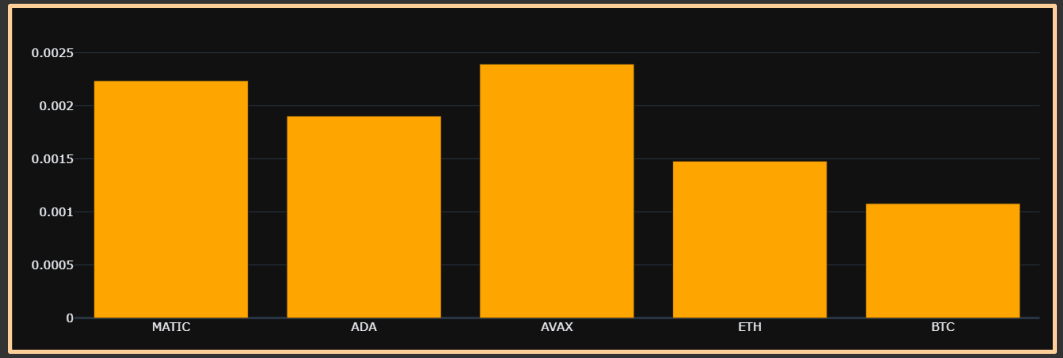


System Design

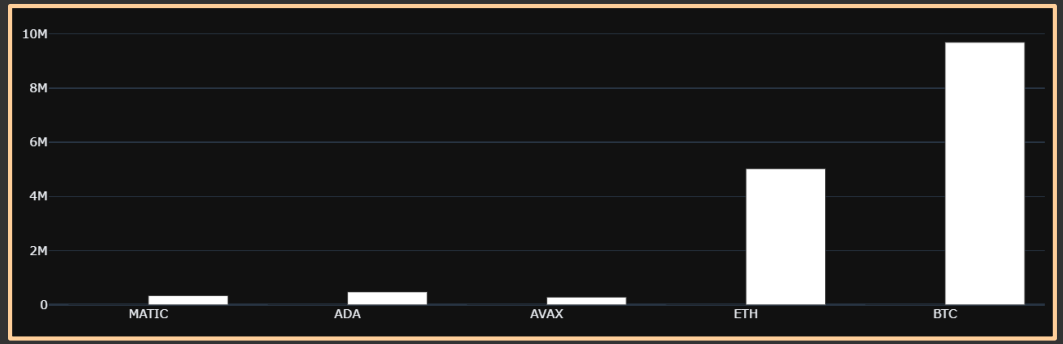
Choosing the Coin

- Comparing coins

- MATIC is 15th coin
  Based on the Market Cap



Volatility



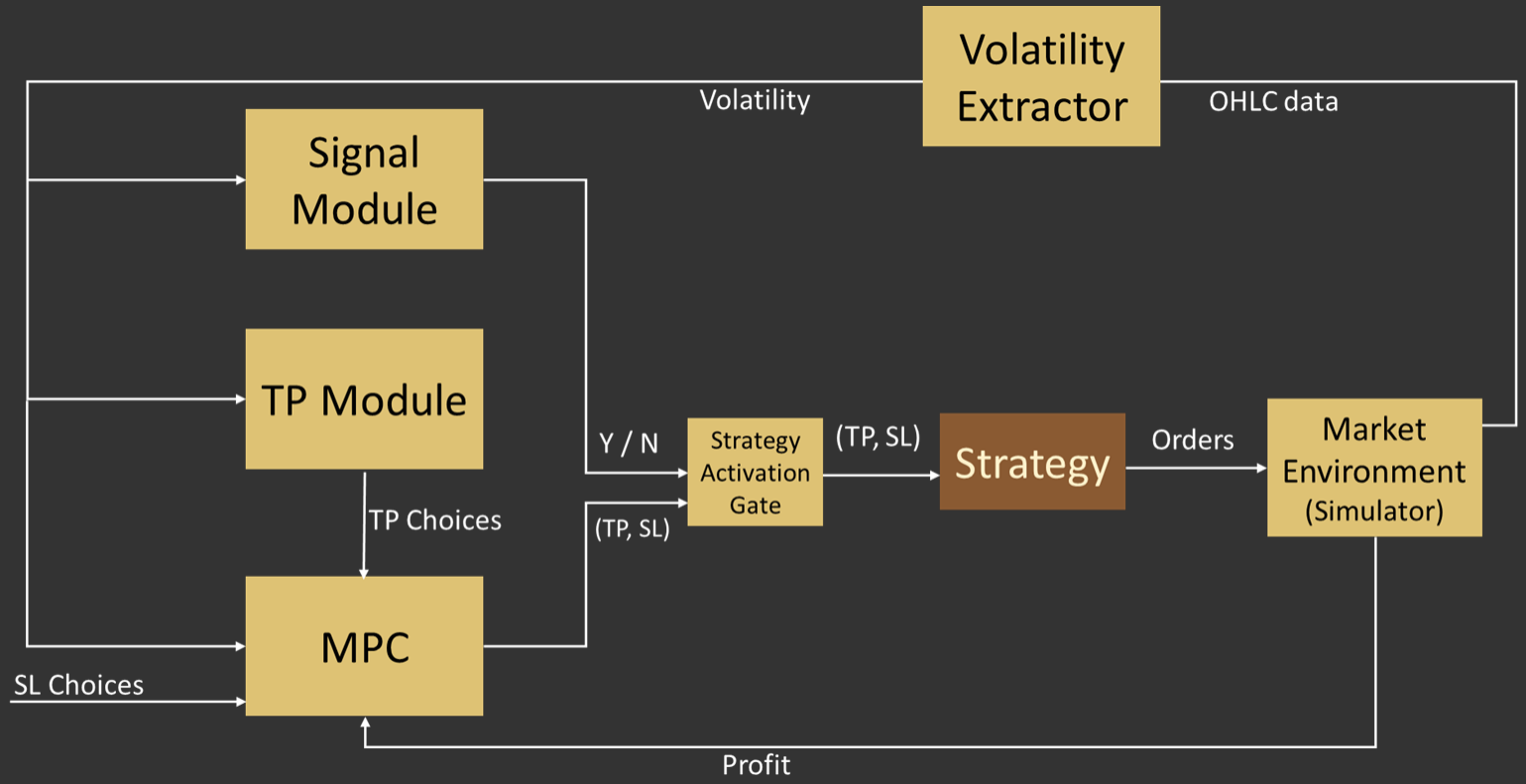
Volume

System Design

Features

Date	Take Profit	Stop Loss	TP category	Ratio	Difference	Volatility	Profit
2020-10-27 7:01:00	0.93%	1.50%	35	0.62041	2.4306	3	$46.79
2020-10-28 7:01:00	0.91%	1.50%	35	0.60665	2.4100	4	$128.46
2020-10-29 7:01:00	0.91%	1.50%	35	0.60959	2.4144	3	$187.26
2020-10-30 7:01:00	0.94%	1.50%	35	0.62417	2.4363	3	$226.93
2020-10-31 7:01:00	1.04%	1.50%	35	0.69275	2.5391	3	$132.67
...	...	...	...	...	...	...	...
2023-07-28 7:01:00	0.20%	6.00%	75	0.03411	6.2047	2	-$215.32
2023-07-29 7:01:00	0.20%	6.00%	75	0.03411	6.2047	1	-$215.32
2023-07-30 7:01:00	0.20%	6.00%	75	0.03411	6.2047	1	-$215.32

