Final project report

Portfolio optimization

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1 Problem

Portfolio optimization involves deciding how to use the available investment budget to maximize the total value of the investment and minimize its risk [4]. The investment budget is allocated to assets which can be for example stocks, gold, foreign exchange, real estate, bonds and cryptocurrencies [2]. For simplicity only stocks are considered in this project.

The problem is difficult because there is a large number of possible assets to include in the portfolio and even larger number of ways to divide the budget among them. Investing also has a lot of uncertainty as stock prices are affected by real world events which are hard to capture in the model [1].

2 Data

Data-driven approach to this problem involves predicting expected return and risk based on historical time-series data of stock prices over given time range, possibly years. Stock price can be sampled e.g. daily, weekly, monthly or quaterly. The stocks that are included in the data-set need to be selected.

The stock price data was collected from Yahoo Finance by calling its api with different

stocks and merging these into one dataset. For example the weekly prices between 2021-05-09 20:55:46 and 2022-05-09 20:55:46 can be queried using following url.

`https://query1.finance.yahoo.com/v7/finance/download/ADS.DE?period1=1620582946&period2=1652118946&interval=1wk&events=history&includeAdjustedClose=true`

Where perdiod1 and period2 are the start and end times of the range as unix timestamps.

3 Modelling

The problem can be modelled as a two objective optimization problem maximing expected return of the investment and minimizing its risk. The decision vector consist of proportions of total budget allocated to n stocks.

$$\begin{aligned} w &= (w_1, w_2, ..., w_n) \\ \Sigma_{i=1}^{n} w_i &= 1 \\ 0 \leq w_i &\leq 1, i = 1...n \end{aligned} \tag{1}$$

Popular way to model these objectives is Markowitz model which is also known as mean-variance model and generalized as modern portfolio theory [3].

Return of an investment between time t-1 to t is calculated by where p(t) and p(t-1) are stock prices at given time.

$roi = \frac{p(t)-p(t-1)}{p(t-1)}$

4 Algorithm

5 Results

References

[1] Ningning Du, Yankui Liu, and Ying Liu. "A new data-driven distributionally robust portfolio optimization method based on wasserstein ambiguity set". In: *IEEE Access* 9 (2020), pp. 3174–3194.

[2] Muhammad Azfar Faizan. "Multiobjective portfolio optimization including sentiment analysis". In: (2019).

[3] Petter N Kolm, Reha Tütüncü, and Frank J Fabozzi. "60 Years of portfolio optimization: Practical challenges and current trends". In: *European Journal of Operational Research* 234.2 (2014), pp. 356–371.

[4] TL van Zyl, Matthew Woolway, and Andrew Paskaramoorthy. "ParDen: Surrogate Assisted Hyper-Parameter Optimisation for Portfolio Selection". In: *2021 8th International Conference on Soft Computing & Machine Intelligence (ISCMI)*. IEEE. 2021, pp. 101–107.