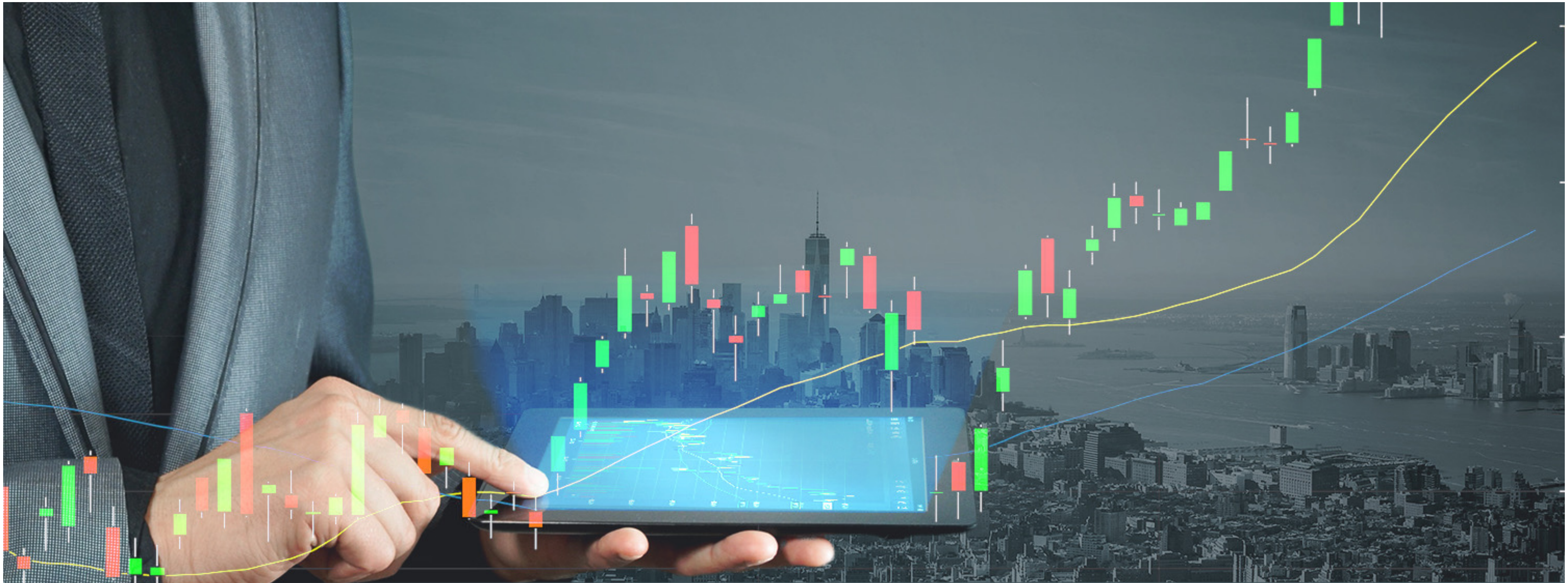


Not So Creative

We see the future

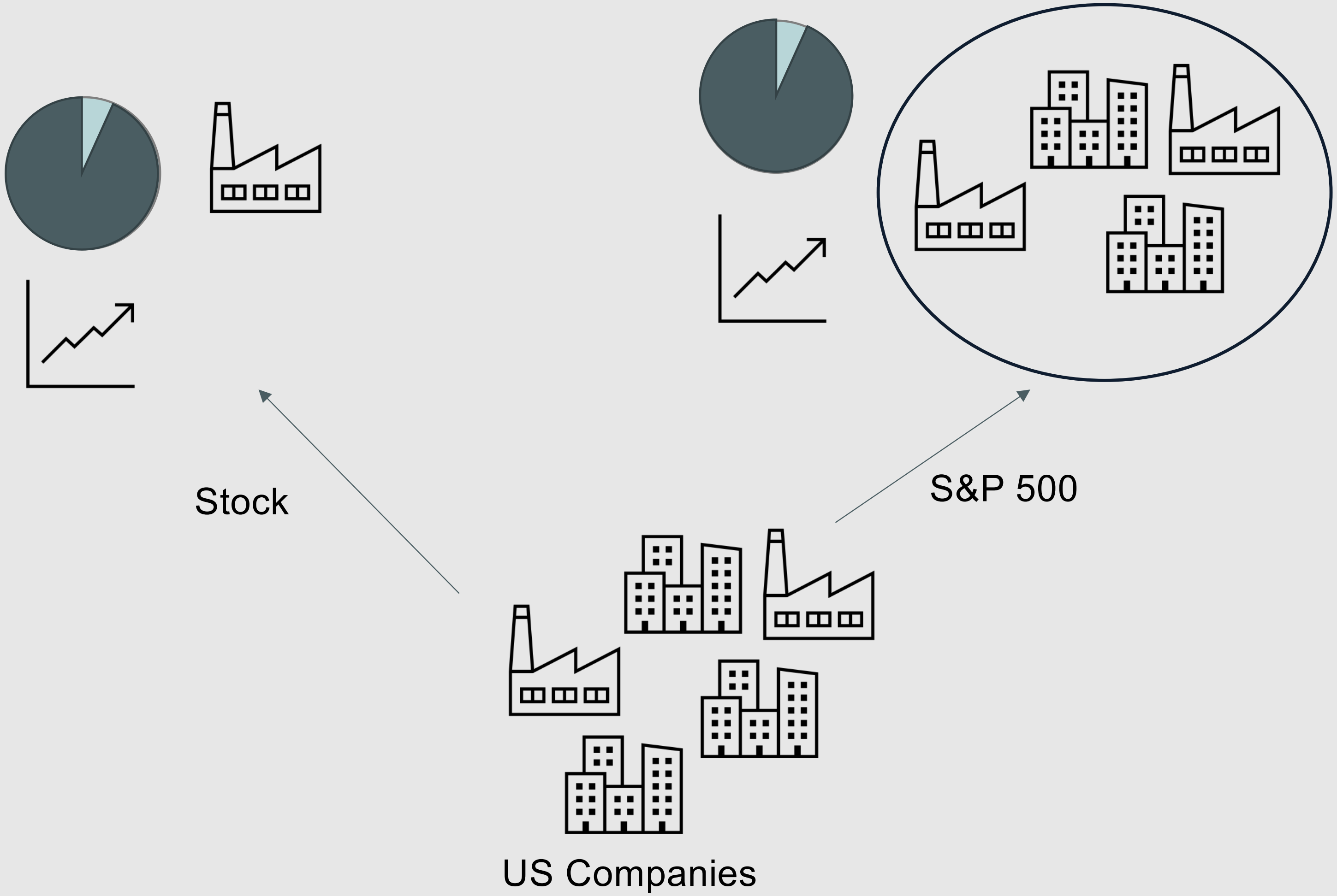
Stock Recommendation Engine

NotSoCreative

Why should we invest ?

