Machine Learning Engineer Nanodegree

Capstone Proposal

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Domain Background

Keeping your money in index funds is one of the best ways right now to insure that your money will rise above inflation over time. Warren Buffett and many other investors say that the best way to build savings over time is to invest in S&P 500. S&P index is a representation of the weighted average of the stock prices of the top 500 companies in the U.S. S&P on average returns 11% a year and 3.8% inflation. That means that if you keep your money in S&P over time, it's worth will increase by 7% each year (S&P 500).

This is a representation of the average increase overtime. If you could time the market and know when the market is about to drop, then you could take your money out during those times and keep your money in during other times. This could potentially allow you to make more money over time. Robert Shiller, the nobel prize winning economist, predicted the market would crash during the dot com bubble and also the crash during the 2008 housing bubble. What I want to do is use his data to figure out if I can time the market (Robert Shiller).

Problem Statement

The problem that I'm trying to solve is that if by timing the market can I make more money than by just keeping my money in the index fund. By timing the market I mean, can I make predictions of the market and decide whether to buy or sell shares? My solution to the problem is to use reinforcement learning on some of the factors that Robert Shiller used to predict the market crash. We can measure the results by money made

Datasets and Inputs

I will be using Robert Shiller's data on U.S. Stock Markets 1871-Present and CAPE Ratio. This is data of the S&P index fund every month from the year 1871 to now. S&P index fund is publicly available information, but he has other things calculated that were specific to the predictions he wanted to make like S&P with account to the value of the dollar today (S&P with inflation).

The data that I'm going to be using is the Real Price, Real Dividend, Long Interest Rate, and the cyclically adjusted Price Earnings Ratio (P ratio). The Real Price is the S&P throughout history using today's value of the dollar. Dividend is the amount

of money that you get for having the index. Besides the overall increase of the stock overtime you also get money given to you for owning a piece of the top 500 companies. The Real Dividend is just the dividend in terms of today's dollar. The Real Price and Real Dividend will just be used to determine how much money you have based on having the stock. The Long Interest Rate and P Ratio is what will be used to determine if we should buy or sell. The Long Interest Rate is how much interest you get by buying bonds. The cyclic P Ratio is the ratio of S&P price divided by the average Earnings in the last 10 years.

In Robert Shiller's article: Price–Earnings Ratios as Forecasters of Returns: The Stock Market Outlook in 1996, it shows that there is a correlation between high P-ratios with decrease of S&P and low P-ratios with growth of S&P. Basically Earning's really determine where S&P will go. If the S&P is a lot higher than the equivalent earnings, the S&P will go down. If the S&P is a lot lower than the equivalent earnings, the S&P will go up. Interest Rates can also predict S&P because if interest rates are high people will buy bonds which will decrease demand for S&P and it will drive S&P down. If interest rates are high, people will make less money from bonds and will be more likely to put money in S&P and it will drive S&P up.

Solution Statement

There could be many different algorithms and methods that we could apply to find the solution to the problem. I will solve it using Reinforcement learning because I feel that it relates more to how humans invest, which is in terms of punishments and rewards. If the stock market goes down negative and money is kept in the market, negative reward will be given. If the stock market does up and money is kept in the market, positive reward will be given. If the stock market goes up and money is not invested, then negative reward will be given. If the stock market goes down and money is not invested, then positive reward will be given. The Reinforcement Learning Algorithm will use these Rewards do determining investment procedures on the test set.

Benchmark Model

The benchmark model is how much money will be made by just keeping the money in S&P and not tampering with it. On average S&P increases overtime even though there are up's and downs and plus you always get dividends as rewards. Another benchmark model is how much money is made by keeping money in bonds which is represented by interest rates. If our Solution Model makes more money than just by leaving it in S&P, our model is a success.

Evaluation Metric

The Evaluation metric is very simple, the percentage difference between the amount of money made during the benchmark model result and the solution model

result. We could also compare both models to bonds to see how they perform. Since the result is how much money is made, percentage difference makes the most sense.

Project Design

The complete data that we have for S&P index is from 1881 to 2017. I will divide the data into a training set and a testing set. The training set will use 70% of the data and the testing set will use 30% of the data. Since we don't have a lot of data and it makes most sense that everything is continuous, the training set will use data from the year 1881 to 1976 and the training set will use the data from 1976 to 2017. The reason why k-fold cross validation doesn't make sense to me in this case is that I want the testing set to be one continuous period and to use as much training as possible. If we had a lot more data, we could test on specific time periods.

Greedy Q-learning is what I will use to decide whether to buy or sell shares of S&P. The learning factor alpha, the decay factor epsilon, and the rewards are the factors that I will be experimenting with. In the beginning of the training, randomness will be used to figure out whether to hold money or keep it in the market. A dictionary will be built based on the Q-learning algorithm with current P ratio's and interest rates. The rewards and the alpha factor will determine how the Q-learning dictionary points are allotted for each specific range of P ratio's and interest rates. The alpha factor I'll just have to experiment with what gives the best results. The epsilon decay factor will determine overtime how much overtime is the prediction going to rely on the Q-learning dictionary vs. randomness. I'm going to start out by only giving rewards and punishments based on monthly results. If money is held and stock goes down, give a positive reward. If the money is held and stock goes up, give a negative reward. If money is kept in S&P and stock goes down, give a negative reward. If money is kept in S&P and stock goes up, give a positive reward. I will also do later trials with giving longer term rewards based on comparisons to the benchmark model maybe every 10 years in the training set.

After I have built up a Q-learning library on the first 100 years of data, I'll use this information to test on the stock market for the last 40 years. We will be able to determine how successful our model is based on how much money is made in our model vs. benchmark model.

Sources:
http://www.econ.yale.edu/~shiller/data/peratio.html : Price Earning Ratios as Forecasters of Returns

https://www.cnbc.com/2017/05/12/warren-buffett-says-index-funds-make-the-best-retirement-sense-practically-all-the-time.html : Warren Buffett says index funds make the best retirement sense 'practically all the time'

http://www.simplestockinvesting.com/SP500-historical-real-total-returns.htm: S&P 500: Total and Inflation-Adjusted Historical Horizons