An Intelligent Cloud-based Risk Management System for Stock Investment

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Abstract—We propose an intelligent risk management system utilizing combination of historical price data with fundamental data available in new machine readable XBRL format. The system is designed to run as a flexible, fast and scalable cloud service, so the system can intelligently guide individual investors to improve their investment decisions without building own infrastructure. With worldwide adoption of XBRL reporting, it is possible to deploy the system across languages and borders. In this paper, we describe the risk-return optimization and explain the system architecture. The system is available at: http://www.gratificari.com

Keywords- stock investment; risk management; portfolio optimization

I. INTRODUCTION

Investing money at stock market is a typical multi-criteria decision problem. Inherently everyone is aiming for the highest return while simultaneously looking for the lowest risk. By investing to larger number of assets, the whole portfolio will become safer than investing all funds into a single asset. As proved by Markowitz in 1952 [1], it is possible to construct the efficient frontier and then each individual investor will choose the point based on his risk preference.

Even though it may sound trivial, the most important question is what exactly is the risk and return. The return can be based on the market price change, the dividends, the change in the company assets, other fundamental indicators or linear combination of the previous. Risk can be based on the price volatility, calculated from the financial reports or use some other measure. Even though the most common similarity measure is the covariance matrix of price volatility, other algorithms can also be used too.

After almost a decade of discussion about new standardized machine readable format of financial data reporting, eXtensible Business Reporting Language (XBRL) becomes mandatory at many stock exchanges around the world. XBRL is a format based on XML, so it is machine readable, language independent, easy to integrate to existing systems and flexible for many data formats. Local authorities issue taxonomies to ensure the consistency with accounting standards and thus restrict the format to previously known structure. The nature of XBRL makes it possible for us to develop an intelligent and robust system to build financial models, combine with other data, calculate the result each time the new reports are published and then apply intelligent algorithms to help user with their investment decisions.

In view of this we propose an intelligent risk management system for providing an easily extensible smart cloud-based solution for investors to optimize their portfolios. We employ machine learning algorithms to optimize portfolios and provide investment recommendations. The system combines data from several different data sources and integrates reports to a single view. The system also automatically queries the data sources and downloads and updates without user intervention.

II. PORTFOLIO OPTIMIZATION

Let \( x \) be a vector of \( n \) individual financial assets, \( r \) is a vector of returns, \( \mu \) minimal required return and \( Cov \) a \( n \times n \) covariance matrix of risk. Then we can formulate the portfolio optimization problem:

\[
\begin{align*}
\text{minimize}(x) & : \text{Risk}(x^T r) \\
& x^T \mathbb{E}(r) \geq \mu \\
& x^T 1 = 1 \\
& x_i \geq 0; \forall i \in \{1, \ldots, n\}
\end{align*}
\]

In case of using the standard deviation and covariance as risk measure then the formulation is:

\[
\text{Risk}(x^T r) = \frac{1}{2} x^T Cov x
\]

And also assume that the expected returns remain same for the next time period:

\[
\mathbb{E}(r) = r_{past}
\]

With these two assumptions about risk and expected return the problem can be solved by Quadratic Programming, but in case the risk is replaced with some other method, the problem becomes a Non-Linear Programming problem and the solution is much more complicated to find. We use the following NLP-solvers: Direct Search [2], Artificial Bee Colony [3] and also generate the program for commercial lingo solver.

III. FEATURES OF PROPOSED SYSTEM

The system can be divided to three main components: data gathering, request processing and user interface. We decided to use REST web services and web browser based JavaScript to decouple the presentation from the server-side data processing.

A. Data acquisition

As any other machine learning system, it is first required to gather required data. Our system combines data from three data sources; the financial reports in XBRL format from TWSE, historical price data and third are other reports from TWSE in various formats, most notably monthly sales data and number of shares.
B. Data preprocessing

First, the system uses scheduler to periodically pull newly available data then it processes the XBRL files to extract important values and prepare values for future calculations and store these data into SQL database. Reports in XBRL format only contain values from the relevant time period, but for many calculations and visualization it is necessary to preprocess all the available reports to single structure. In this step we calculate financial ratios and stock valuation models.

C. Portfolio Optimization

Using whole set of assets available on the stock exchange would make the optimization problem too complex. To mitigate, we provide several options to reduce the complexity by removing some of the less important assets from the calculation: top-k Sharpe ratio, remove negative returns and top-k linear regression. Calculating the optimal portfolio is a time-consuming task so it’s necessary to use request queue and thread pool executors to distribute the load, enable scaling the service and keep the server responsive.

D. Performance trade-offs

Because the financial reports are updated only once a month, XBRL reports are issued quarterly, we was able to further improve the speed and responsiveness of the system by caching both the raw data and calculated values in memory key-value store.

E. User Interface

Building user interface for cloud service with a lot of data poses several challenges for both the design and technology. To cope with the computational complexity of visualization we offload the charting to the client and let the server only send the data. We decided to use Web services technology and AJAX for transferring the data.

IV. CONCLUSION AND FUTURE WORK

In this paper we propose an intelligent system for portfolio optimization and investment recommendation. This system lets users customize personal preferences in a user-friendly and efficient way and deliver quick and robust advice utilizing machine learning algorithms for their individual investment decisions.

In the world of electronic trading, it becomes possible for individuals to manage their own investment online, so our plan for further improvement is to enable the system to import user’s portfolio from their brokerage accounts so the system can have access to real data.

Later, we want to try to explore and develop new options to overcome the two assumptions in the model, let the users model the expectation of future return and also create new methods for calculating the risk.

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REFERENCES