Project 8: Strategy Evaluation

ML4T CS7646

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Introduction—The project objective is to use a Manual Strategy based on stock indicators, and a strategy learner (ML base learner) and compare their performance to the benchmark (JPM). For this project Reinforcement learner (Q-learner) is selected as our strategy learner to predict stock action (buy, hold or sell).

INDICATORS OVERVIEW:

The indicators used for this project are Bolinger Band % (BB%), Stochastic Oscillator and Relative Strength Index. And a look back of n=20 is used to capture enough information and at the same time not wait too long (vs higher look back window) to miss trading opportunities.

Bollinger Band% (B%): The Bollinger Band % measures hows close the price to the upper bollinger band and the lower bollinger band, for example bollinger band% >=100 mean the price is at or above the upper bollinger band, similarly if bollinger band% <0 means that the stock price is below or at the lower bollinger band.

The bollinger band % is calculated as follow:

BolligerBand% [price-Lower Band]/[Upper Band -Lower Band]*100

wherein the Lowe Band is equal to [price-SMA]/2*standard_deviation

and the Upper Band os equal to [price+SMA]/2*Standard_deviation.

Bolinger band % can exceed 100 meaning the stock is overbought or drop below 0 which means the stock is oversold, and

Relative Strength Index (RSI): Relative Strength index is used to help traders identify a combination of momentum, overbought and oversold as well as divergence in price.

the RSI is calculated as follow:

RSI =100 -100/[1+ |Average_Gain/Average_Loss|]: if Average_Loss !=0

RSI =100 if Average_Loss =0

wherein the Average_Gain is the average of the positive daily returns over a window period of time (20 days in this report).

Similarly the Average_Loss is the average of the negative daily returns over a window period of time. The value of the RSI range between 0 and 100.

Stochastic Oscillator Indicator (STO): The Stochastic Oscillator indicator is used to indicate overbought and oversold trading signals. The STO indicator compares the closing price to its prices over a certain period of time (in this report we used 20 days).

The STO is calculated as follow:

STO =[CP-LP]/[HP-LP]

wherein CP is the closing price.

LP is the lowest price in the previous n-trading days (n= 20 in this report).

HP is the highest price in the previous n-trading days (n=20 in this report)

The Value of The Stochastic Oscillator indicator (STO) ranges between 0 and 100.

1.   **Manual Strategy:**

For the Manual strategy we used a look back window=20 that is not too low or too high to capture enough information and at the same time not wait too long to miss trading opportunities, ,and the following threshold for each indicator and to generate buy, hold and sell signals, For Bollinger Band % a value over 100 is considered an overbought therefore it is a sell signal (sell signal= -1), a value lower than 0 is oversold therefore it a buy signal (buy signal =1) and any value in between is a hold/ do nothing signal (hold signal=0).

Similarly for Stochastic indicator (STO) we tuned in the upper and the lower threshold to get best return, we used STO > 60 is sell signal, STO <20 is a buy signal, and anything in between is hold signal. For Relative Strength Index (RSI), with   RSI >60 is sell signal, RSI<30 is buy signal and anything in between is hold signal.

We used a majority vote from the three signals to take action of buy, sell or hold, meaning that all indicators have to signal buy (+1) in order to take a buy action, similarly all indicators have to signal a sell (-1) in order to take a sell action, anything else is considered a hold signal.

To translate this into code, the sum of all three signals from the three indicators has to be 3 to make a buy action (e.g [1, 1, 1]), and the sum of of all three signals from the three indicators have to be 3 (e g [-1,-1,-1]) , anything else is hold (e.g [1, 0, -1], [0,0,0], [1,0,0] etc..), this method gives a better cumulative return, having all three signals agree on a buy or sell signal increases the chance of making an accurate prediction.

We also believe the combination of BB% , RSI and STO works better because each indicator has certain characteristic and provide some information about how the stock behavior and how it is traded in the past, for example BB% measures how far the price has gone up or down from the average moving price (fair price), and it also take into consideration the volatility of the stock (standard deviation), RSI measures the recent change   in price (gave more weight to recent information) and price movement. Stochastic oscillator (STO) is a momentum indicator taking into consideration a particular price close to a stock to a range of the stock prices over a certain period of time. The sensitivity of the oscillator to market movements is reducible by adjusting that time period.

