GARCH

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Project overview

GARCH if a mathematical tool that works on the basis of log likelihood to compute future volatility based on past volatility and stock prices.

We have used a rolling window to compute the variance (volatility) of data. The window size we have set is 5. We have compared the results of this actual volatility with the one that is predicted using GARCH.

We have taken GARCH as a baseline model and compared it with various deep learning models using time series analysis.

The models we have used are:

1. LSTM
2. GRU
3. RNN
4. CNN-BiLSTM

To further enhance the understanding of volatility, we have used this volatility and input it into the Black Scholes model to predict the fair European call option price. Based on the predictions of Black Scholes, if the current call option value was less than the predicted value, it suggests that it is undervalued and we do not buy it. Otherwise we do buy it. Finally we compute how much profit and loss we have made.

There is a paper : A Hybrid GARCH and Deep Learning Model for Volatility Prediction - that uses a combination of GARCH and SARIMA along with the deep learning model of CNN-BiLSTM to predict the stock price.

Since we are working on predicting volatility, we have taken only the CNN-BiLSTM part to predict the time series of volatility. We have further used black scholes and calculated the profit loss as mentioned above.

As the paper has mentioned, we have created our model with the following deep learning layers and configurations.

CNN-BiLSTM	conv1D layer (filters: 256, filter size: 2, Relu activation) + maxpooling1D (pooling size: 2, padding: same) + conv1D layer (filters: 128, filter size: 2, Relu activation) + maxpooling1D (polling size: 2, padding: same) + flatten layer + BiLSTM layer (neurons: 128, Relu activation) + BiLSTM layer (neurons: 50, Relu activation) + dense layer (neuron: 1, linear activation)

For completeness, we have further tried to add SARIMA and GARCH the way the paper had told us to follow:
“First, the mean model was built using SARIMA, which was well known for its ability to detect seasonal and temporal trends in financia time series data. Second, the volatility was estimated using GARCH. As a result, asymmetry and time-varying patterns can be captured. SARIMA residuals were used as input to estimate volatility in the GARCH family models. Lastly, CNN and BiLSTM architectures receive the predicted output of the GARCH model. CNN effectively captures spatial dependencies,while BiLSTM excels at capturing long-term dependencies,leveraging both temporal and spatial features for improved forecasting”.

Furthermore, we would like to comment on our use of black scholes:
Black scholes Black-ScholesTrading.ipynb - This is a simulation taken from the internet that we have used to understand black scholes. What black scholes is essentially doing is that it is computing all the possible future paths of the stock and commuting its average to give the predicted call option price. However, this is a probabilistic approach thus we need to trade a lot of times to ensure this works well.

In accordance with the above written paragraph, we have made more than 5000 trades for each stock to ensure that we beat the odds of ‘bad luck’ in probability.

To conclude we share the results of our experiments in the following spreadsheets:

1. SARIMA-GARCH-BiLSTM-CNN stock predictions
2. Combining auto-regressive models for volatility predictions and black scholes

In general we observe the following trend:

1. CNN-BiLSTM model is doing the best job in predicting the volatility, then RNN, the GRU, then GARCH, then LSTM
2. Also, when modelling using Black Scholes, it can be further observed that the percentage of correct decisions made, both in terms of buying a call option or ignoring it, follows the same trend for CNN-BiLSTM in where it has the highest percentage profit. However, the others don’t match the pattern of the above volatility, in the sense that better volatility measure does not lead to better profits. We could say that Black Scholes is not the perfect call option predictor in the real life scenario.