Not So Creative
We see the future

Stocks & The S&P 500



Problems with Investing!

- **Uncertainty about Stock Price development**
- **When is the best starting point for investing?**
- **Information Overload**
- **Possible Risk to lose money**
- **Investing is intimidating**

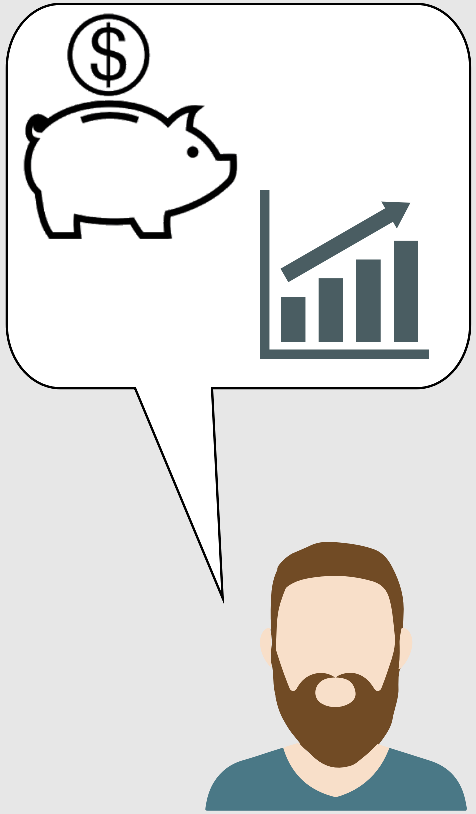
Possible Investment Solutions

Not So Creative

- Do Nothing
- Random Investment
- Buy and Hold (BaH)
- Cost Average (CA)

Boundaries:

- Worst Investment Action (WIA)
- Best Investment Action (BIA)

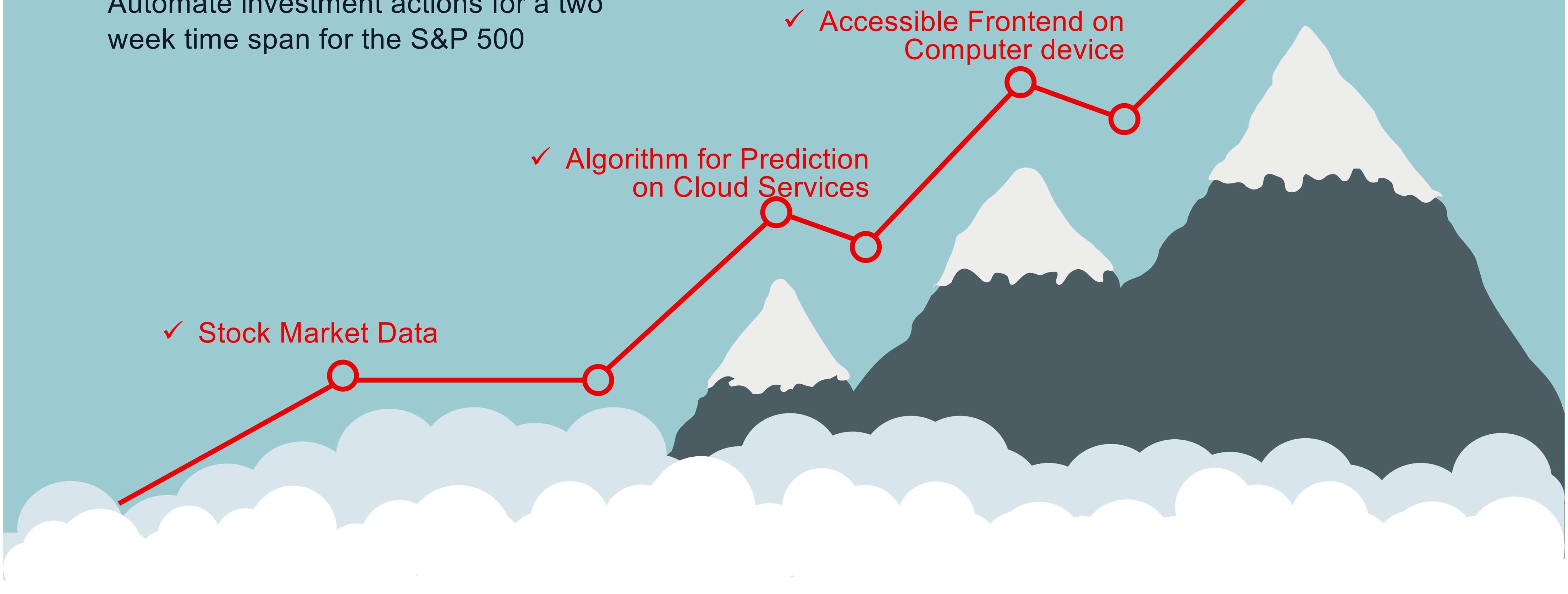


We use these as a Benchmark

Our Solution

Stock Recommendation System

Automate investment actions for a two week time span for the S&P 500

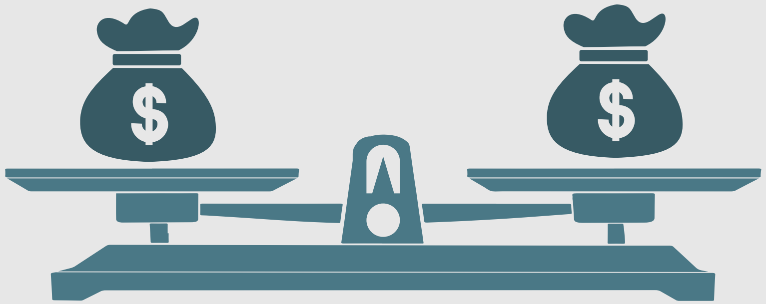


Metrics for Success

- Easy Answer? : "Of course the amount of Money we made is the most important Metric!"

