FOREX Price Movement Predictor

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Problem Statement

According to the 2019 Triennial Central Bank Survey of FX and OTC derivatives markets, the **foreign exchange** or **forex market** is the largest financial market in the world with a daily volume of **$6.6 trillion**. This is larger than the entire world's stock markets put together (approximately $84 billion for equities worldwide).

Within this huge amount of **intraday transactions**, 70% are made by institutional investors while the remaining **30%** made by private **retail traders**.

In this project, we will attempt to create a **predictive model** for **Intraday Retail Traders**. The model will use **historical Price** and **technical indicators** data to predict **probability of price increase** or **decrease** within the next defined time period (24hrs, 7 days etc).

The model must first **generalize** well for both seen and unseen future time-series data. Once that is achieved, model should conceptually allow user to be **profitable**.

Disclaimer

- Foreign Exchange (FOREX) is a form of leveraged trading with significant levels of risk.
- One may suffer the complete loss of all initial investments.
- One should only trade what one is ready to lose.
- Past results will not guarantee future gains/losses
- The developer will not be responsible for any losses incurred by any users
- Any trading advice given during the course of development is just for education and illustrations only.

Forex Introduction: Simultaneous buy & Sell

EUR / USD

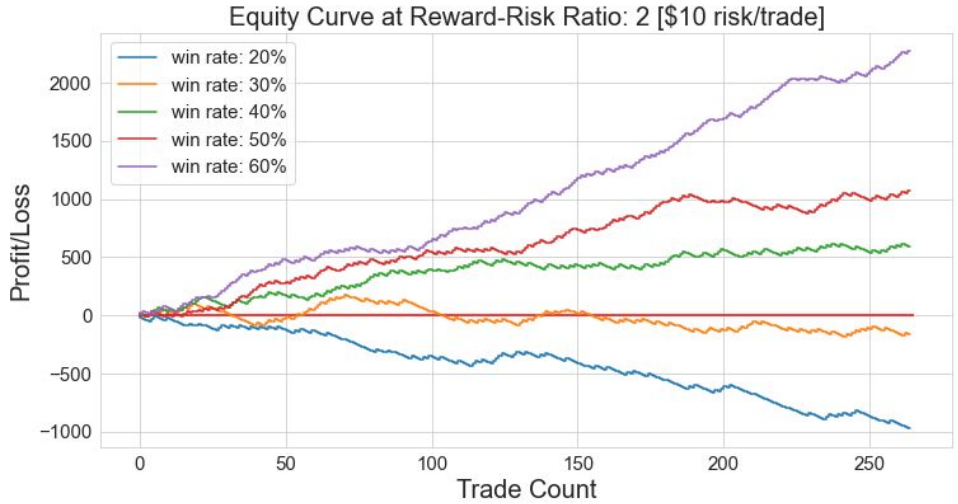
- Forex trading is the **simultaneous buying** of one currency and **selling** another.
- Currencies are quoted in relation to another currency.
    - In this project, we will only focus on the most frequently traded **EURUSD** pair
- If we believe the EUR will **appreciate** relative to USD, we will open a **BUY/LONG** trade.
    - If EUR **rises** against USD in the future, trader will close the trade with a **profit**
    - If EUR **falls** against USD in the future, trader will close the trade with a **loss.**
- If we believe the EUR will **depreciate** relative to USD, we will open a **SELL/SHORT** trade.
    - If EUR **rises** against USD in the future, trader will close the trade with a **loss**
    - If EUR **falls** against USD in the future, trader will close the trade with a **profit**.

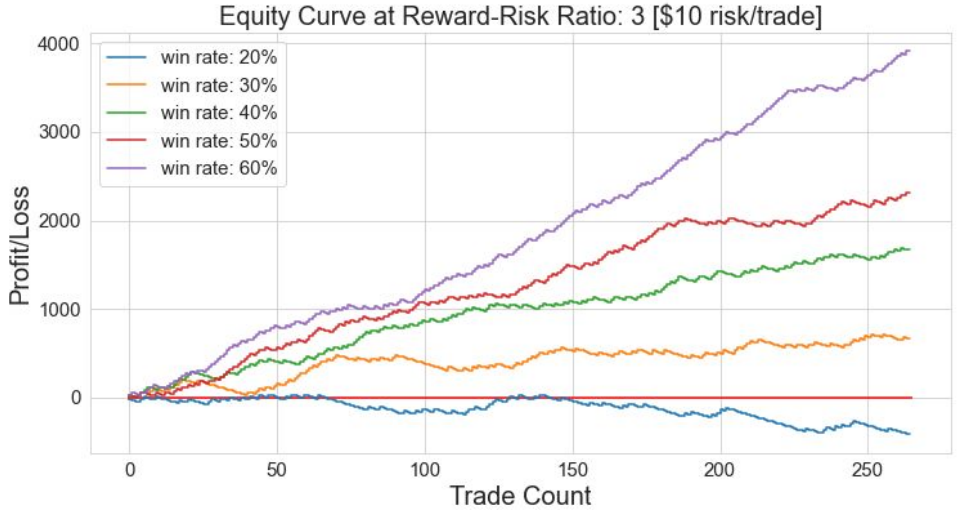
Forex Introduction: Take Profit & Stop Loss