System Schematic

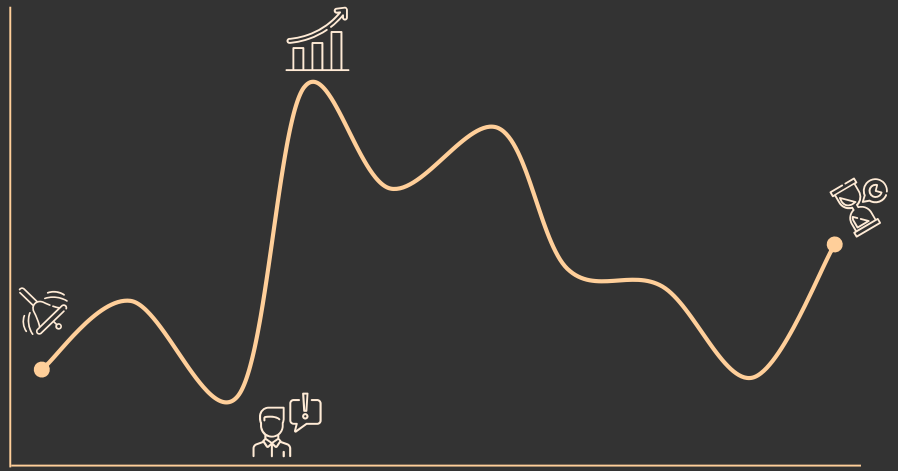


System Design

Strategy Module

Inputs:

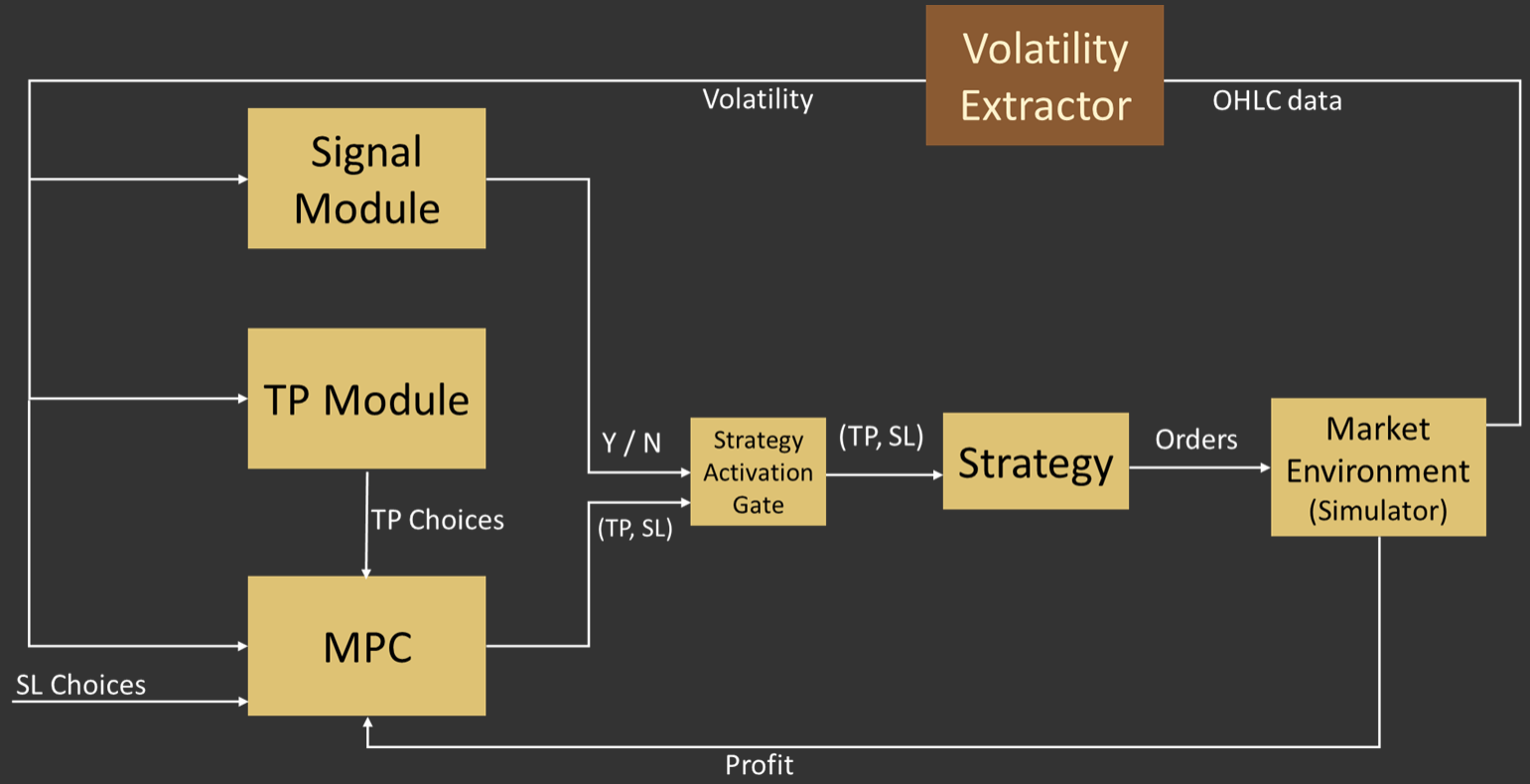
- Take Profit (Dynamic)
- Stop Loss
- Time Limit
- Signal



Output:

- Orders (Buy/Sell)
- Profit

System Schematic



System Design

Volatility Extractor

$$\text{len} = \frac{\text{high} - \text{low}}{\text{open} \le \text{close} \cdot \text{low} + \text{open} > \text{close} \cdot \text{high}}$$

$$\text{inc100} = \frac{\max_{100}(\text{high}\_{100}) - \text{close}}{\text{close}}$$