Note: Per project requirement, the trades are restricted to either 1000 shares for long, -1000 for sell or 0 shares for hold, However if we are at 1000 hold we can go -2000 short and vice versa.

In sample ManualStrategy VS Benchmark JPM portfolio value

Out of sample ManualStrategy VS Benchmark JPM portfolio
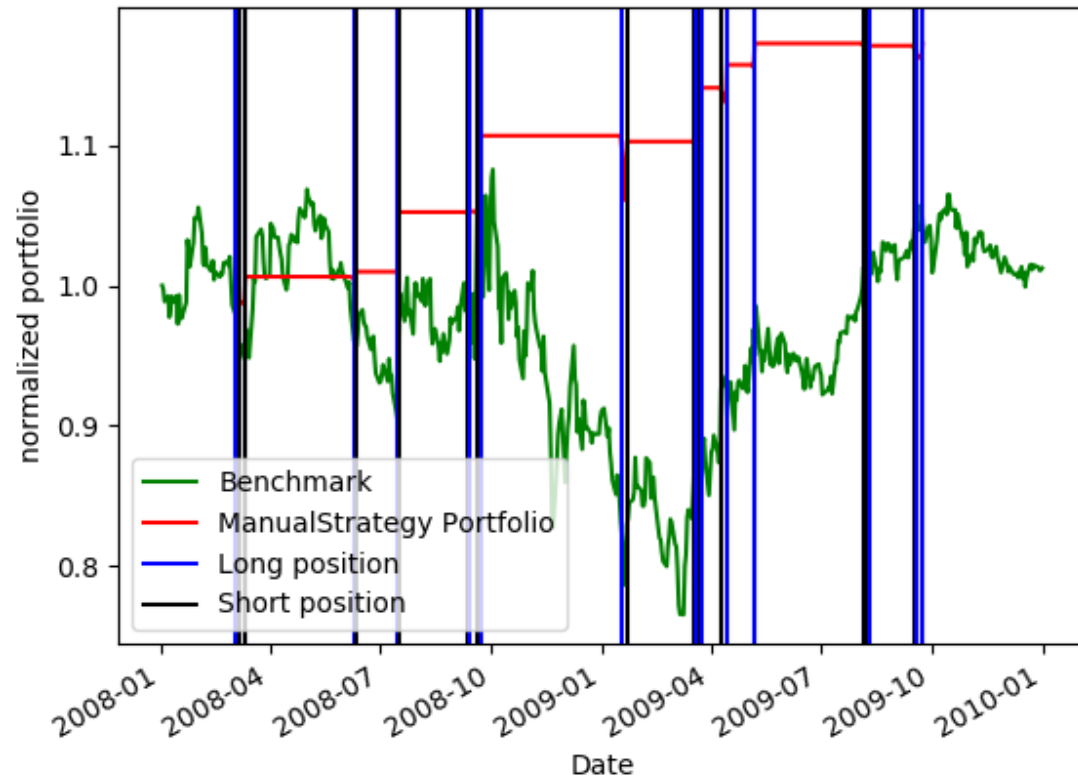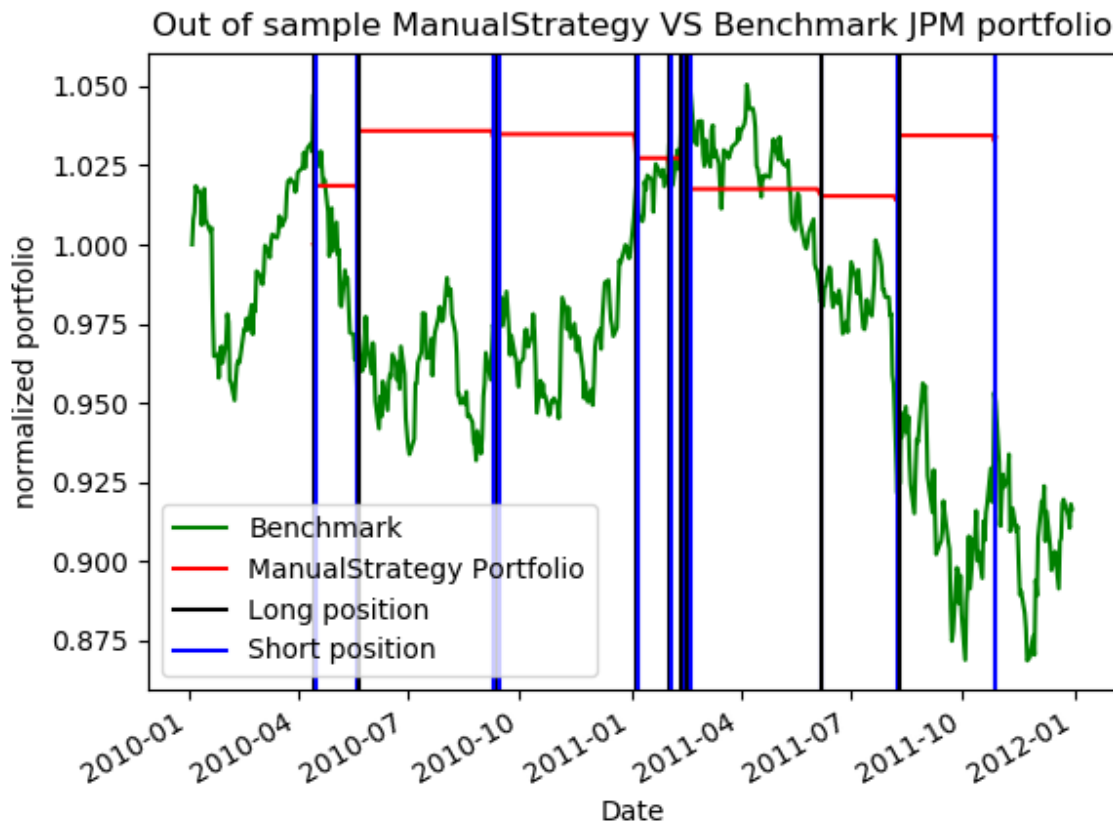
Note: the flat portions in manual strategy return indicate an exit of position and just holding cash and waiting for the next signal, also note that we exit before the end of the year and we just hold cash for the rest of the year.

