Computers and Mathematics with Applications 66 (2013) 1743–1757

Contents lists available at ScienceDirect

Computers and Mathematics with Applications

journal homepage: www.elsevier.com/locate/camwa

Adopting genetic algorithms for technical analysis and portfolio management

Tak-chung Fu [a,*], Chi-pang Chung [b], Fu-lai Chung [b]

[a] Department of Computing, Hong Kong Institute of Vocational Education, Hong Kong
[b] Department of Computing, The Hong Kong Polytechnic University, Hong Kong

ARTICLE INFO

Keywords:
Portfolio management
Technical indicator
Genetic algorithms

ABSTRACT

This research examines two different applications of the Genetic Algorithms (GA) in portfolio management. GA is adopted to determine the optimized parameters setting of different technical indicators and portfolio weighting. Besides the Traditional GA, the Hierarchical GA is also adopted in this research. Different algorithms and the usage of different numbers of technical indicators are evaluated in different economic situations. GA shows its optimization power over different tasks in portfolio management.

1. Introduction

The number of people who participate in the stock exchange market grows rapidly. This generates the needs of developing the tools for the investors to manage their investment portfolios [1]. It is difficult for the investors to well distribute their stocks on hand. Wrong allocation of investment affects the return of their investment. However, if the investment is allocated correctly, the portfolio will contain less risk and higher return. Therefore, proper investment distribution and portfolio management are required.

On the other hand, technical analysis [2] is a security analysis methodology for forecasting the future direction of security prices through the study of the past market data, the primarily price and the volume. Technical analysts may employ models and trading rules especially based on price and volume transformations, such as the Relative Strength Index (RSI), and Moving Averages (MA), etc. Each technical indicator has its own characteristic. However, it is difficult to set the corresponding parameters of different indicators because of their unique behavior. Therefore, an optimization strategy for tuning the parameters of different indicators is necessary.

The objectives of this research are to tackle the problems of the two areas mentioned above, i.e. (1) the difficulty of allocating the portfolio weighting based on the Genetic Algorithms (GA) and (2) the ambiguity in setting the parameters of the technical indicators. A brief review on adopting GA to portfolio management will be given in Section 2. Section 3 focuses on the second objective, GA is proposed to determine the parameters of different technical indicators. Applying GA for portfolio weighting determination will be introduced in Section 4. The experimental result will be discussed in Section 5 whereas the conclusion will be made in Section 6.

2. Literature review

Genetic Algorithms (GA) [3] are well-known approaches to provide a reasonable solution for optimization problems. It is first proposed by Holland [4,5]. Based on its characteristic, it is one of the common algorithms adopted for different financial

* Corresponding author.
E-mail addresses: cstcfu@vtc.edu.hk (T.-c. Fu), 05097606d@polyu.edu.hk (C.-p. Chung), cskchung@comp.polyu.edu.hk (F.-l. Chung).

0898-1221/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.camwa.2013.08.012

Table 1
Common technical indicators.

Simple Moving Average (SMA)
Calculate by summing up the prices of instrument closure over a certain number of single periods.
Exponential Moving Average (EMA)
Calculate by adding the moving average of a certain share of the current closing price to the previous value. (Remark: this indicator adopts in the MACD, see Section 3.2).
Moving Average Convergence/Divergence (MACD)
A next trend-following dynamic indicator. It indicates the correlation between two price moving averages.
Stochastic Oscillator (STC)
Compare where a security's price closed relative to its price range over a given time period.
Relative Strength Index (RSI)
A price-following oscillator that ranges between 0 and 100.
Williams' Percent Range (W%R)
Determine whether the market is overbought / oversold. Williams' %R is very similar to the Stochastic Oscillator.
Money Flow Index (MFI)
Indicate the rate at which money is invested into a security and then withdrawn from it.
Momentum (MTM)
Measure the amount that a security's price has changed over a given time span.

problems. Allen and Karjalainen [6] propose to adopt GA to learn technical trading rules. It shows that the result does not earn consistent excess returns over the Buy and Hold strategy due to the low-order serial correlation in stock index returns. Jiang and Szeto [7] propose an investment strategy discovery method in portfolio management using GA. The method uses the relation of the closing price moving averages in stock market analysis. Oh et al. [8] adopt GA to develop a portfolio optimization scheme for index fund management.

In the field of portfolio management, the Markowitz model [9] is one of the most classical and widespread theories which uses the mean and the variance of historical returns to measure the expected return and the risk of a portfolio. Researchers propose different approaches, such as goal programming [10] and multiple objective programming [11], to handle multi-objective portfolio selection.

GA attracts much attention in portfolio optimization problems [12,13]. Arnone et al. [14] present a GA for an unconstrained portfolio optimization problem with the risk associated with the portfolio. A distributed GA is introduced by Loraschi et al. [15] to tackle the portfolio selection problems based on PVM. Shoaf and Foster [16] apply a GA to solve the Markowitz portfolio selection problem and found that the time complexity of GA approximates $O(n \log n)$ which is better than that of quadratic programming. However, most of the approaches do not consider the existence of minimum transaction lots. Lin and Liu [17] compare three models for portfolio selection with minimum transaction lots. GA is adopted to improve the performance on determining the solutions. This research shows that the portfolios obtained using the proposed algorithms are close to the efficient frontier. Chang et al. [18], on the other hand, introduce a heuristic approach to portfolio optimization in different risk measures by employing GA. It shows the efficiency of using GA to solve portfolio optimization problems in different risk measures.

Besides the satisfactory performance in terms of speed, Chang et al. [18] also demonstrate that a small size of portfolio could have a better performance in terms of the number of assets hold in the portfolio. There are lots of factors that affect the performance of the portfolio [19]. The risk and the correlation risk between stocks are needed to be taken into account. One of the objectives in this paper is to determine the weighting of individual stock in a portfolio based on GA which the idea is stimulated by Yoshida and Liu [20]. Another objective of this research is to adopt GA for determining the setting of the technical indicators' parameters which research can seldom be found in this area. The major interest in this paper is on studying the profitability of different approaches instead of the computational performance.

3. GA parameter optimization of technical indicators

There are three main mechanisms in the Genetic Algorithms (GA). They are chromosome encoding, fitness evaluation and genetic operators. As based on the customization of the chromosome representation and the fitness evaluation strategy, traditional genetic operators (i.e. crossover and mutation) can be adopted. Therefore, this section will mainly focus on defining the chromosome encoding methods and the corresponding evaluation strategies which are based on the common technical indicators in the stock market.

3.1. Chromosome encoding

The most common technical indicators will be used to represent the genes of each chromosome. The best combination of the indicator(s) will be selected for decision making. In this research, seven technical indicators are adopted. They are: Simple Moving Average (SMA), Moving Average Convergence/Divergence (MACD), Stochastic Oscillator (STC), Relative Strength Index (RSI), Williams' %R (W%R); Money Flow Index (MFI) and Momentum (MTM). Table 1 briefly describes each of them and the detail can be found in [2].