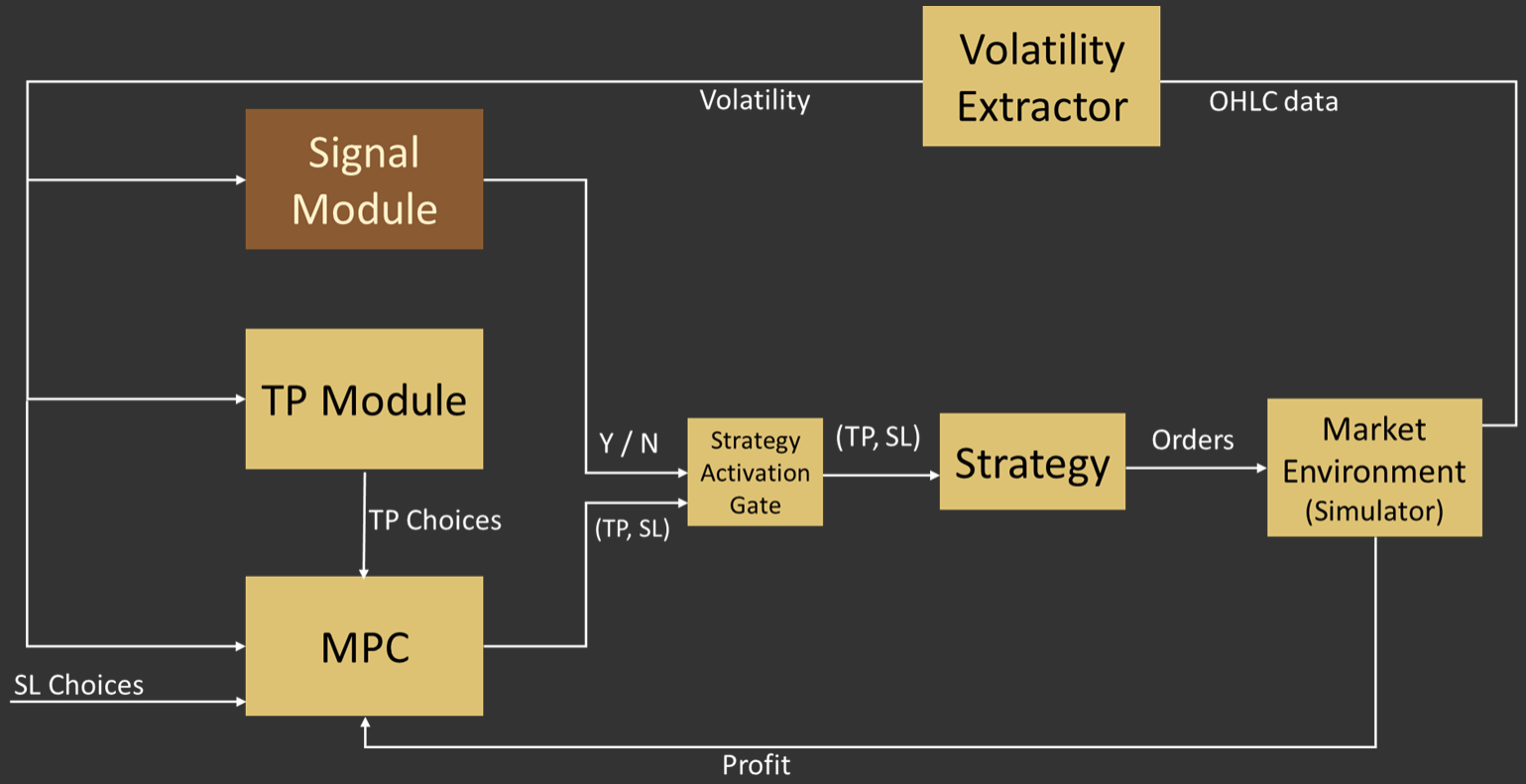
Backward Volatility List → To TP module

$$\text{len}_{w1} = \frac{1}{w1} \sum_{i=-w1+1}^{0} \text{len}_i$$

Mean Volatility List → To Signal Module

Volatility category → To MPC Module

System Schematic



System Design

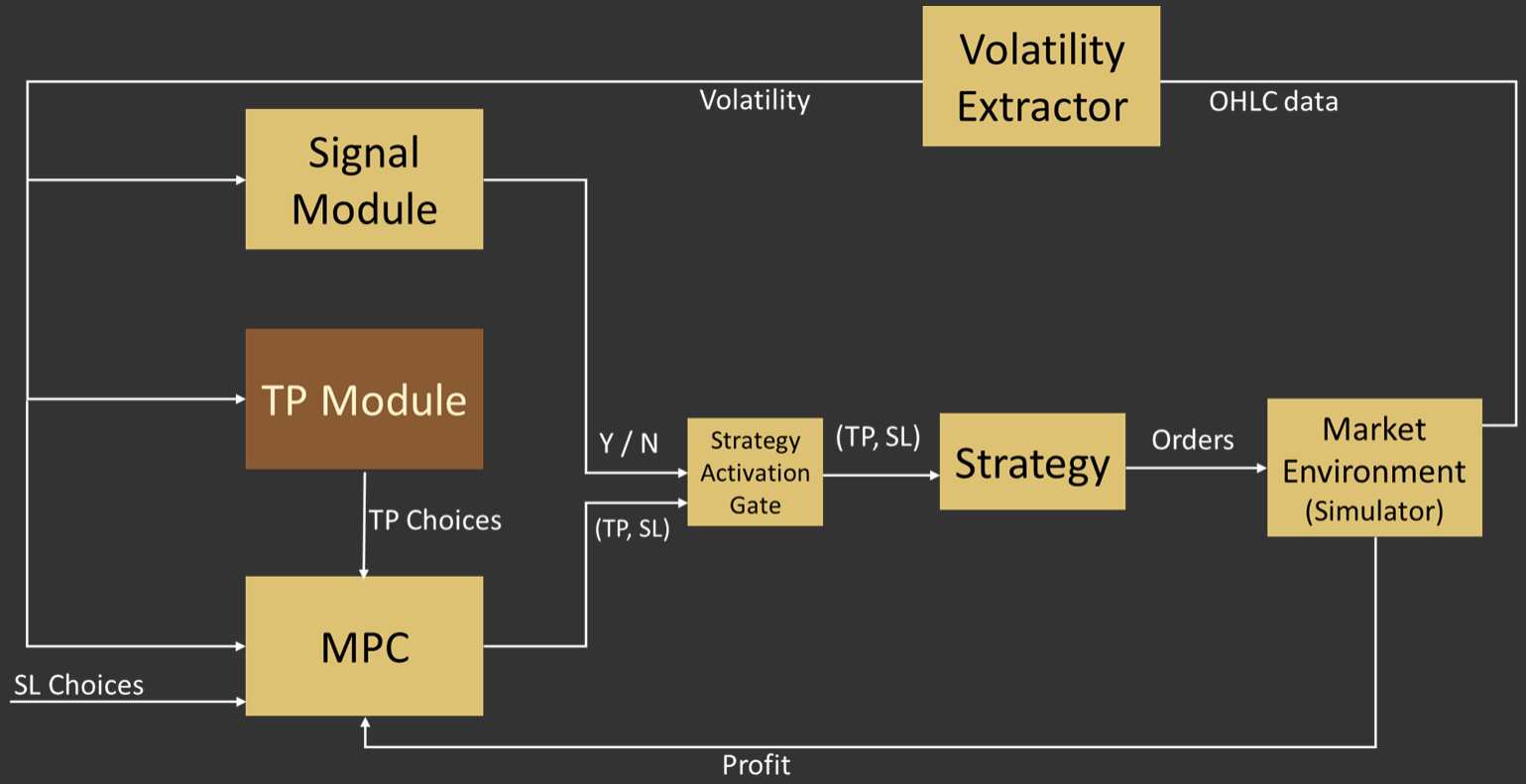
Signal Module

Inputs
OHLC data → Volatility
Configs

Output
Boolean
(True/False)

$$\text{signals} = \text{len}_{w1} > 1.5 \times \text{len}_{w1}.\text{rolling}(3 \times 1440).\text{mean}()$$