In Sample stats: 01/01/2008 to 12/31/2009

	Manual Strategy	Benchmark JPM
Cumulative Return	0.172215	0.012322
STDEV of daily return	0.0050786	0.01702
Average daily return	0.000415	0.000168

OUT of Sample stats: 01/01/2010 to 12/31/2011

	Manual Strategy	Benchmark JPM
Cumulative Return	0.033839	-0083579
STDEV of daily return	0.0017925	0.008491
Average daily return	$8.648*10^{-5}$	-0.0001371

The manual strategy performs better than the benchmark for in sample as well as out of sample, which is expected because technical indicators can inform us and give us some insight of trading behavior and trading activities of a certain stock and trading opportunities (such as the overbought or oversold situation , also technical indicators can detect trends and patterns. These information provided by indicators increase our chance to make better predictions of stock movement. However the cumulative return is lower for out sample compared to in sample which is expected the insample data are always too optimistic and running learner on test data is expected to produce lower result

2.   Strategy Learner:

For the Strategy learner with implement the following steps to setup the stock trading environment for the Q learner:

Step 1: scaling the three indicators values to be between [0,1]

Step 2: discretize the indicators values to 10 bins equal intervals, and mapping each interval to a number from 0-9 using the cut method in python

Step 3: Create a state from the discretized indicators by concatenating the discretized values of the three indicators, for example if discretized values of BB%, STO and SRI are 2, 5, 0 respectively , the state will be 250. The number of states is 1000 (10*10*10 combination).

S**tep 4:** building Qlearner with states_num=1000, action_num=3 ([buy, hold , sell] or [1, 0,-1])

Step 5: define the reward function, in this case we use daily portfolio value return as our immediate reward.

Step 6: train the Qlearner over the in-sample data between 1/1/2008 and 31/12009 and update the Q table.

Step 7: build a test function and query the data to get the predicted next action and output a dataframe with trading recommendation/predictions.

Note: Per project requirement, the trades are restricted to either 1000 shares for long, -1000 for sell or 0 shares for hold. However if we are at 1000 long we can go -2000 short and vice versa.

After the above steps we tweaked the hyperparameters to different values to get better cumulative return and convergence, using trial and error method, we used a learning rate of 0.5, discount rate of 0.9, random action rate of 0.4, and decay rate of 0.9.