- When a trader opens a position. The price level at which the trade was open is call the entry price.
- **Take Profit (TP)** and **Stop Loss (SL)** are preset price levels where the open trade will be closed once those price levels are reached.
    - For long trades, TP are set **above** the entry price and SL is set **below** the entry price
    - For short trades, TP are set **below** the entry price and SL is set **above** the entry price

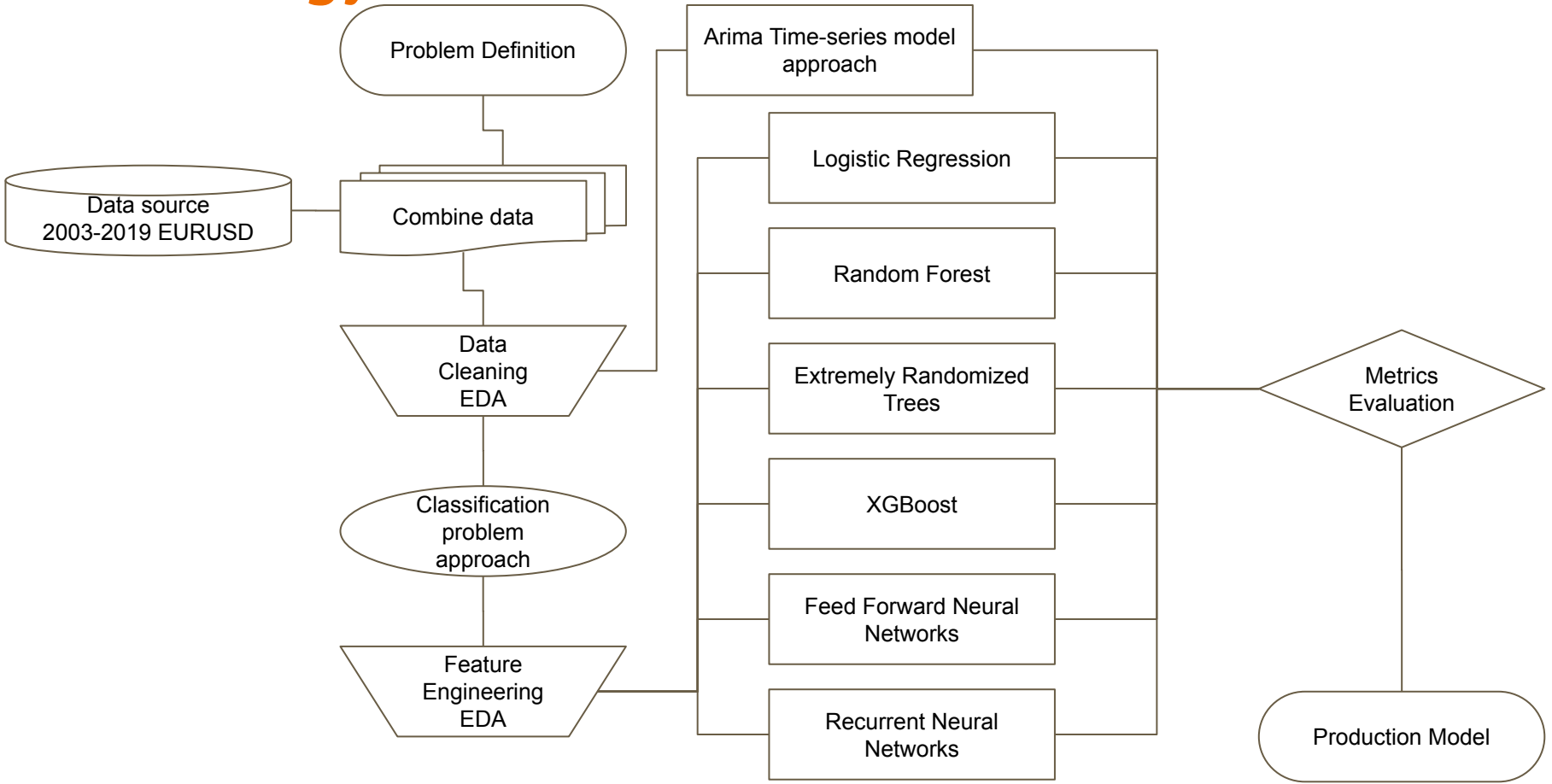
Forex Introduction: Reward-Risk Ratio

- It is impossible to profit at every trade. Traders objective is to **accumulate more wins than losses (net positive)** over any time period.
- A popular method is to set **TP and SL with ratio > 1**. Even at win-rate significantly less than 50%, traders can still be profitable as long as their **reward-risk ratio** is high.
- The caveat is that when SL is closer to the entry price, the **probability of price reaching the the SL level is higher than reaching the TP level.price**