System Schematic



System Design

Take Profit (TP) Module

Inputs	Backward Volatility List Configs

Output	TP % of the volatility

System Design

Take Profit (TP) Equations

1. $$\text{len} = \frac{\text{high} - \text{low}}{\text{open} \le \text{close} \cdot \text{low} + \text{open} > \text{close} \cdot \text{high}}$$

2. $$\text{len}_{10} = \frac{1}{10} \sum_{i=-9}^{0} \text{len}_i$$

3. $$\text{inc100} = \frac{\max_{100}(\text{high}\_{100}) - \text{close}}{\text{close}}$$

4. $$TP = \text{inc100}(10, \text{ds}) \cdot P\%$$

System Identification Methods

Linear Regression	■□□□□	Linear Systems
Machine Learning	■■□□□	Black Box
Dynamic Mode Decomposition	■■■□□	LTI systems
SINDy	■■■■□	Prefered option

System Identification Methods

- SINDy algorithm (Sparse Identification of Nonlinear Dynamics)

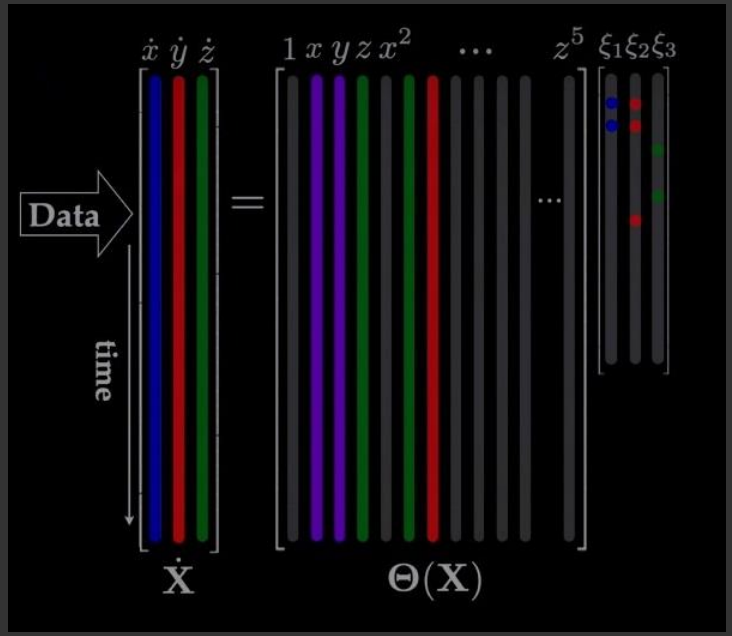
Lasso Regression:

$$Min(sum\ of\ squared\ residuals + \alpha * |slope|)$$

$$\mathbf{X} = \begin{bmatrix} \mathbf{x}^T(t_1) \\ \mathbf{x}^T(t_2) \\ \vdots \\ \mathbf{x}^T(t_m) \end{bmatrix} = \overrightarrow{\text{state}} \begin{bmatrix} x_1(t_1) & x_2(t_1) & \cdots & x_n(t_1) \\ x_1(t_2) & x_2(t_2) & \cdots & x_n(t_2) \\ \vdots & \vdots & \ddots & \vdots \\ x_1(t_m) & x_2(t_m) & \cdots & x_n(t_m) \end{bmatrix} \downarrow \text{time}$$

$$\Theta(\mathbf{X}) = \begin{bmatrix} | & | & | & | & & | & | & \\ 1 & \mathbf{X} & \mathbf{X}^{P_2} & \mathbf{X}^{P_3} & \cdots & \sin(\mathbf{X}) & \cos(\mathbf{X}) & \cdots \\ | & | & | & | & & | & | & \end{bmatrix}$$

$$\dot{\mathbf{X}} = \Theta(\mathbf{X})\Xi.$$



System Equations

» Equations of system using SINDy

1

$$p_{1(k+1)} = 4.5p_{1(k)}.sl - 0.1p_{1(k)} + 165061.5\ sl^2 + 42.5sl.tp - 10938.6sl - 0.1tp + 98.8$$

2

$$p_{2(k+1)} = 0.1p_{2(k)}.sl - 71275.5sl^2 - 188.5sl.tp + 14002.3sl + 4.1tp - 27$$

3

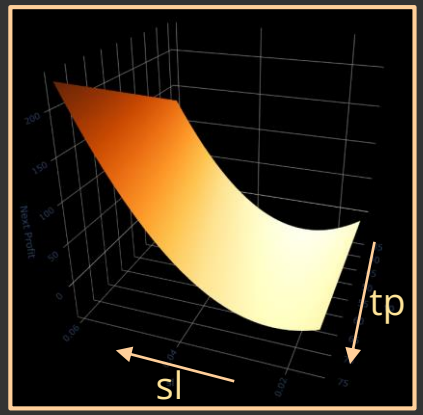
$$p_{3(k+1)} = 50777.6\ sl^2 - 39.3sl.tp + 136.3sl + 0.7tp - 23.$$

4

$$p_{4(k+1)} = 21.2p_{4(k)}.sl - 0.6p_{4(k)} - 2493396.46\ sl^2 - 1798.8sl.tp + 245808.8sl - 0.1tp^2 + 53.7tp - 4340.8$$

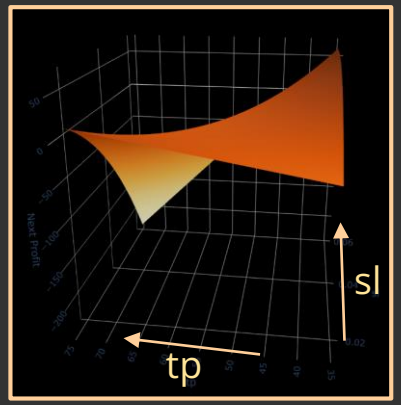
System Equations

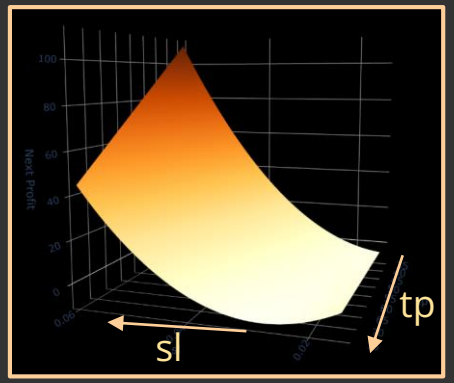
- Relationship between TP, SL, Next Profit