2 most important Metrics:

1. **Mean Portfolio Value** (MPV)
2. Gain (percentage, absolute)

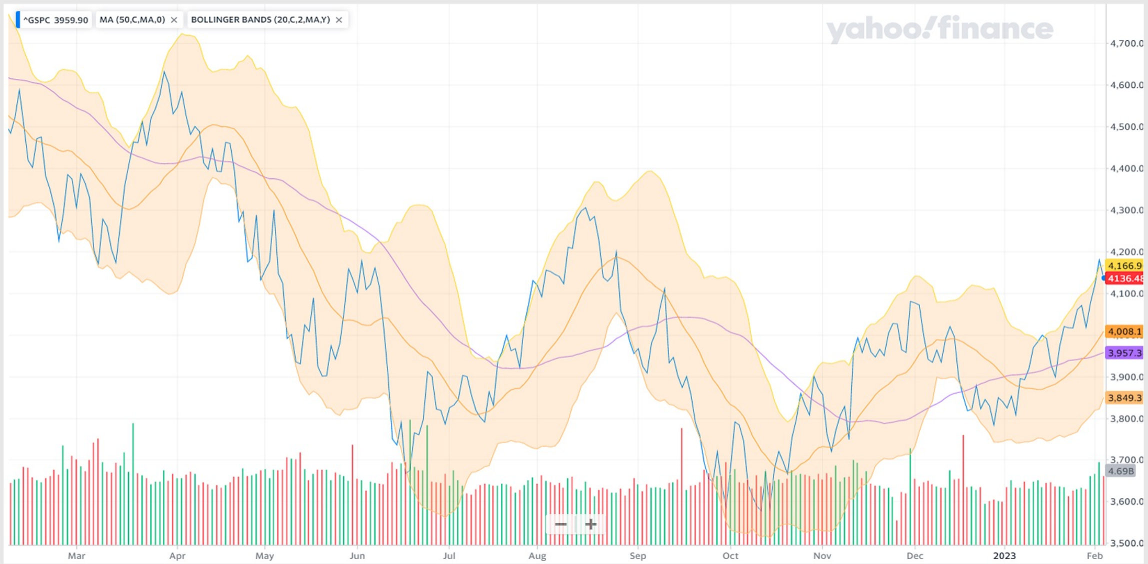


How to analyze the Stock Market

1. Fundamental Analysis
2. **Technical Analysis**

Technical Analysis to analyze Stocks

- **Technical analysis** = Analysis considering patterns & price trends
- **Tools** = Technical Indicators
- **Types** indicators:
  - Trend
  - Momentum
  - Volatility
  - Volume



Designing our Algorithm

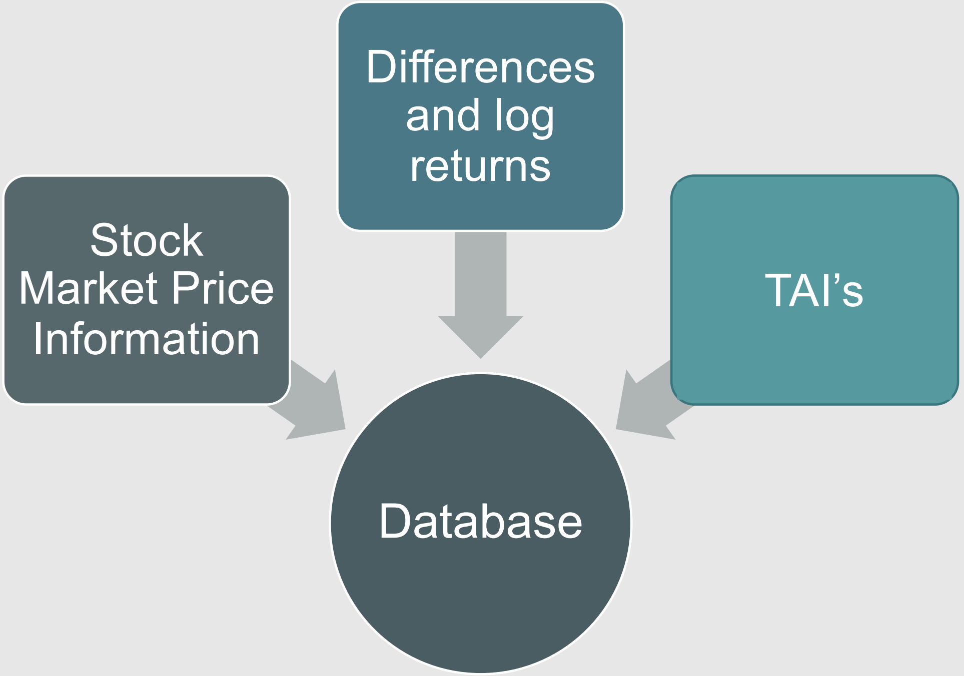
Feature Selection

Data Collection & Feature Extraction

- **Stock Market Price information**
  Open, Close, Volume, High and Low

- **Differences and Logarithmic Returns**
  - i.e. open(t) – open(t-1)
  - i.e. log[open(t)] – log[open(t-1)]