3.   Experiment 1:

For both manual and the Strategy learner we set the look back window to 20, using the indicators BB%, RSI and STO. and we set the impact to 0.005, commission=0 and the starting balance is $100000. The trades are restricted to either 1000 shares for long, -1000 for sell or 0 shares for hold. However if we are at 1000 long we can go -2000 short and vice versa.

We compare the portfolio values of benchmark, ManualStrategy and Strategy learner over the in -sample period between 1/1/2008 and 12/31/2009.

The hyperparameters for Qlearner used in Strategy learner are: learning rate of 0.5, discount rate of 0.9, random action rate of 0.4, and decay rate of 0.9.

We expect the Strategy Learner to perform better than the manual strategy and the benchmark for the in-sample data.
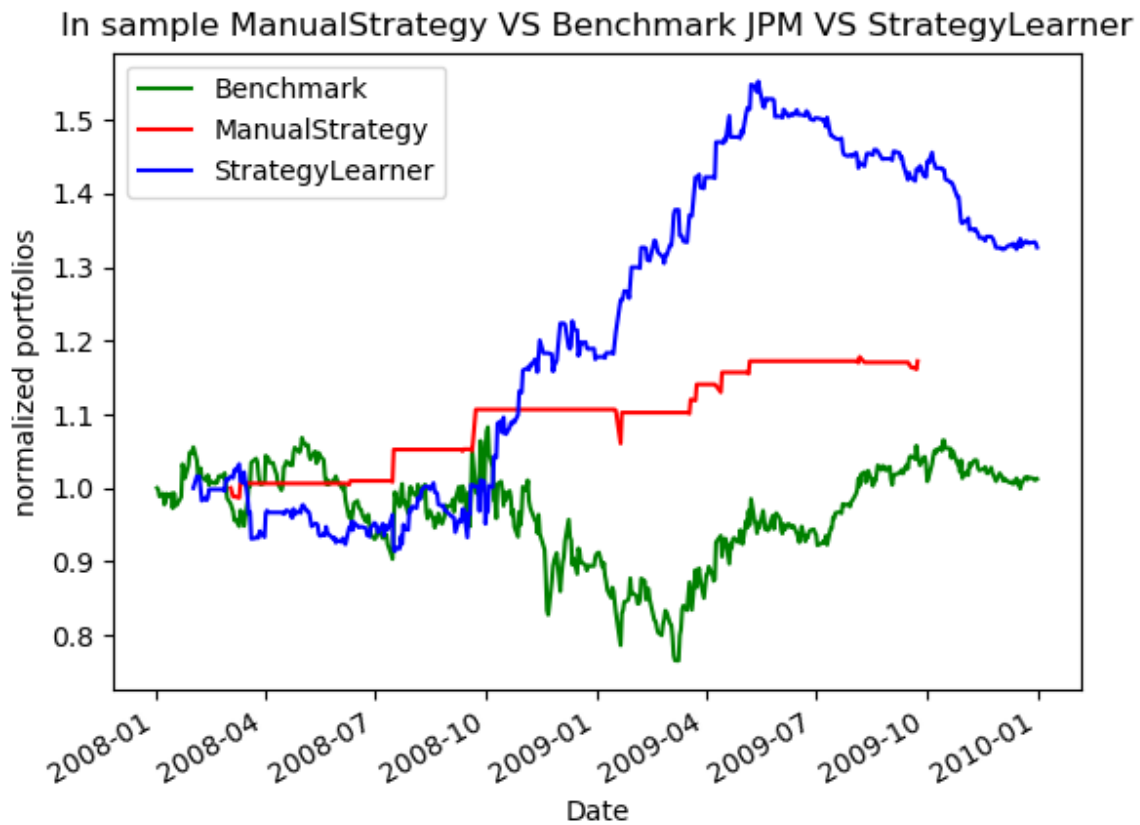
In sample ManualStrategy VS Benchmark JPM VS StrategyLearner

Table below summarize the output result stats for the in-sample period of Strategy learner vs Manual Strategy vs Benchmark.

	Manual Strategy	Strategy Learner	Benchmark
Cumulative Return	0.172215	0.326644	0.012322
STDV of daily return	0.0050786	0.0107749	0.017024
Average daily return	0.000415	0.0006419	0.000168

The Strategy learner out performed the manual and the beachmask as expected.because the strategy learner is trying to maximize the return (reward) as we trade and update the next action to take., also the Q learner learns from interacting with the environment and past experience. However there is no guarantee that the Strategy learner will perform better for the out of sample data due to overfitting.

