Expert Systems with Applications 38 (2011) 14072–14085

Contents lists available at ScienceDirect

Expert Systems with Applications

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

Applying a GA kernel on optimizing technical analysis rules for stock picking and portfolio composition

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ARTICLE INFO

Keywords:
Stock trading
Portfolio composition
Technical analysis
Evolutionary computation
Optimization

ABSTRACT

The management of financial portfolios or funds constitutes a widely known problematic in financial markets which normally requires a rigorous analysis in order to select the most profitable assets. The presented paper proposes a new approach, based on Intelligent Computation, in particular *genetic algorithms*, which aims to manage a financial portfolio by using technical analysis indicators (EMA, HMA, ROC, RSI, MACD, TSI, OBV). In order to validate the developed solution an extensive evaluation was performed, comparing the designed strategy against the market itself and several other investment methodologies, such as *Buy and Hold* and a purely random strategy. The time span (2003–2009) employed to test the approach allowed the performance evaluation under distinct market conditions, culminating with the most recent financial crash. The results are promising since the approach clearly beats the remaining approaches during the recent market *crash*.

1. Introduction

The fast technology evolution together with the massive evolvement of financial markets in modern societies leads, nowadays, to an increasing interest to the field of computational finance.

This field is becoming popular among computer scientists, especially to computational intelligence specialists who try to combine elements of learning, evolution and adaptation in order to create intelligent software. In particular, subjects such as neural networks, swarm intelligence, fuzzy systems and evolutionary computation are becoming extremely notorious on market's domain. The mentioned techniques can be applied to financial markets in a variety of ways; as to predict the future movement of a stock's price, or to optimize a collection of investment assets, such as a fund or a portfolio. This innovation is of special importance due to the high volume of securities (financial instruments) involved, normally, it is very hard for a simple investor to optimize his profits without requiring the skills of financial markets specialists. The goal of this work is to provide an application which tries to partially replace those specialists in order to help an investor or an investment company to achieve a significant profit on buying and selling (trading) financial instruments. In order to apply such procedures we must accept that the historical data related to stocks and markets gives appropriate signals about the market future performance. This premise constitutes the basis of technical analysis which simply tries to analyze the securities past performance in order to evaluate investments at the present time. This philosophy relies on three bases (Murphy, 1999); the fact that market action discounts everything, the fact that price moves in trends, and that history tends to repeat itself. These considerations allow, through the study of charts and financial data, the recognition of which way the market is more likely to go. Despite the fact that technical analysis is becoming widely used, there are still some criticisms to this perception on the market evolution. For instance, Burton Malkiel (Malkiel, 1973) stated that the "past movement or direction of the price of a stock, or overall market cannot be used to predict its future movement". His findings become popular, leading to a new investment theory called The Random Walk Theory where the author stipulates that if we cannot beat the market, then the best investment strategy we can apply is Buy and Hold in which an investor buys stocks and holds them for a long period of time, regardless of market fluctuations. For the technical community, this idea of purely random movements of prices is totally rejected, and more recent studies (Lo & MacKinlay, 2001; Park & Irwin, 2007) try to evidence their beliefs. For instance, in (Lo & MacKinlay, 2001) the author demonstrated the validity of technical analysis using more than seventy technical indicators which showed that market movements can be predicted at a certain degree. Also, if we consider the price movement as unpredictable, how can we explain that price moves in trends? If we observe several stock charts considering a predefined period we can easily detect an uptrend or a downtrend.

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doi:10.1016/j.eswa.2011.04.216

The presented paper provides a detailed discussion on a new approach for intelligent portfolio management. The paper is structured as follows: Section 2 addresses the theory behind the developed work, namely the concepts of financial portfolio, portfolio management, and technical analysis. Also, in this section, it is given a brief overview about different methodologies which can be used to address the portfolio management problematic. Section 3 illustrates the system architecture. Section 4 proposes the validation procedure used to evaluate the developed strategy. Section 5 summarizes the provided document and supplies the respective conclusion.

2. Related work

To get a better understanding about the underlined problem and the existing solutions, some of the fundamental concepts and tools related to the financial portfolio composition are explained in the following subsections.

2.1. Financial portfolio

A *financial portfolio* (Maginn, Tuttle, McLeavey, & Pinto, 2007) consists in a group of financial assets, also called securities or investments, such as stocks, bonds, futures, contract for difference (CFDs), or groups of these investment vehicles known as exchange-traded-funds (ETFs). In order to construct a portfolio, it is capital to define investment objectives that should focus on a certain and accepted degree of risk, i.e. the chance of incurring in a loss.