- **Technical Analysis Indicators**



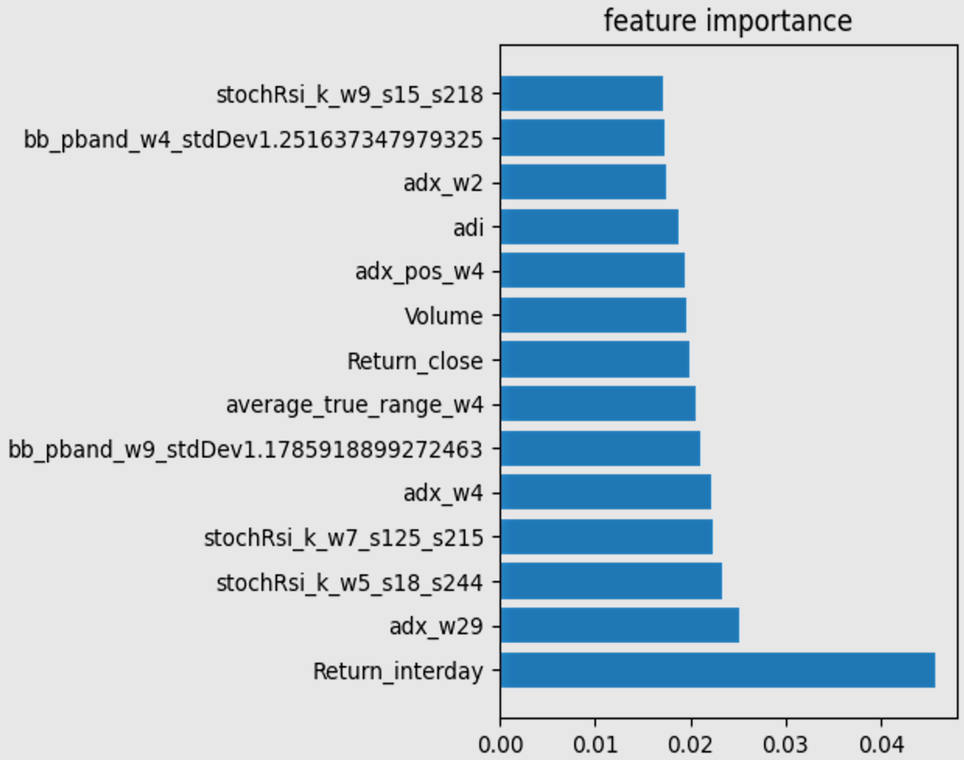
Feature Selection

- **Correlation Analysis**

  Neglect correlated features
  From 425 to 100 features

- **Decision Tree Regressor**

  Order the remaining features given their importance



Designing our Algorithm

Data Scaling

Robust Scaler → Robust & Min-Max Scaler

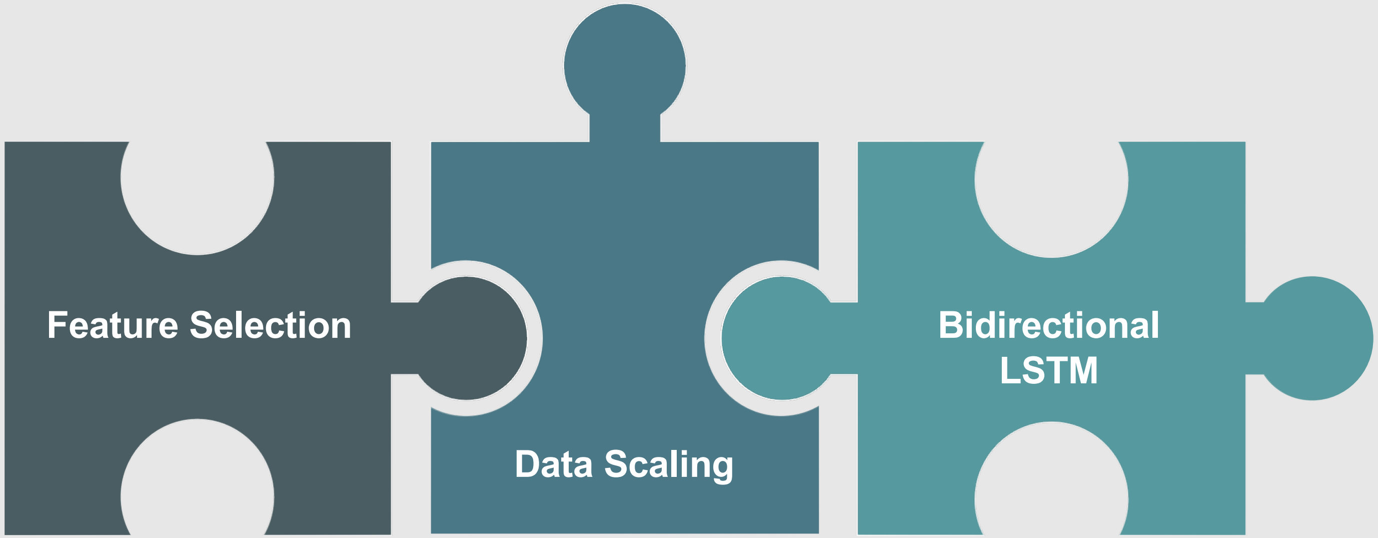
01 **Robust Scaler**

This scaler removes the median and scales the data according to the quantile range.

02 **MinMax Scaler and Robust Scaler**

Performs the best compared to other combinations

Designing our Algorithm



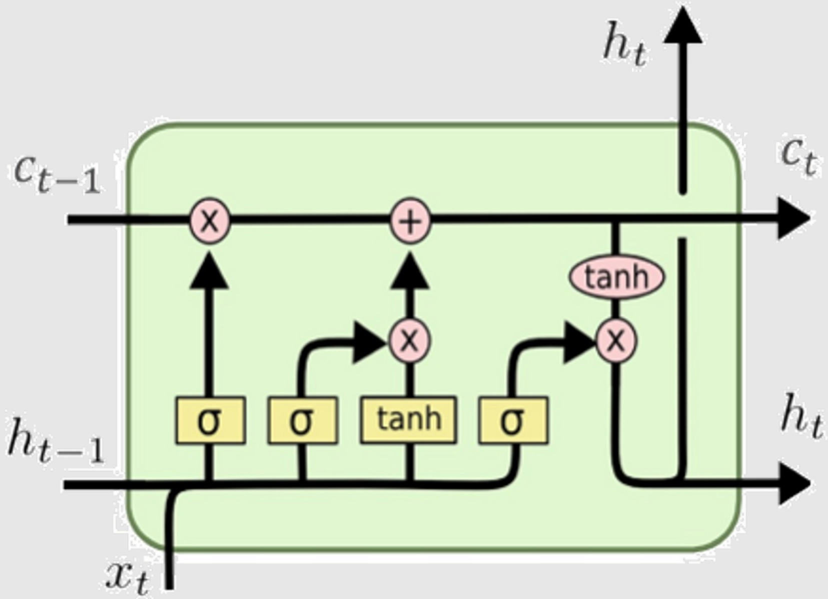
Error Metrics

Model	MAE train	RMSE train	MAPE train	MAE test	RMSE test	MAPE test
XGBOOST	38.519	61.335	0.0138	374.531	465.743	0.0736
Random Forest	50.786	81.912	0.0171	204.864	258.227	0.0512
LSTM	18.702	28.728	0.0063	43.572	55.644	0.0112
Bi-LSTM	**15.085**	**25.298**	**0.0051**	**42.524**	**53.582**	**0.01098**

What is a LSTM?