1

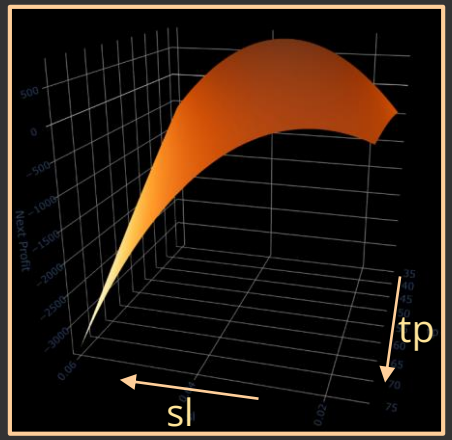
2





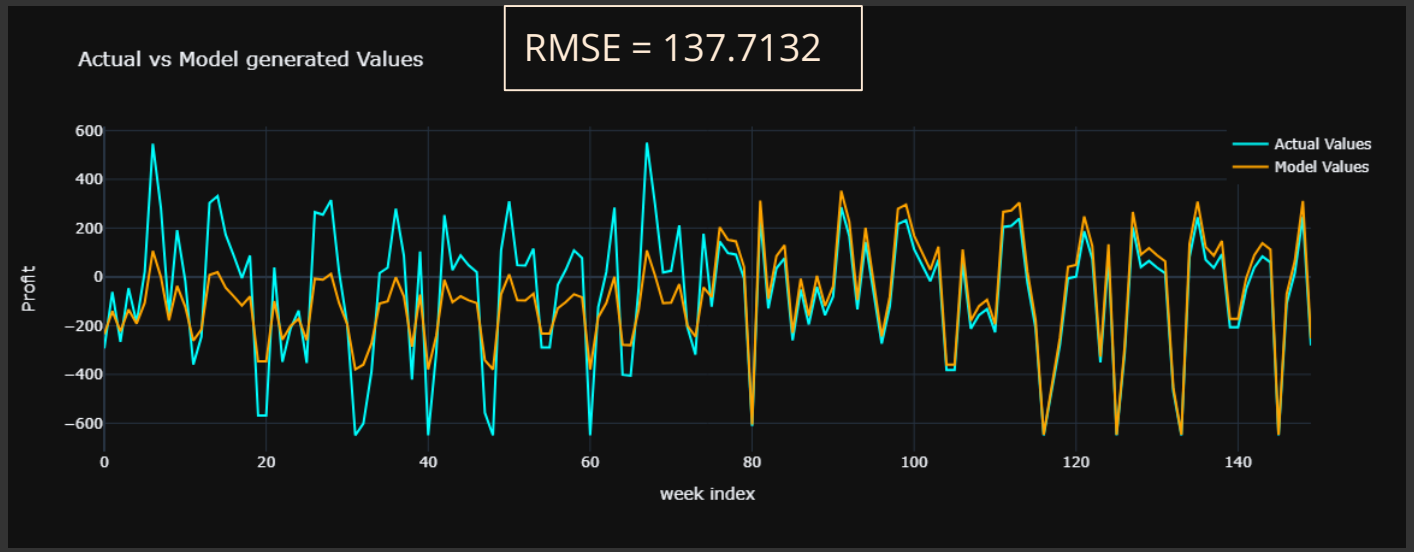
3

4

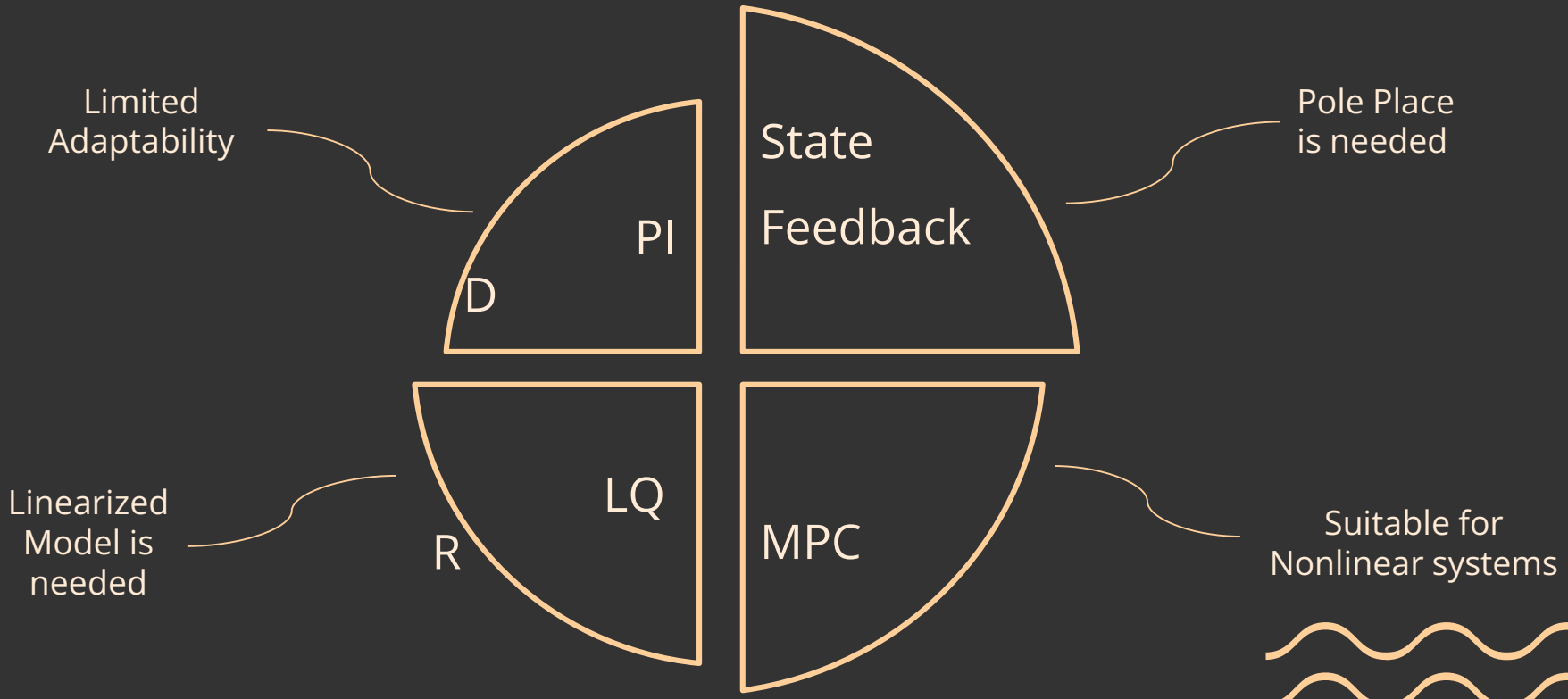


System Identification

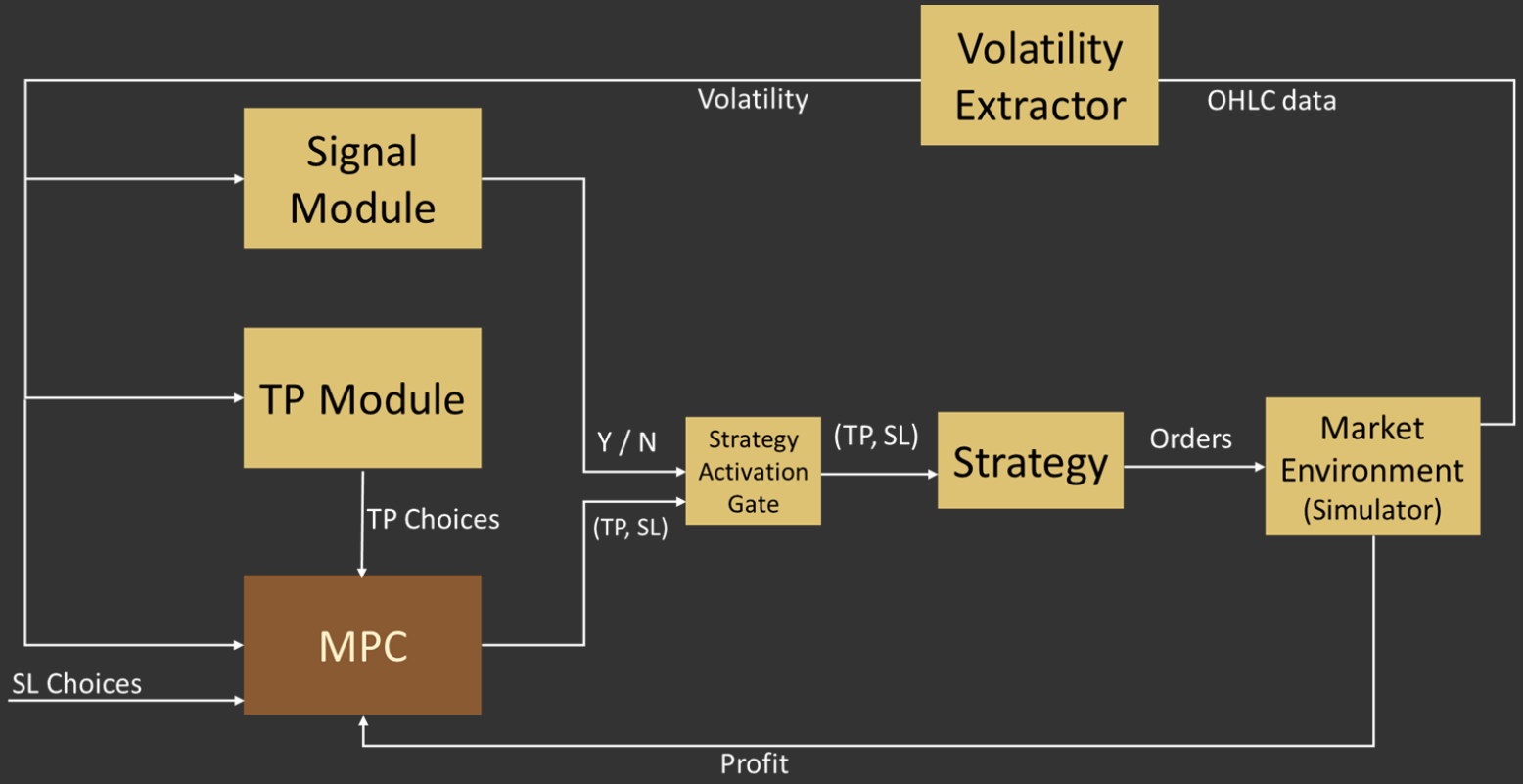
- SINDy (Sparse Identification of Nonlinear Dynamics)