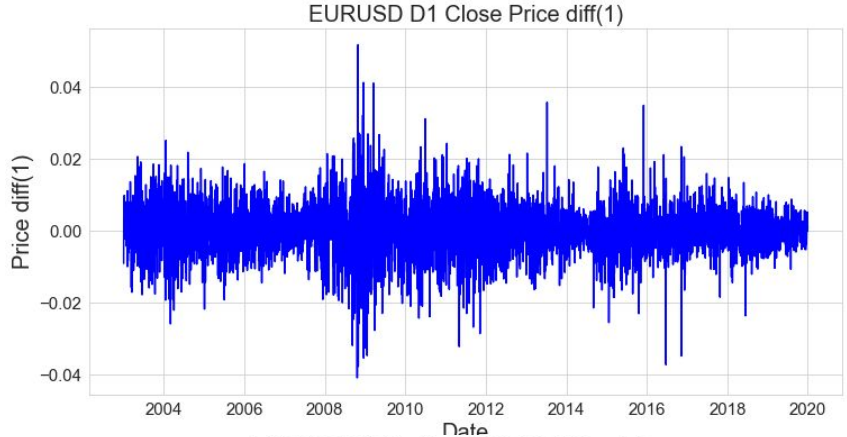


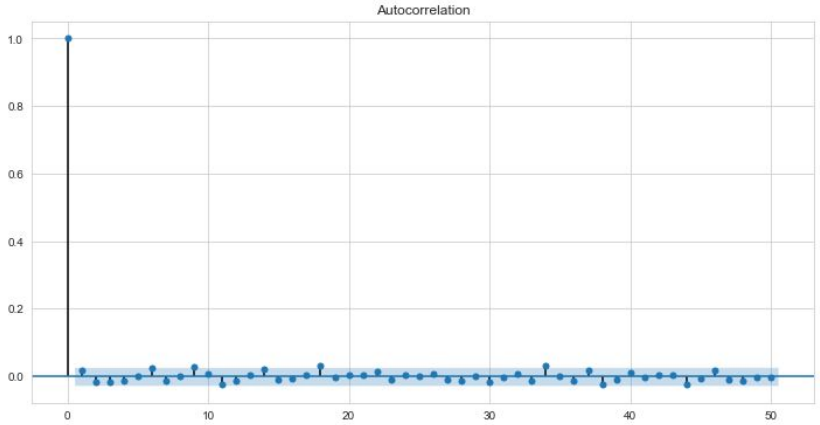


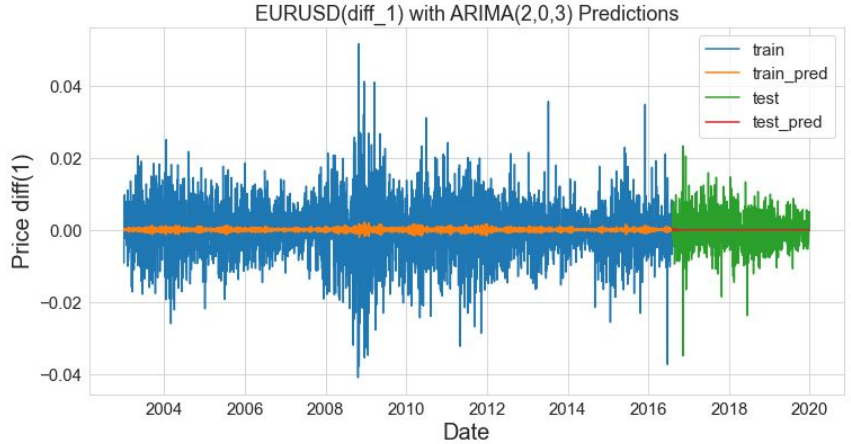
Methodology

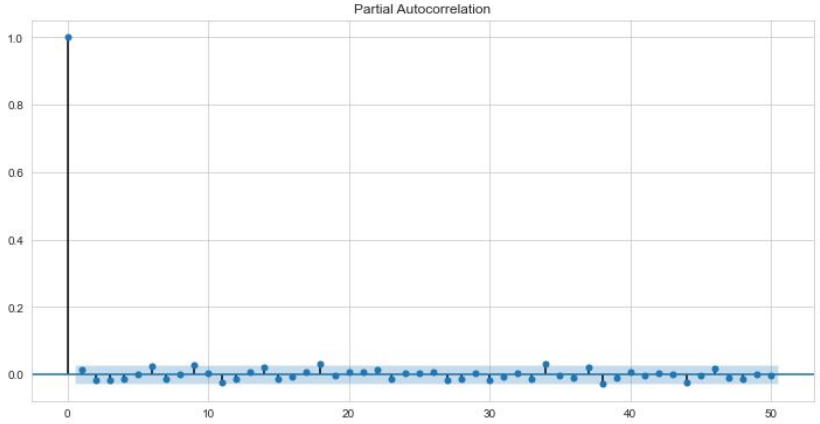


ARIMA Time-series: Noisy Data, No useful models



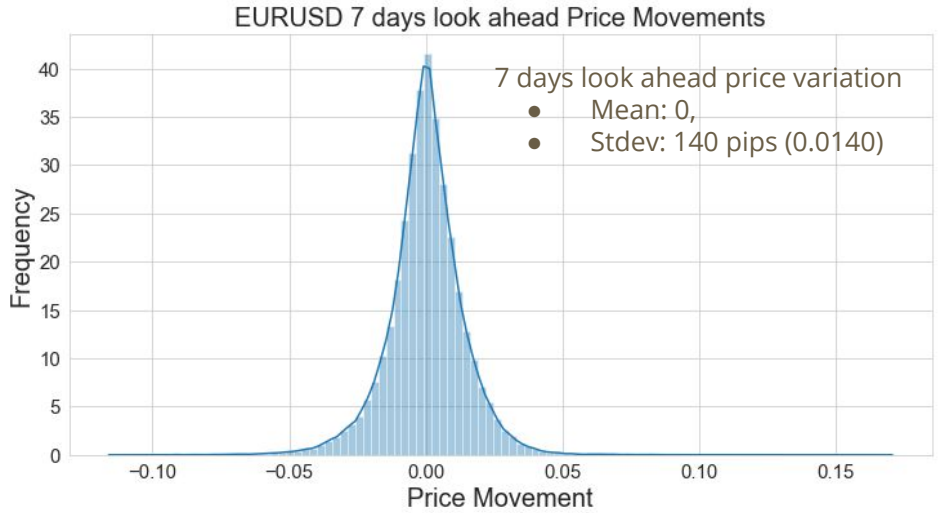


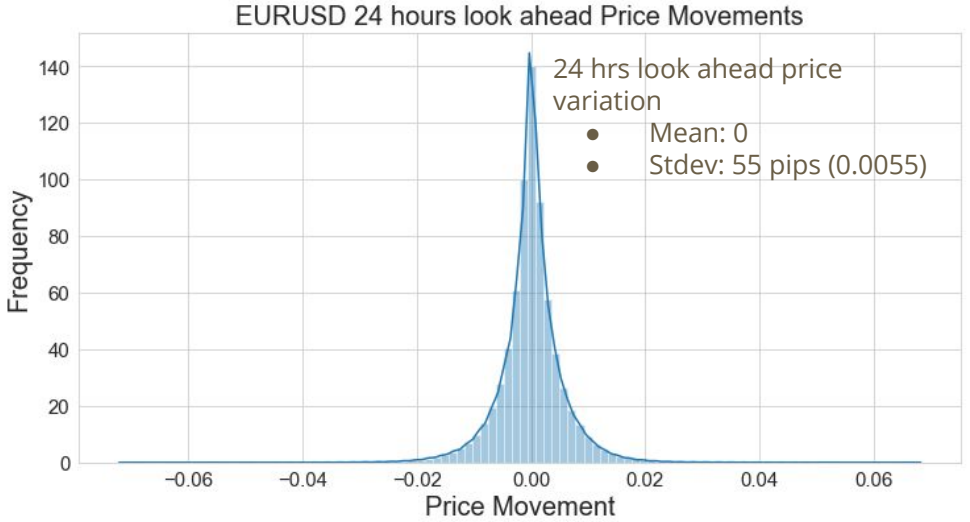




Classification Problem: Multi-Class Definition

- Set Take Profit (TP) at χ sigma of look ahead prices (140 pips for D1, 55 pips for H1)
- Set Stop Loss at (SL) 0.33 * (χ sigma) for **Reward-Risk Ratio (RRR) of 3** or 0.5 * (χ sigma) for **RRR of 2**
  - Using D1 time frame as example
  - For every look ahead day, if price did not cross -0.33 * 140 and crosses +140 TP >> Label 1, Profitable Long/Buy Trade
  - For every look ahead day, if price did not cross +0.33 * 140 and crosses -140 TP >> Label 2, Profitable Short/Sell Trade
  - If price persits sideways >> Label 0





Classification Problem: Feature Engineering

Close Price Shifts

- Price movements can be very correlated to their previous period close. We create new columns for shift 1,2,3,5,8,13,21,34,55,89. The relative price distance between current close and shifted closed will also be added.
- Relative distances between each shifted prices will also be introduced into the modelling

Simple Moving Averages (SMA)

- A simple moving average (SMA) calculates the average of a selected range of prices, usually closing prices, by the number of periods in that range.
- The SMA is a technical indicator that can aid in determining if an asset price will continue or reverse a bull or bear trend.
- The relative distances of the current close price to the SMA can also help predict price movement
- We create new columns for SMA with periods 2,3,5,8,13,21,34,55,89.
- The relative distances between current close price and SMAs will also be added
- Relative distances between each SMAs will also be introduced into the modelling

SMA


EUR/USD, 1D, OANDA
O1.17194 H1.17240 L1.17190 C1.17221
MA (5, close) 1.1742
MA (10, close) 1.1785
MA (20, close) 1.1866
MA (30, close) 1.1997
MA (40, close) 1.2075
MA (50, close) 1.2127
MA (75, close) 1.2197
MA (100, close) 1.2215
MA (200, close) 1.2019
1.26000
1.24000
1.22000
1.20000
1.18000
1.17221
1.16000
1.14000
1.12000
1.10000
1.08000
1.06000
1.04000
2017
Mar
May
Jul
Sep
Nov
2018
Mar
May