- Due to its capability of storing past information, LSTM is very useful for predicting stock prices

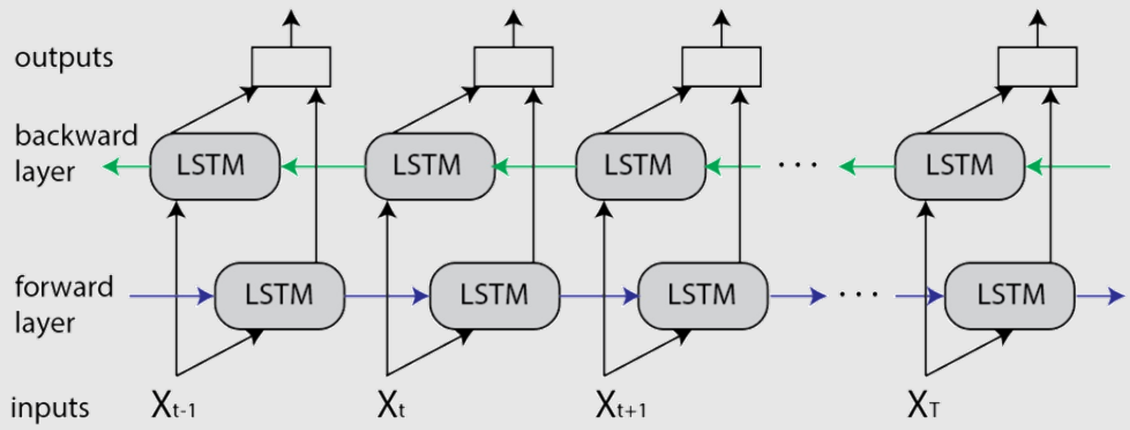
- LSTM combats RNN's vanishing gradients or long-term dependence issue



http://colah.github.io/posts/2015-08-Understanding-LSTMs/

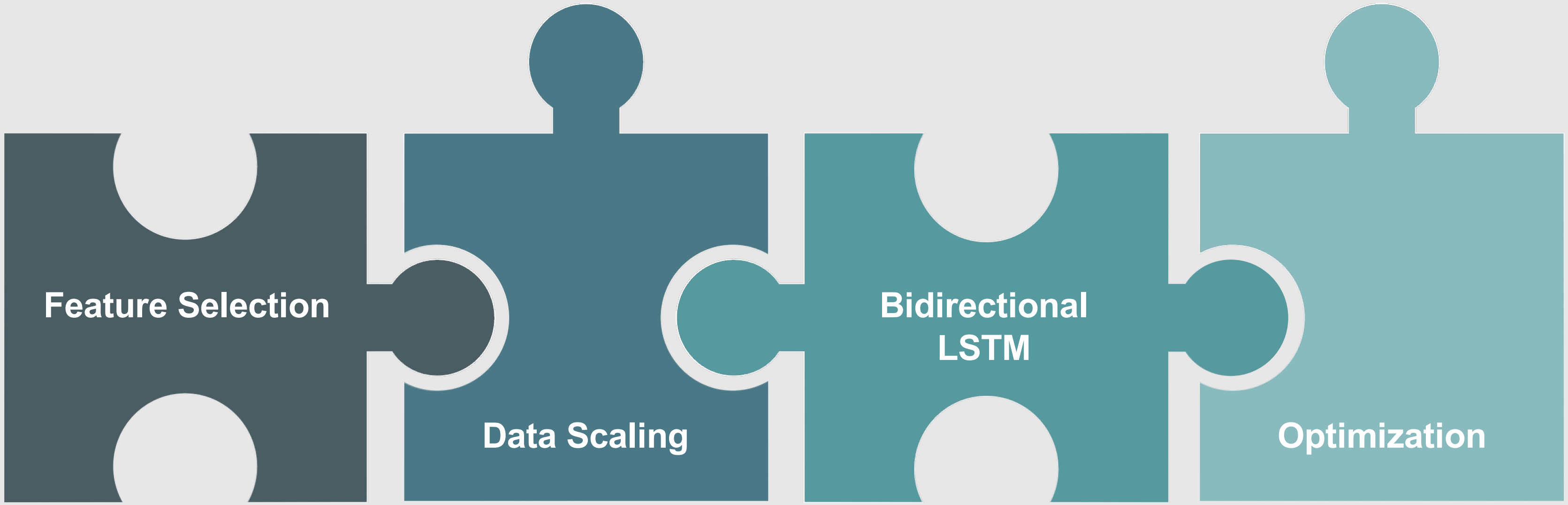
Our Solution: Bidirectional LSTM

- Input in both directions and is capable of utilizing information from both sides
- Bi-LSTMs with additional training outperforms regular unidirectional LSTMs



https://www.baeldung.com/cs/bidirectional-vs-unidirectional-lstm#:~:text=Bidirectional%20LSTM%20(BiLSTM)%20is%20a,utilizing%20information%20from%20both%20sides.