The core of this work is related to *portfolio management*, the act of deciding which assets need to be included in the portfolio, how much capital should be allocated to each kind of security and when to remove a specific investment from the holding portfolio. During this process, it is required to take into account the investor's preferences since some investors are more willing to accept a specific degree of risk than others, hoping that way to achieve better returns.

2.2. Portfolio management

As it was already mentioned, the goal of this work is concentrated on the automatic management of a portfolio. So, it is important to understand that we can apply two forms of management (Maginn et al., 2007):

Passive management in which the investor concentrates his objective on tracking a market index. This is related to the idea that it is not possible to beat the market index, as stated by the Random Walk Theory (Malkiel, 1973). More concretely, a passive strategy aims only at establishing a well diversified portfolio without trying to find under or overvalued stocks.
Active management in which the main goal of the investor consists on outperforming an investment benchmark index, buying undervalued stocks and selling overvalued ones.

In the case of the work here described, the purpose is to adopt an active management approach by using technical analysis indicators and evolutionary computation techniques.

2.3. Technical analysis

When defining a financial fund or portfolio the goal is to pick the best potential assets within the market in order to minimize losses and maximize returns. There are several ways to perform a reasonable evaluation of the market to select potential profitable securities. Usually, investment analysts perform a fundamental or a technical analysis of the market. In this work, a pure technical analysis (Murphy, 1999) methodology was employed. A technical analyst believes that market action, namely, the volume of transactions and the securities prices include all the fundamentals that can possibly affect market's price; political, economical, or psychological. The applied strategies based on technical analysis normally embody a set of technical indicators which try to give a future perspective of market development according to what is visible on price charts. A technical indicator consists in a formula that is normally applied to stock's prices and volumes. The resulting values are plotted and then analyzed in order to offer a perspective on price evolution. More specifically, a technical indicator tries to capture the behavior and investment psychology in order to determine if a stock is under or overvalued. In Section 3, several technical indicators will be discussed and illustrated.

2.4. Automatic portfolio management approaches – overview

In respect to the solutions already developed to address the portfolio management problem, most of them focus on a passive management approach by using the Mean–Variance model (Markowitz, 1972) proposed by Harry Markowitz. The author is pioneer in the Modern Portfolio Theory (MTP) after analyzing the effects related with risk, correlation and diversification over the expected returns of investment portfolios. After completing his study, Markowitz concluded that rational investors should diversify their investments, in order to reduce the respective risk and increase the expected returns. The author's assumption focus on the basis that for a well diversified portfolio, the risk which is assumed as the average deviation, from the mean, has a minor contribution to the overall portfolio risk. Instead, it is the difference (covariance) between individual investment's levels of risk that determines the global risk. Based on this assumption, Markowitz provided a mathematical model which can be easily solved by metaheuristics such as Simulated Annealing (SA), Tabu Search (TS) or genetic algorithms (GA).

Generally, solutions (Chang, Meade, Beasley, & Sharaiha, 2007; Cura, 2009; Schaerf, 2002), based on this model, focus their goal on optimizing a single-objective; the risk inherent to the portfolio, in order to determine the optimal portfolio composition and the weights assigned to each of the chosen stocks. Besides this single-objective formulation, other approaches (Branke, Scheckenbach, Stein, Deb, & Schmeck, 2009; Streichert, Ulmer, & Zell, 2003) try to optimize simultaneously two conflicting objectives, the global risk and the expected returns of the securities within the portfolio.

Besides the referred works which mainly generate a diversified portfolio maintaining it for a specific set of time, Aranha and Hitoshi (Aranha & Hitoshi, 2008; Aranha & Iba, 2007, 2009) provided a very interesting active management approach, by coupling the Markowitz's model with a modeling cost mechanism, responsible for rebalancing the portfolio trough time while, at the same time, minimizing the transaction costs. In their works, a completely different portfolio representation is used, based on a tree structure, which allowed them to obtain very interesting results.

Although Markowitz's model is widely used to design the portfolio optimization problem, other models can also be considered. For instance, Black and Litterman (Black & Litterman, 1992) suggested a new formulation, the *Black–Litterman* model. In their work they propose means of estimating expected returns to achieve better-behaved portfolio models. The designed model is very similar to the Markowitz's one, the main difference is concentrated on the calculation of the expected returns which generates portfolios considerably different when using the original model. According to the authors their new design tries to rectify some of the flaws presented by Markowitz's model.