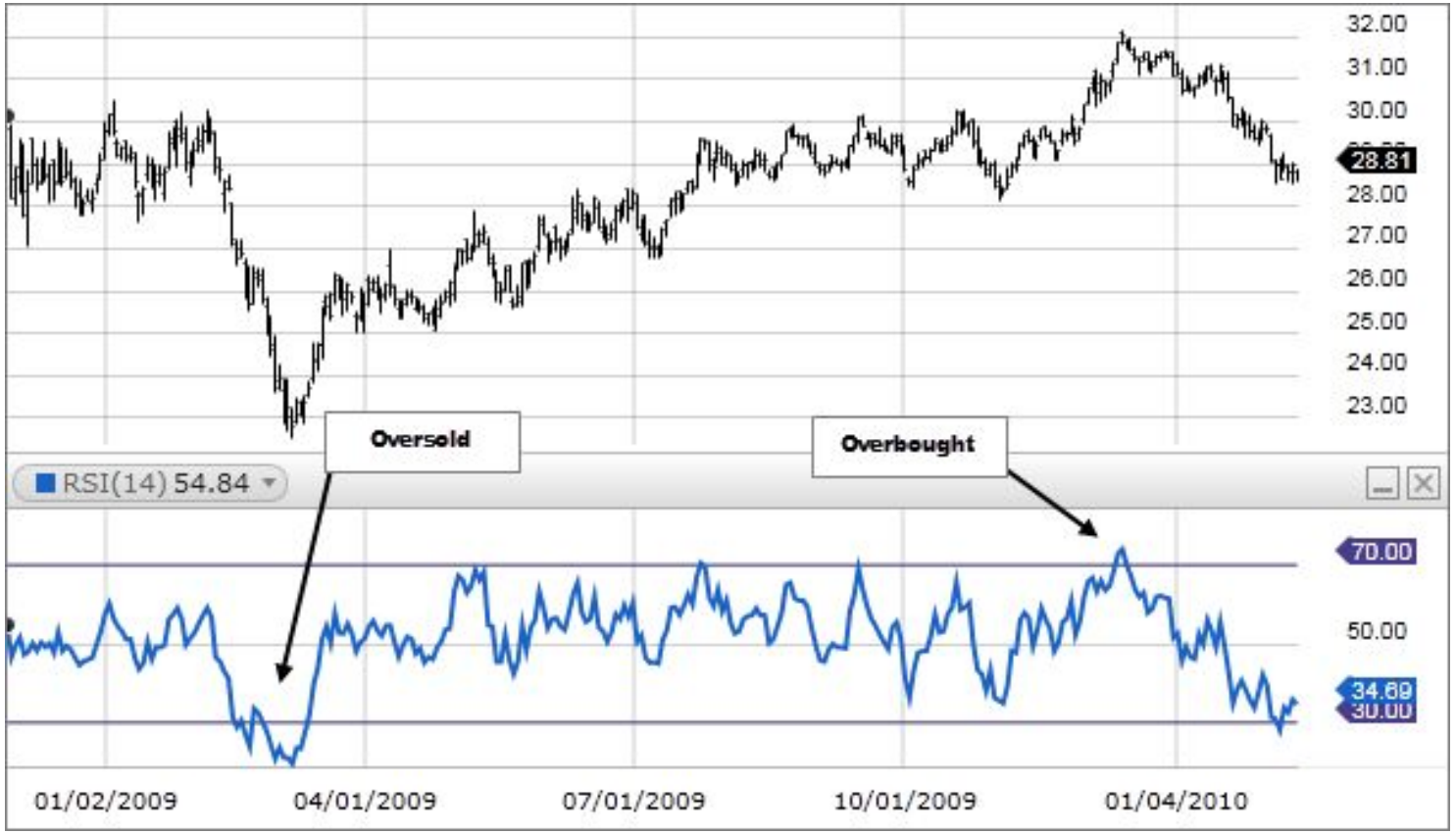
Classification Problem: Feature Engineering

Relative Strength Index (RSI)

- The relative strength index (RSI) is a popular momentum oscillator developed in 1978.
- The RSI provides technical traders signals about bullish and bearish price momentum
- An asset is usually considered overbought when the RSI is above 70% and oversold when it is below 30%.
- We create new columns for RSI(14)
- formula for RSI: https://en.wikipedia.org/wiki/Relative_strength_index
- RSI(14) is a rather noisy signal line.
- We will introduce simple moving averages to this indicator with periods 2,3,5,8,13,21.
- Similarly, relative distances between the MA and current RSI will be added
- Relative distances between the MAs will also be added

In total, 160 features will be introduced for model training

RSI


32.00
31.00
30.00
28.81
28.00
27.00
26.00
25.00
24.00
23.00
Oversold
Overbought
RSI(14) 54.84
70.00
50.00
34.69
30.00
01/02/2009
04/01/2009
07/01/2009
10/01/2009
01/04/2010

Classification Problem: Model Selection

0: No Profitable Trade
1: Profitable Long/Buy Trade
2: Profitable Short/Sell Trade

Logistic Regression

- Predicted very few short trades

	pred 0	pred 1	pred 2
actual 0	0	713	1
actual 1	0	297	1
actual 2	2	281	8

Random Forest:

- Predicted Mostly Long trades

	pred 0	pred 1	pred 2
actual 0	22	631	61
actual 1	21	228	49
actual 2	30	211	50

Extremely Randomized Trees

- Predicted very few short trades

	pred 0	pred 1	pred 2
actual 0	0	705	9
actual 1	0	288	10
actual 2	0	265	26

XG Boost

- Predicted very 0 short trades

	pred 0	pred 1	pred 2
actual 0	0	714	0
actual 1	0	298	0
actual 2	0	291	0

FF Neural Networks

- Predicted Mostly Long trades

	pred 0	pred 1	pred 2
actual 0	255	454	5
actual 1	71	212	15
actual 2	67	210	14

Recurrent Neural Networks

- Best balance for 0, 1 and 2 predictions

	pred 0	pred 1	pred 2
actual 0	269	394	51
actual 1	72	179	47
actual 2	58	176	54

Classification Problem: Model Metrics

0: No Profitable Trade
1: Profitable Long/Buy Trade
2: Profitable Short/Sell Trade

	pred 0	pred 1	pred 2
actual 0	269	394	51
actual 1	72	179	47
actual 2	58	176	54

- Model will open a LONG trade when it predicts 1
- Model will open a SHORT trade when it predicts 2
- Model will not open any trade when it predicts 0
- Traders are concern with their WINNING Rates
- Therefore PRECISION of OPENED trades will be the important criteria

Short Precision = 54 / (51 + 47 + 54) = 35.5%

Long Precision = 179 / (394 + 179 + 176) = 23.59%

Long & Short Precision = (54 + 179) / (394 + 179 + 176 + 294 + 179 + 176) = 25.86%

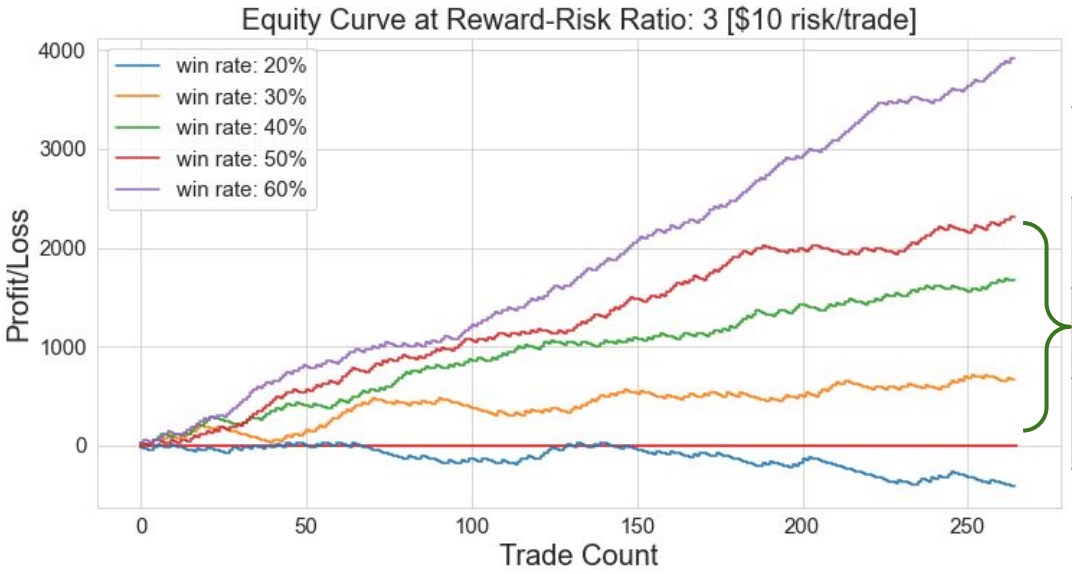
Effects of different Take Profit Price Level (D1)

	TP @ 0.50 Sigma RRR @ 3	TP @ 0.75 Sigma RRR @ 3	TP @ 1.0 Sigma RRR @ 3	TP @ 0.50 Sigma RRR @ 2	TP @ 0.75 Sigma RRR @ 2	TP @ 1.0 Sigma RRR @ 2
Train Accuracy (Model/Baseline)	**55.8%** / 49.7%	**58.6%** / 47.6%	**60.7%** / 41.3%	**60.2%** / 50.0%	**63.9%** / 47.8%	**57.6%** / 41.4%
Test Accuracy (Model/Baseline)	**47.9%** / 47.3%	**41.1%** / 36.4%	**38.9%** / 54.8%	**47.8%** / 48.1%	**37.4%** / 36.9%	**37.6%** / 54.6%
Long Precision (Model/Baseline)	**47.2%** / 46.0%	**34.3%** / 34.0%	**25.2%** / 22.9%	**46.3%** / 45.5%	**35.1%** / 34.0%	**24.7%** / 23.0%
Short Precision (Model/Baseline)	**49.0%** / 47.3%	**45.1%** / 36.4%	**26.8%** / 22.3%	**52.3%** / 48.1%	**38.3%** / 29.1%	**35.4%** / 22.4%
Long & Short Precision (Model)	**47.8%**	**36.0%**	**25.9%**	**47.8%**	**36.2%**	**25.6%**