Designing our Algorithm



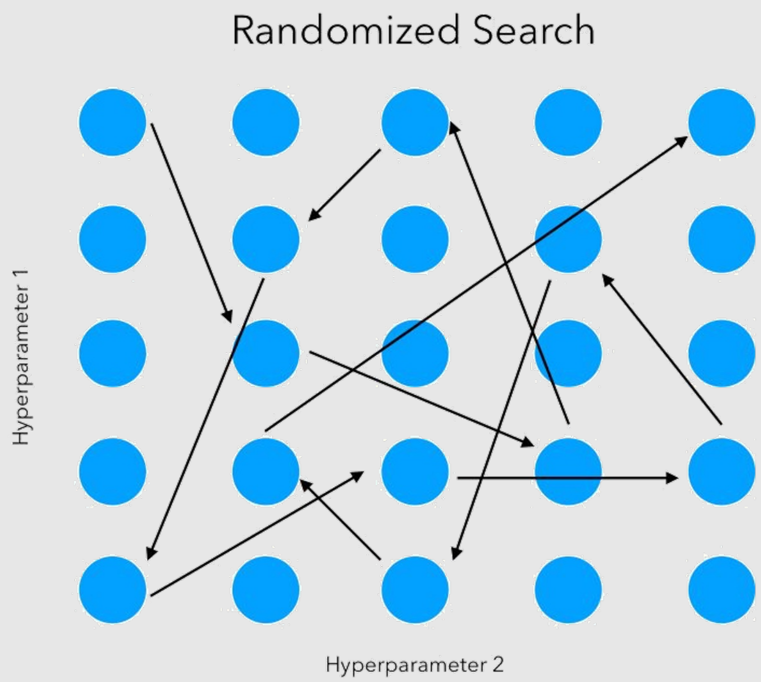
Hyperparameter Optimization

Random Search

Tries a random combination of parameter values

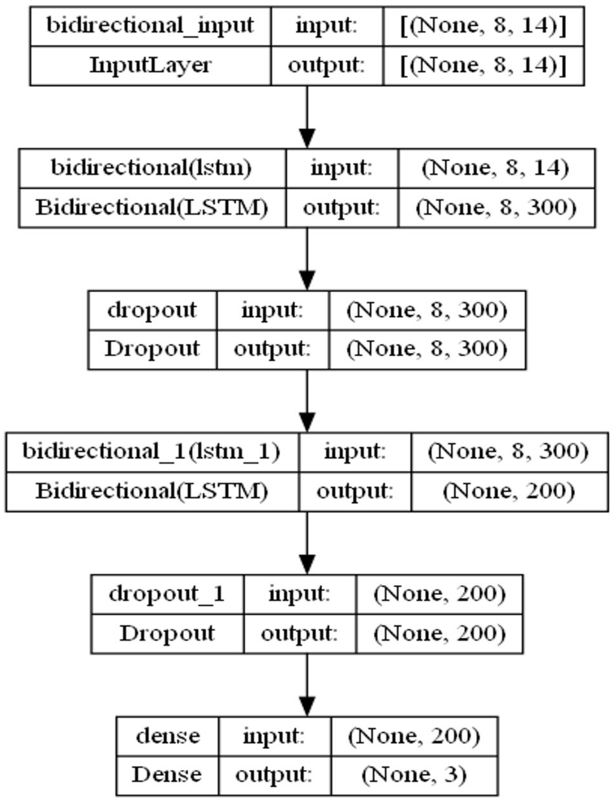
Advantages

- Good results (*Bergstra Bengio 2012*)
- Parallelizable
- Easy implementation



Model Architecture

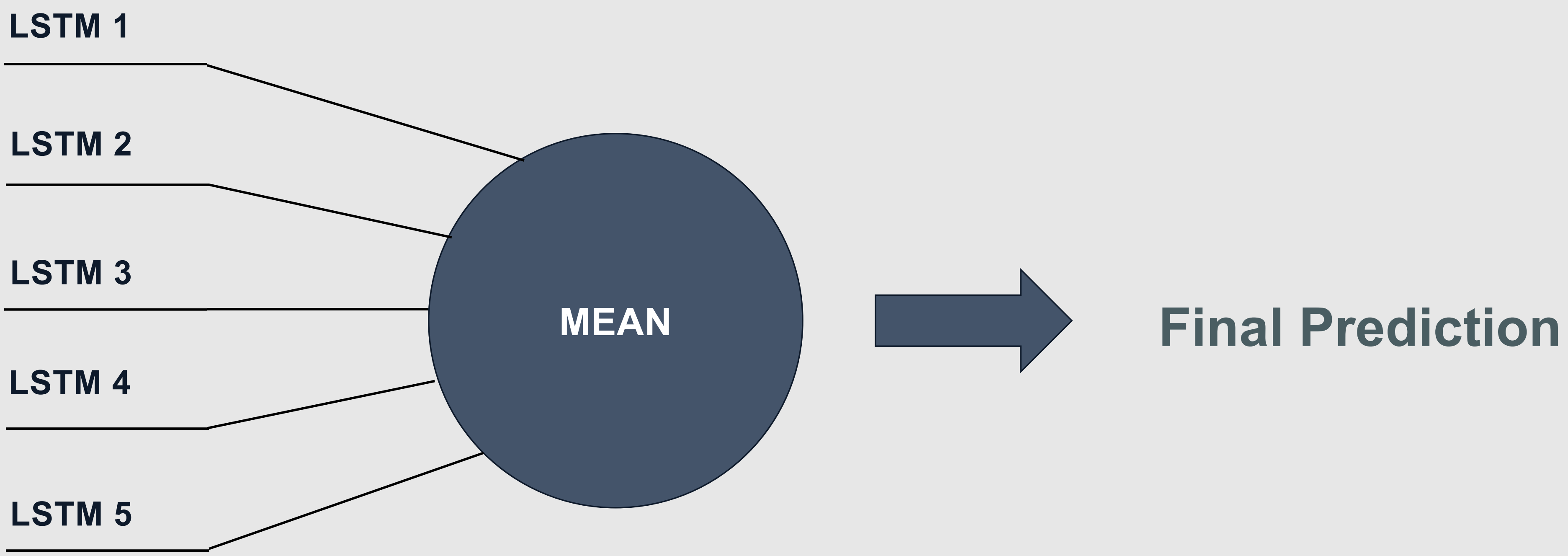
Structure



Hyperparameter

Batch size:	32
Epochs:	36
Number of layer:	2
Number neurons:	150, 100
Learning rate:	0,00224
Dropout rate:	0,2
Optimizer:	Adam
Initializer:	He_uniform