Control & Optimization Methods



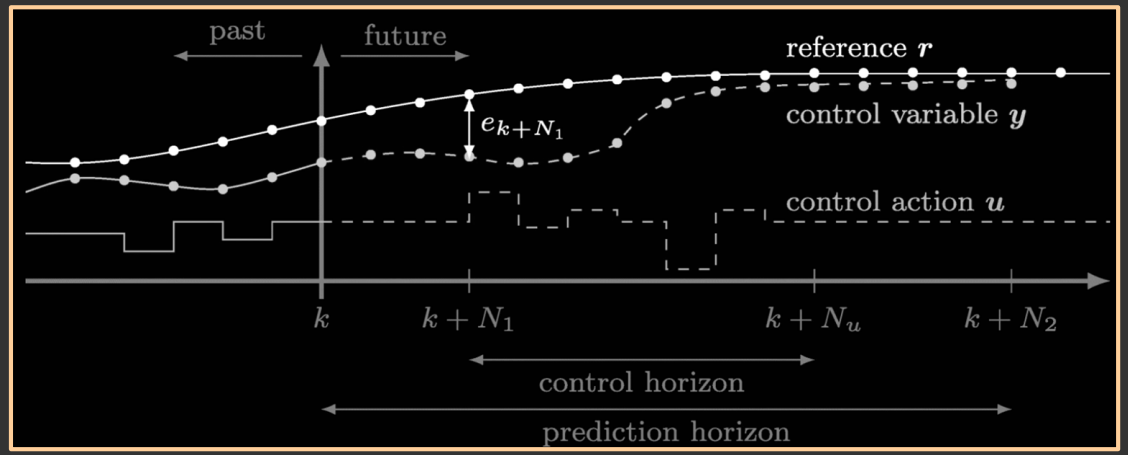
System Schematic



Optimization Method

MPC (Model Predictive Control)

- Handling Nonlinear Systems
- Handles Constraints
- Online Optimization
- High Flexibility