* Due to the nature of price volatility changes and non-randomize train-test sets, the baseline accuracies for train and test sets can be rather different

Effects of different Take Profit Price Level (D1)

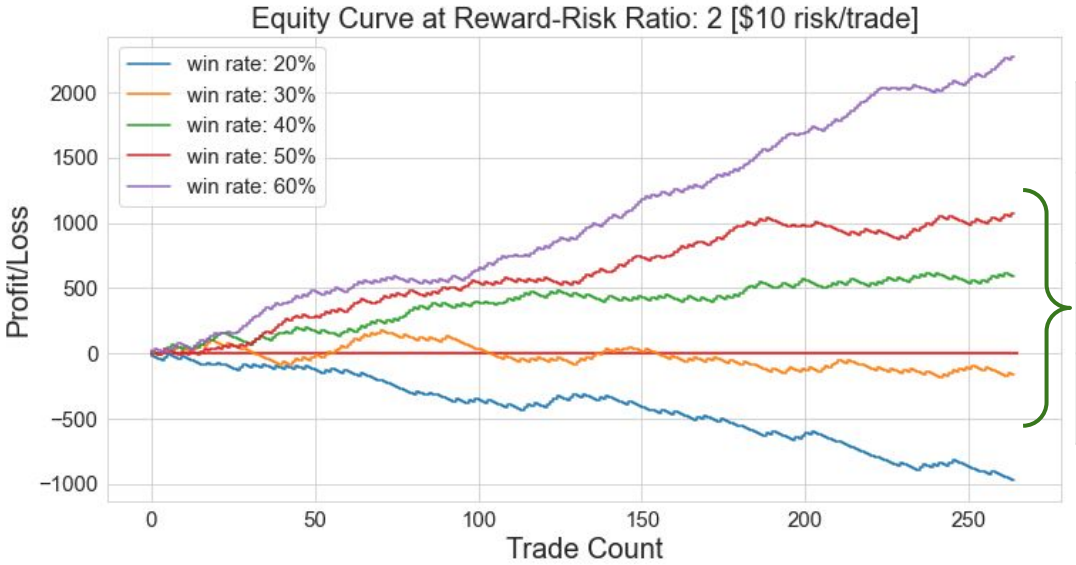
@ Reward to Risk ratio = 3



	TP @ 0.50 Sigma RRR @ 3	TP @ 0.75 Sigma RRR @ 3	TP @ 1.0 Sigma RRR @ 3
Long Precision (Model/Baseline)	**47.2%** / 46.0%	**34.3%** / 34.0%	**25.2%** / 22.9%
Short Precision (Model/Baseline)	**49.0%** / 47.3%	**45.1%** / 36.4%	**26.8%** / 22.3%
Long & Short Precision (Model)	**47.8%**	**36.0%**	**25.9%**

Effects of different Take Profit Price Level (D1)

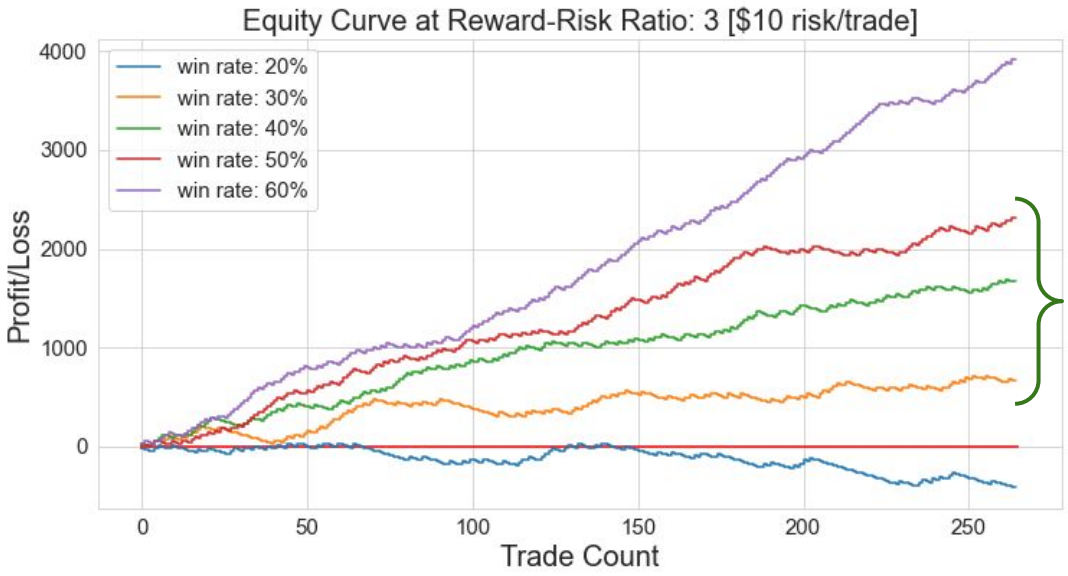
@ Reward to Risk ratio = 2



	TP @ 0.50 Sigma RRR @ 2	TP @ 0.75 Sigma RRR @ 2	TP @ 1.0 Sigma RRR @ 2
Long Precision (Model/Baseline)	**46.3%** / 45.5%	**35.1%** / 34.0%	**24.7%** / 23.0%
Short Precision (Model/Baseline)	**52.3%** / 48.1%	**38.3%** / 29.1%	**35.4%** / 22.4%
Long & Short Precision (Model)	**47.8%**	**36.2%**	**25.6%**