Tackling Randomness



Deciding to Buy, Sell or Hold

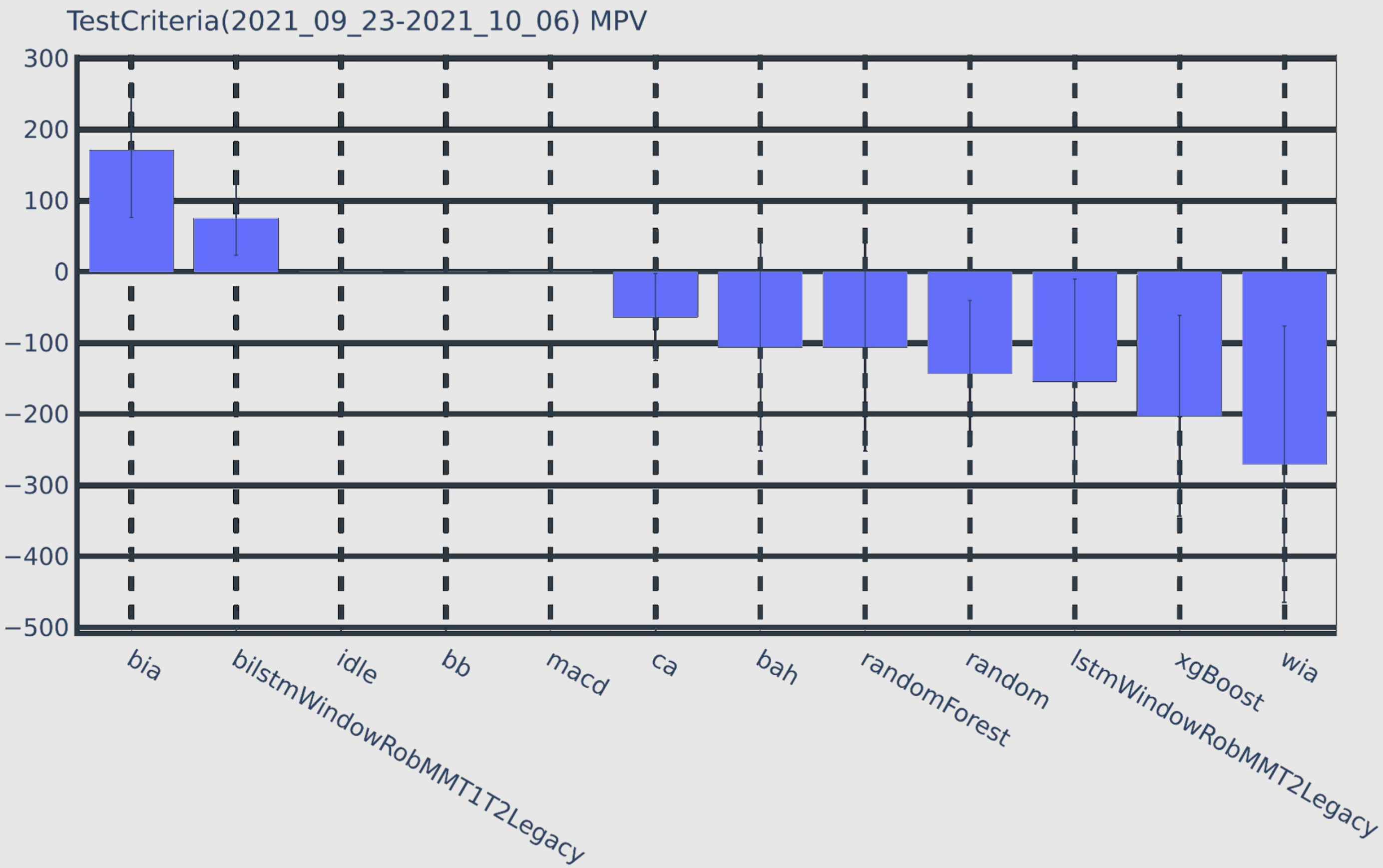
Decision Rule & Amount of Money invested depending on:

- Open Price
- Predicted Value of day after tomorrow
- Predicted Value of day after after tomorrow

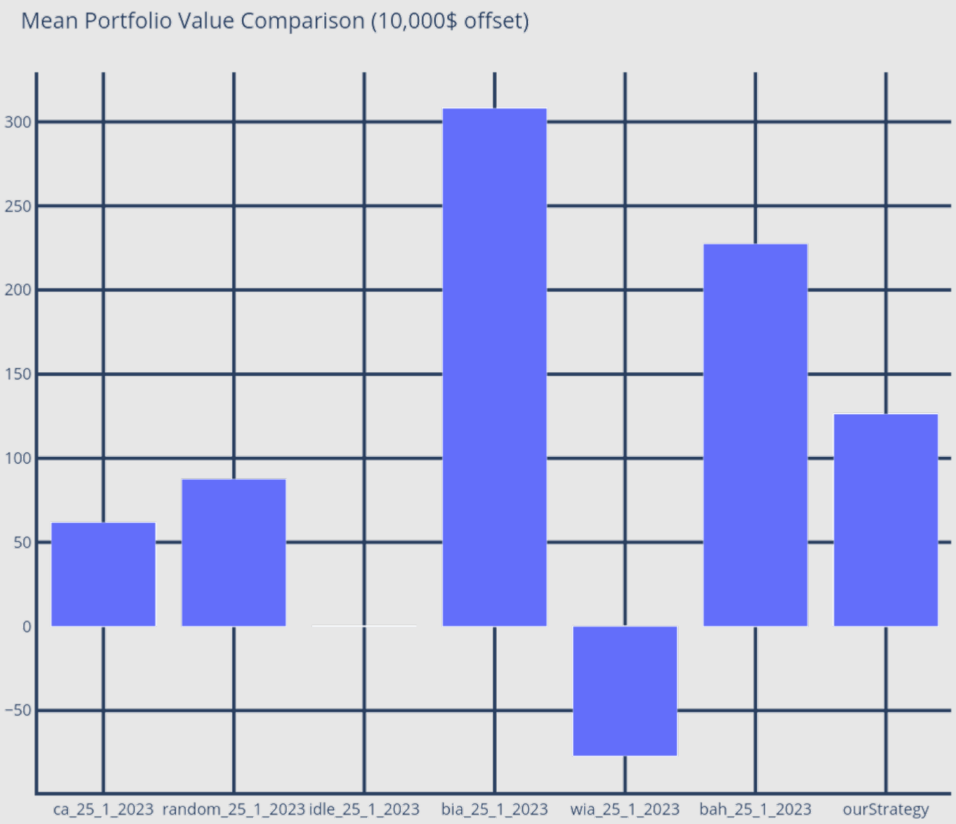
Example:
Open(t) < Predicted(t+2) < Predicted(t+3)