4. Experiment 2:

Hypothesis: a higher impact will decrease the performance and portfolio value (lower profit) in-sample trading behavior and result.

Note: Impact is the price change against the trader, meaning a buy order of a stock at a certain price results in buying price stock plus impact (price+impact) and a sell order results in sale price of (stock price minus impact (price -impact).

Description: comparing the Strategy learner portfolio values using different impact values:

Using different impact values of 0, 0.01 and 0.02 and setting the commission to zero.

Trading over the in-sample period between 1/1/2008 and 31/1/2009.

Comparing the   results using metrics (such as cumulative return, standard deviation daily return, average daily return) with different impact values and commission set to 0:
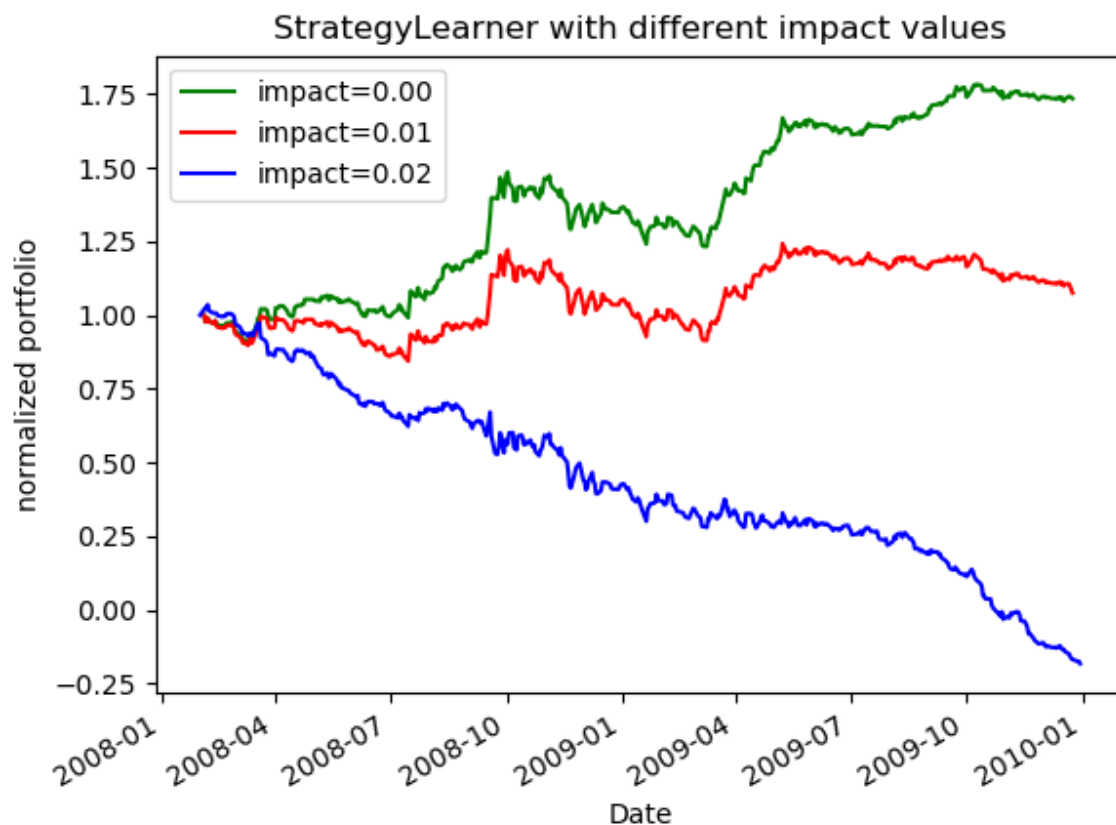
Table below show stats of strategy learn for each impact value for in sample trading bahavior

	Impact =0	impact=0.01	impact=0.02
Cumulative return	0.734399	0.07523	-1.18201
STDV of daily return	0.011899	0.014526	0.36805
Average daily return	0.00122	0.000256	-0.00674

As we can see from the charts and the stats the impact negatively affects the portfolio performance as expected. a higher impact will discourage the Strategy learner to make more trades. Also we expect that q learner will perform worse in an environment where there are low trading volume stocks where the gap between bid and the ask is wider (higher gap between the bid and the ask can result in higher impact).

1   REFERENCES

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