Effects of different Take Profit Price Level (H1)

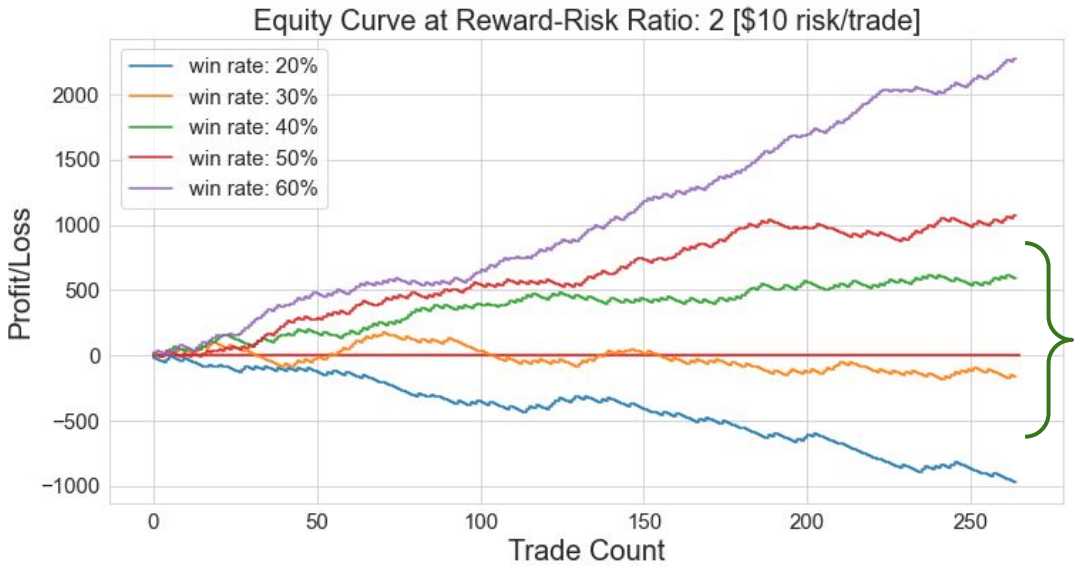
@ Reward to Risk ratio = 3



	TP @ 0.75 Sigma RRR @ 3	TP @ 1.0 Sigma RRR @ 3	TP @ 1.25 Sigma RRR @ 3
Long Precision (Model/Baseline)	**48.9%** / 47.6%	**48.6%** / 45.6%	**24.3%** / 15.9%
Short Precision (Model/Baseline)	**51.6%** / 51.2%	**49.1%** / 47.2%	**45.3%** / 15.6%
Long & Short Precision (Model)	**51.0%**	**48.9%**	**28.1%**

Effects of different Take Profit Price Level (H1)

@ Reward to Risk ratio = 2



	TP @ 0.75 Sigma RRR @ 2	TP @ 1.0 Sigma RRR @ 2	TP @ 1.25 Sigma RRR @ 2
Long Precision (Model/Baseline)	**34.5%** / 34.3%	**25.0%** / 24.9%	**22.2%** / 16.0%
Short Precision (Model/Baseline)	**37.3%** / 33.1%	**31.3%** / 24.1%	**44.8%** / 15.7%
Long & Short Precision (Model)	**35.4%**	**26.5%**	**24.8%**

Conclusion & Limitation

- **Conclusion**
  - Using RNN, we are able to achieve Opened Trades Precision between 28% to 50%
  - Combined with Reward to Risk ratio of 2 or 3, we have demonstrated the possibility of using machine learning to achieve profitable intraday trading.
- **Limitation**
  - Will model generalize well?
    - Due to the nature of price volatility changes and non-randomize train-test sets, the baseline accuracies for train and test sets can be rather different
    - Therefore it is a challenge to assess whether model can actually generalize well
  - Can model be applied to other time frames
    - Most likely usable for EURUSD for D1, H4, H1 time frames.
    - Longer time frames like W1 and M1 will be more influence by unpredictable economic events
    - Shorter time frames like M30, M15, M5, M1 may be too volatile
  - Can model be applied to other currencies pairs
    - Different currencies pairs are known to have different level of volatility
    - Model should be trained separately using their own historical data

Recommendations

- **Recommendation**
  - Proof of Concept
    - Integrate python and MQL4 (Metatrader4 trading platform)
    - Forward testing to confirm whether profitability can be achieve with Live and Future price movements
  - Further Improvement
    - More data to assess that model can generalize well (USDJPY, GBPUSD, USDCAD etc)
    - Research, innovate methods to assess model generalization
    - In this project, the most granular data studied was the 1 minute OHLC
    - It is possible for price to fluctuate even within 1 minute
    - Explore modelling with with price "tick' data (every price movement of at least 0.00001)
  - Introduce other Indicator features:
    - Bollinger Bands
    - Moving Average Convergence Divergence (MACD)
    - Stochastic Oscillators and many more