Stock Portfolio Optimization using LSTM and MPT

T&T Project

Portfolio management

❏ Portfolio management refers to managing an individual's investments in the form of bonds, shares, cash, mutual funds etc so that he earns the maximum profits within the stipulated time frame.

❏ Portfolio management minimizes the risks involved in investing and also increases the chance of making profits.

❏ So, the goal of this project is to build an optimized portfolio for investment in the stock market where the investor will provide the names of certain number stocks and the model will return the best possible combination of shares amongst the top-performing stocks which will be first predicted by the **LSTM model** and then the selected stocks will be optimized using **Markowitz Portfolio Theory.**

LSTM

- ❏ The Long short-term memory (LSTM) is a special type of Recurrent Neural Networks (RNN) architecture that is mainly used in deep learning.
- ❏ LSTM uses a set of feedback connections to process sequences of data.
- ❏ This architecture is known for its efficiency in making predictions, processing, and classifying large-scale time-series data despite the presence of some lags between events.
- ❏ It was named long short-term memory because its cell unit has the ability to forget a part of previously stored data and can, at the same time, memorize additional new pieces of information.
- ❏ An LSTM unit encapsulates the following elements:
  - ❏ Cell: represents the memory part of the LSTM that monitors the dependencies between different elements constituting the input sequence.
  - ❏ Input gate: regulates the information flowing into the cell.
  - ❏ Output gate: regulates the information flowing out of the cell.
  - ❏ Forget gate: remember the different values over a time interval.

MPT

- ❏ Modern portfolio theory (MPT) is a theory on how risk-averse investors can construct portfolios to maximize expected return based on a given level of market risk. Harry Markowitz pioneered this theory in his paper "Portfolio Selection".
- ❏ Modern portfolio theory argues that an investment's risk and return characteristics should not be viewed alone, but should be evaluated by how the investment affects the overall portfolio's risk and return.
- ❏ MPT shows that an investor can construct a portfolio of multiple assets that will maximize returns for a given level of risk.
- ❏ Likewise, given a desired level of expected return, an investor can construct a portfolio with the lowest possible risk.
- ❏ Based on statistical measures such as variance and correlation, an individual investment's performance is less important than how it impacts the entire portfolio.
- ❏ MPT assumes that investors are risk-averse, meaning they prefer a less risky portfolio to a riskier one for a given level of return.

Efficient Frontier Curve and Max Sharpe Ratio

- ❏ The efficient frontier, a cornerstone of modern portfolio theory, shows the set of portfolios that provide the highest level of return for the lowest level of risk.
- ❏ When a portfolio falls to the right of the efficient frontier, they possess greater risk relative to their return. Conversely, when a portfolio falls beneath the slope of the efficient frontier, they offer a lower level of return relative to risk
- ❏ Sharpe Ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk. Volatility is a measure of the price fluctuations of an asset or portfolio.
- ❏ So what is the dream portfolio and how can you make one? According to Markowitz's theory, there is an optimal portfolio that could be designed with a perfect balance between risk and return.

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

R_p = Return of portfolio

R_f = Risk-Free rate

σ_p = Standard deviation of portfolio's excess return

Implementation

❏ As accurate as MPT is for portfolio optimization, its dependency on covariance and correlation sometimes tend to overlook the sudden changes in the market price also called downside risk.
❏ Two portfolios that have the same level of variance and returns are considered equally desirable under modern portfolio theory.
❏ One portfolio may have that variance because of frequent small losses.
❏ In contrast, the other could have that variance because of rare spectacular declines.
❏ Even though the two stocks behaviour might show satisfactory correlation according to MPT, it might result in overall loss in a shorter span of time.
❏ What LSTM will do is predict such a sudden change and will discard the risky stock well before passing it into the MPT model and not only it will satisfy the diversity of MPT but also takes care of sudden decline in stock value making the model more accurate and useful for investment in a shorter span of time and on a higher frequency.

CONCLUSION

Through this project, we learnt how to apply deep learning techniques such as LSTM and Linear Regression Models, how to use keras-tensorflow library, how to collect and preprocess given data, how to analyze model's performance and optimise LSTM Network and to ensure increase in positive results. We built a model to accurately predict the future closing price of a given stock, using the Long Short Term Memory Neural Net algorithm. And also using the predicted stock prices from the LSTM, we were able to make an optimized portfolio which can help investors in making risk-averse decisions using Markowitz Portfolio theory .

Resources

Modern Portfolio Theory (MPT) Definition (investopedia.com)

LSTM Networks | A Detailed Explanation | Towards Data Science