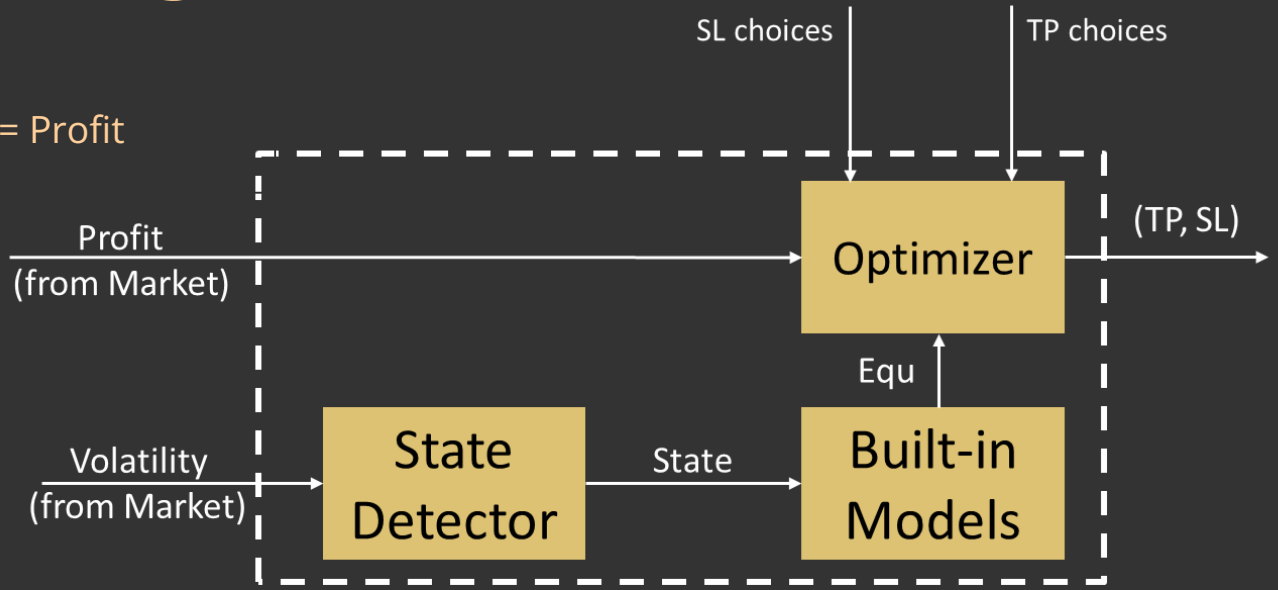


Objective Function = Profit

System Design

MPC

Objective Function = Profit



$$\text{volatility} = \frac{\text{Rank of the rolling window of 'len\_w1'}}{\text{rolling window size}}$$

$$\text{v\_label} = \text{Categorize}\ (\text{volatility}, \text{labels} = [1, 2, 3, 4])$$

Results

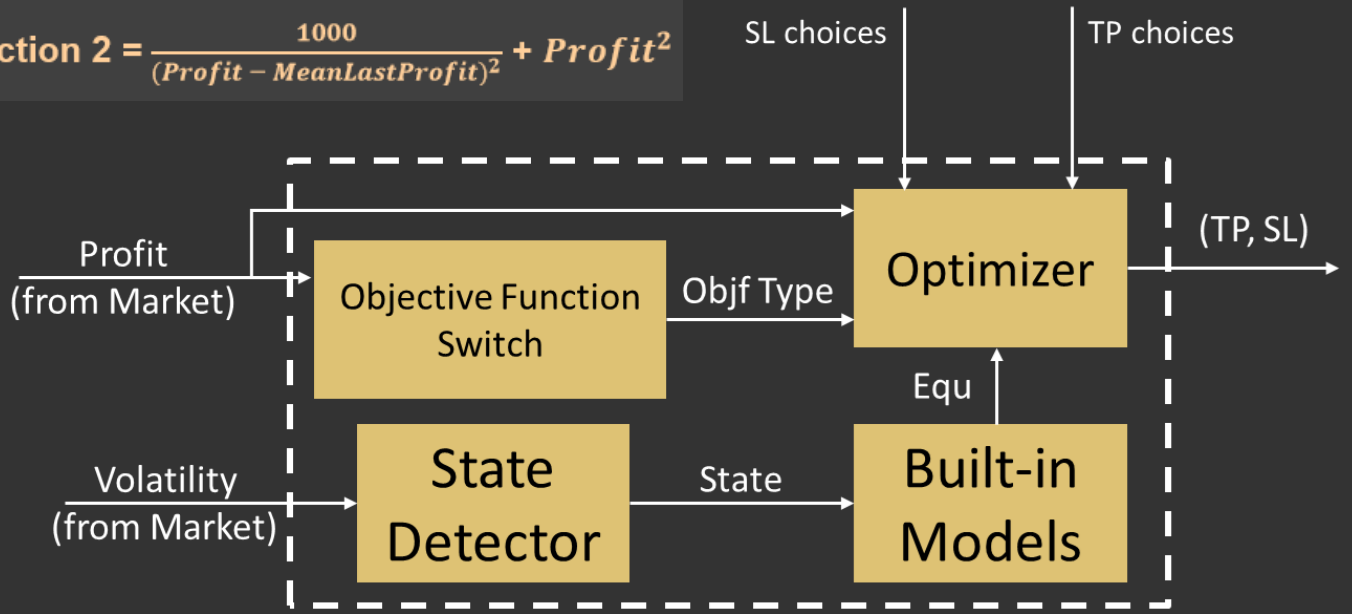
- Improvement by using MPC (compared to random)

