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Bayesian Neural Networks for Option Pricing

BEM114 final project proposal version 2

Overview

In this course, we have seen that machine learning can be leveraged to predict returns in the stock market. However, the model that we implemented was naive and simple. For example, rather than choosing a combination of weights of factors, it chooses the factor that will maximize returns. Additionally, the model only predicts the return, but provides no information about the probability distribution of future returns. To improve upon our already existing model, we can switch our model architecture to a Bayesian neural network. Rather than outputting a single value as a prediction for returns, this model will output a posterior probability distribution, providing more information about the future. We can also leverage this information to trade on not only the underlying stock but also options. We will trade on the NYSE on the market level (ticker SPX).

Logic

We believe that by predicting a posterior distribution on the underlying stock's price, we will have generated more information than a strategy which just predicts a future price. We can integrate over the distribution of possible future underlying prices to more accurately determine exactly what an option's price should be today. Then, we will buy the options whose trading prices are lower than our expected price, and sell the options whose trading prices are higher.

Backtesting

To backtest this strategy, we will start with the Homework 5 file, and switch the feed-forward neural network to a Bayesian neural network. Instead of picking the factor with the highest returns, we will look at the distribution of prices for 'Mkt-RF' + 'RF'.

To keep this analysis simple to start, we will restrict our portfolio to SPX call options with a strike price at the current trading price and an expiration date 1 year out. For these specific options, we will buy if they are undervalued, and sell if they are overvalued, rebalancing our portfolio daily. Finally, using daily SPX returns data, it will be easy to calculate the returns of our portfolio.

Additional Ideas

In addition to switching to a Bayesian neural network, we also want to add other layers to our strategy. Simply buying and selling specific options when our model's expected price is higher and lower respectively may not fully exploit the information generated by our Bayesian neural network. We may also test more complicated ways to execute trades given the posterior distribution of the underlying, such as layering butterfly spreads in a way that approximates the posterior as closely as possible. Additionally, rather than predicting just the returns of the market portfolio, we can try applying the Bayesian neural network to each of the 6 factors and creating a more nuanced portfolio. We may also experiment with the features, activation functions and parameters of our models including adding idiosyncratic volatility, trading volume, or sentiment as features.