→ We Buy the Maximum

Performance of our Algorithmn



Results after 2 weeks test period



Communication with Frontend

Backend

- Computing power
- Strategy logic

Frontend

- User-friendly GUI

User expectations

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UIX

Resource Utilization
- Huge local CPU requirements
- Unusable device during calculation

Excessive Waits
- Long hours until recommendation
- Need of device turned on

Local Storage Utilization
- Peril of deleting critical files
- Inaccessibility from other devices

Alternatives apart from GUI
- Access to data only through frontend
- Daily time allocation to examine data

Backend Evolution

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Fully User dependent

- Up to user to run the script
- Local CSV generated
- Device turned on
- Environment installation needed

User-resource dependent

- Still need of user's device
- Local CSV generated
- Still need of device turned on
- Still environment installation needed

More drawbacks

- Slow calculation
- Abuse of user's resource
- Internet needed
- Non-scalable
- Poor maintenance in real scenario

Poor UIX

Manually Activated Local Script

Periodically Activated Local Script

Cloud Solution

Cloud Backend to reduce Local Computing Power

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Google Cloud

Daily digest
Email service enabled

No local docs
Data access from anywhere

Google Cloud's Google Storage

Bucket that keeps the strategy data and the description of the strategy

Reduced time
Possibility of powerful resources

Instance Selection

Roughly 10 min calculation.
4 VCPU's with 16GB

No user's device
Cloud-based solution

Google Cloud's Computer Engine

Cloud-based Debian 11 VM running the script
SSH and Crontab

Frontend Dashboard

Dashboard

Dashboard for your important informations, current and last recommendations

Overview over all important Metrics with real Time Updates

Different Options for Aesthetics and Colorblindness

Available E-Mail Subscription

Available Version for Windows and MacOs soon

Frontend Live Demo

Future Work

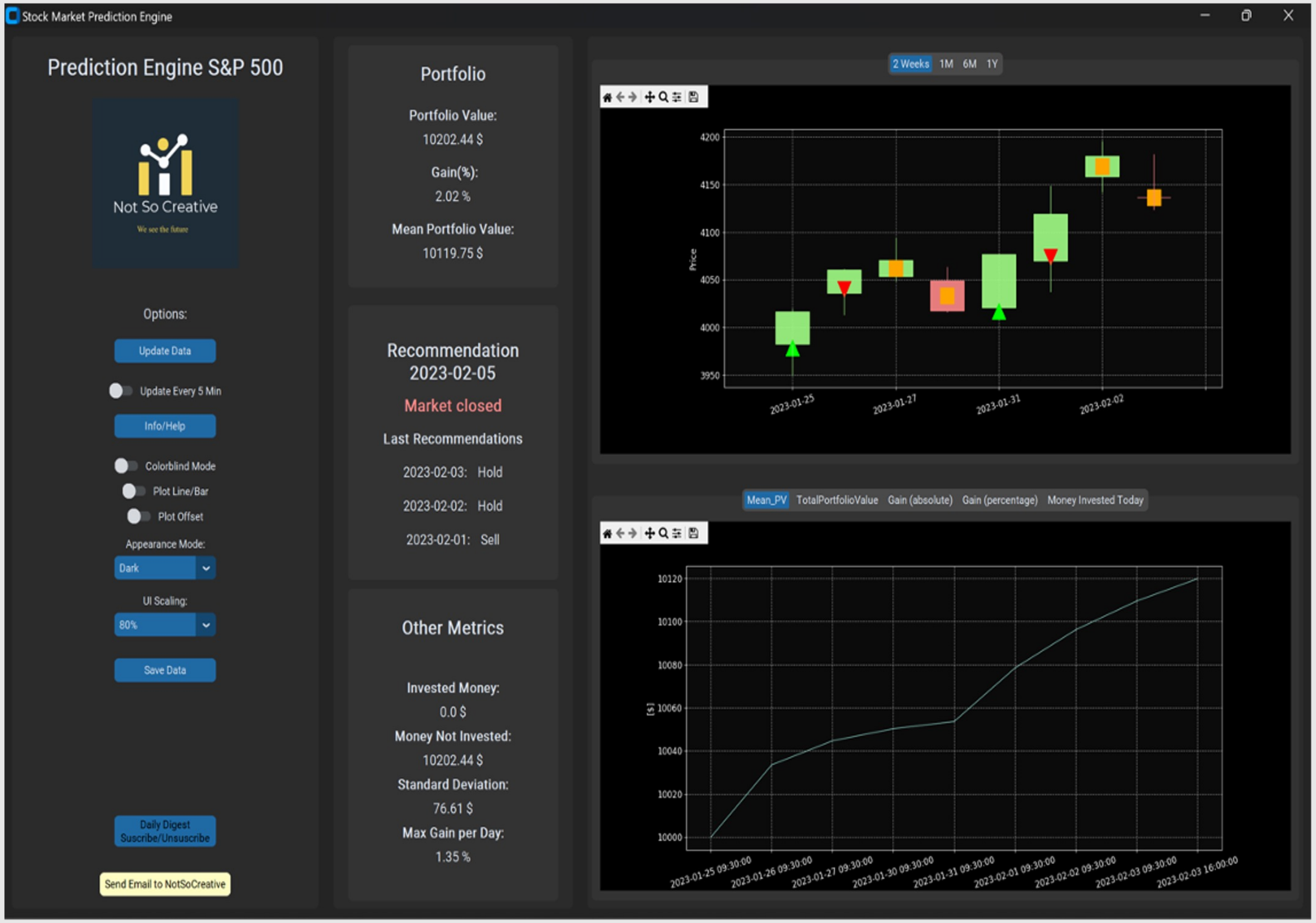
01 Include fundamental analysis

02 Frontend application on every device

03 Increasing the number of operations per day

04 Include tax & transaction fees

Product Summary



- Recommendation Engine for S&P 500
- Mean Portfolio Value = 10,144.59$ in a two-week time window with starting capital of 10,000$
- Accessible frontend
- Backend hosted on Google Cloud
- Full stack product