System Design

» MPC with Risk Management

Objective Function 1 = Profit

Objective Function 2 = $\frac{1000}{(Profit - MeanLastProfit)^2} + Profit^2$

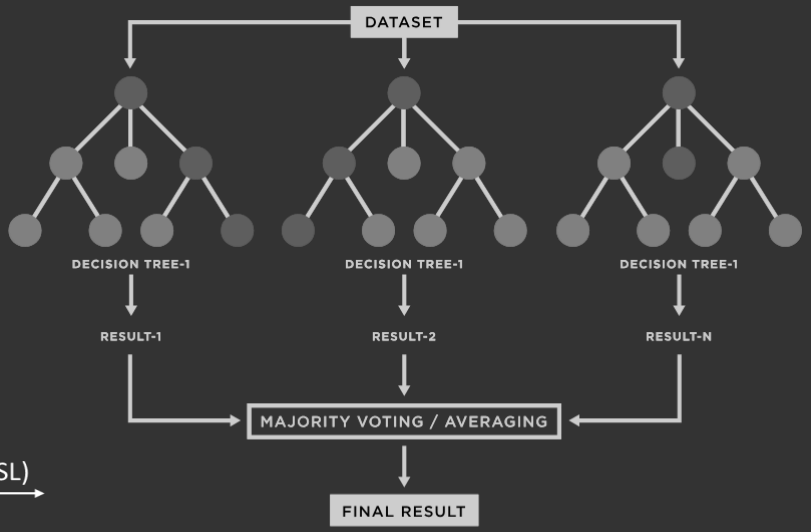


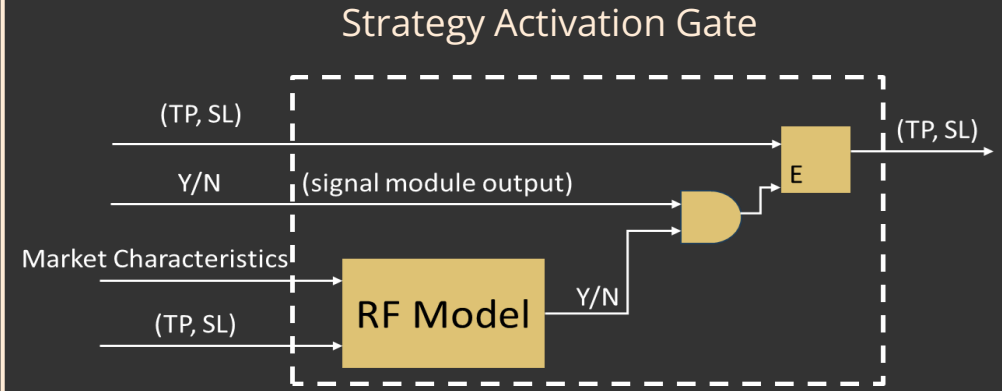
Results

- Improvement by using Risk Manager

System Design

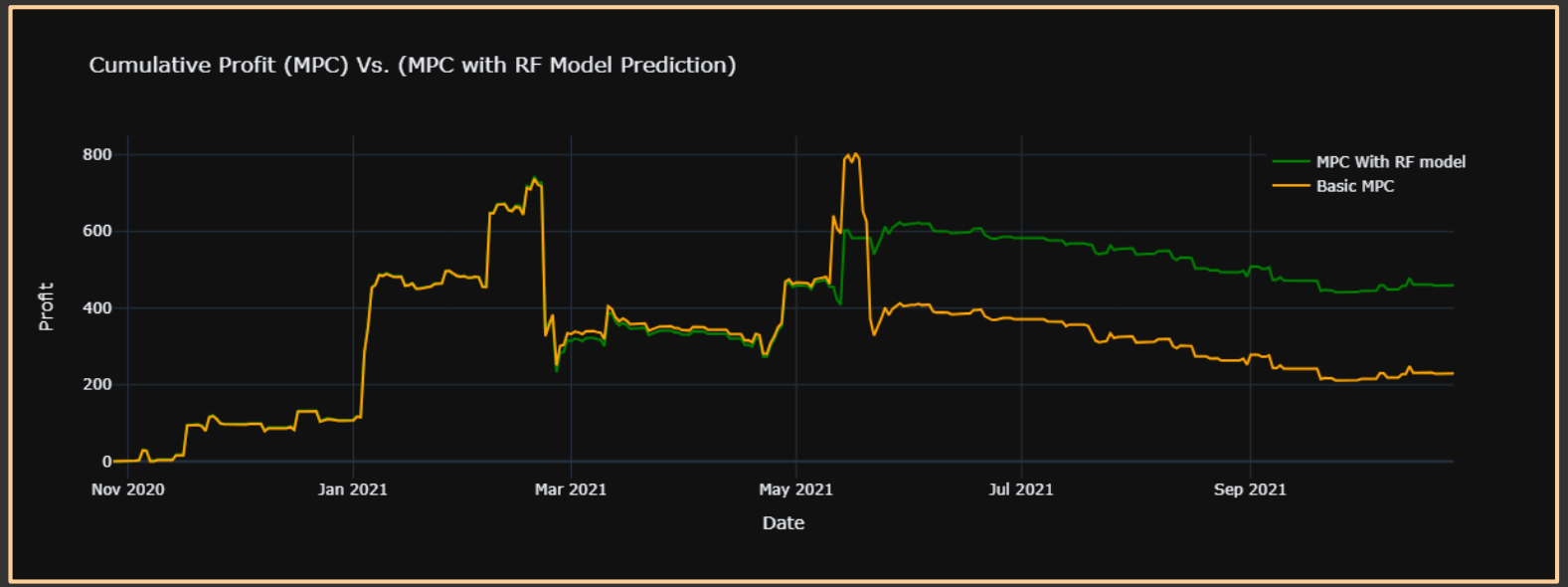
- **Random Forest**





Results

- Reducing great loss by using Random Forest



Future Work

Compounding (reinvestment)

Reinvesting the profits earned rather than withdrawing them

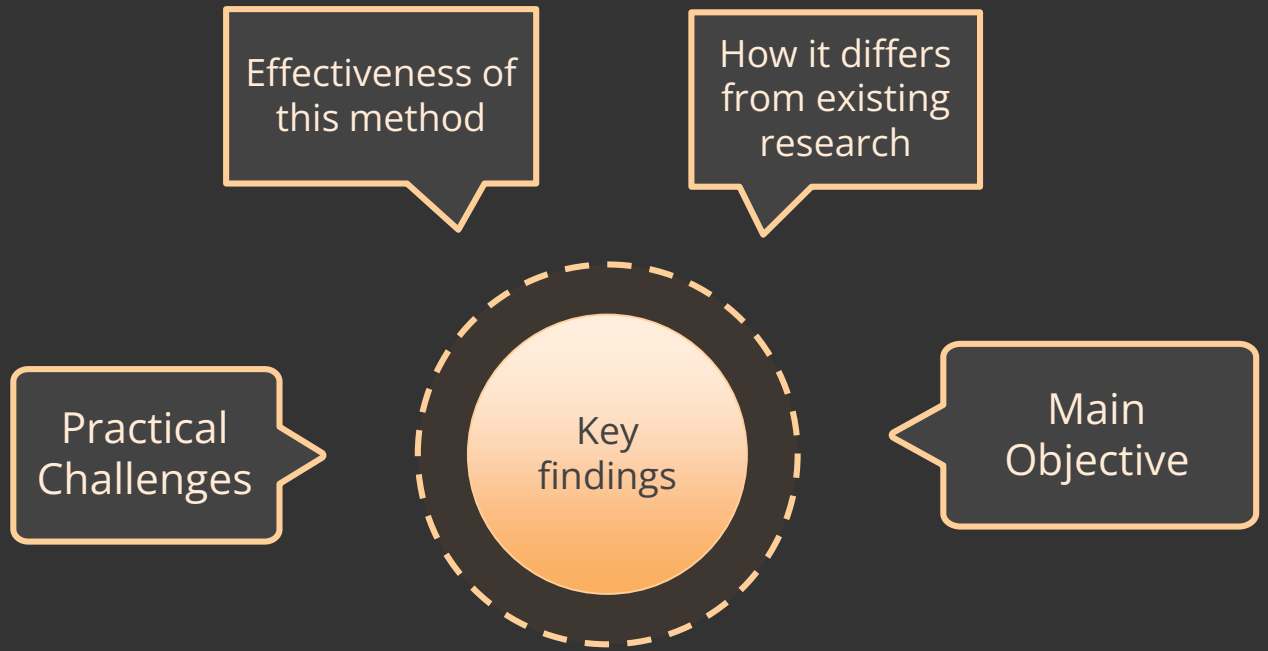
- Increased Position Size
- Exponential growth
- Withdrawal Challenges

Adding Other Coins

Handling multiple coins in portfolio

- Risk Management
- Market Correlations
- Complex Implementation

Discussion


Effectiveness of this method
How it differs from existing research
Practical Challenges
Key findings
Main Objective

References

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- MATLAB; What Is System Identification? |System Identification; https://www.youtube.com/watch?v=Z1QS6FsxrJI.
- Steven L. Brunton, Joshua L. Proctor, and J. Nathan Kutz; “Discovering governing equations from data by sparse identification of nonlinear dynamical systems”, 10.1073/pnas.1517384113, Princeton University, Aug. 2015.
- Steve Brunton; Sparse Identification of Nonlinear Dynamics: Sparse ML Models; https://www.youtube.com/watch?v=NxAn0oglMVw.

Thank You for Your Time