Expert Systems with Applications 42 (2015) 7070–7083

Contents lists available at ScienceDirect

Expert Systems with Applications

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

Decision-making system for stock exchange market using artificial emotions

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ARTICLE INFO

Article history:
Available online 7 May 2015

Keywords:
Decision-making system
Artificial emotions
Stock exchange market

ABSTRACT

This work presents an autonomous affective decision-making system devoted to the support of decision-making processes in the stock exchange market domain. The current proposals of intelligent systems and automated platforms to support operations in the stock exchange market use strongly analytical indicators. However, the above represents an important limitation because all decisions made by these proposals must be defined and constantly monitored by human investors. The use of artificial emotions allows the system to configure its own notion of confidence based on the correlation between investment decisions made and the associated emotional reactions. The above allows the system to increase the degree of autonomy in its decisions by providing a mechanism that is more adaptive to changing stock exchange market conditions. In this way, the delegation of decision-making by human investors is promoted. A definition of an artificial emotional decision-making system was implemented and applied to real data of the New York Stock Exchange Market. The results are promising and suggest that using artificial emotions in autonomous decision-making systems can represent an important future research area, improving the effectiveness of each decision.

1. Introduction

Every day, people should make decisions, that is, select an alternative from a set of possible alternatives to be chosen to pursue their goals. Decisions vary with complexity, requirements, available information, and time. Two decisive factors in decision-making are the value that each alternative represents for the person and the likely outcome of the decision. In an ideal scenario, a decision maker has all the information and mechanisms to define each alternative action, the criteria for selection, and of course, time to execute the described process. This ought to lead to an optimal choice. A good example of this conceptualization is the expected utility model (Smith & Kosslyn, 2008). However, human decisions often break two central principles of expected utility model. First, decision are not always are transitive; that is, if one chooses A on B, and B on C, it does not necessarily choose A on C. Second, human decisions do not satisfy the principle of "procedural invariance"; that is, alternative ways of asking a question about specific preferences lead to different answers. This allows us to think that humans make their decisions with an awareness of "partial or incomplete rationality". In a first approach, to calculate and maximize expected utility, humans seek to achieve a level of "satisfaction", that is, sufficiently good solutions, not necessarily optimal ones (Simon, 1955). Understanding decision-making as a purely rational process is a mistake. Every human decision is made using a rational and emotional component. The rational and emotional components represent a unique and indivisible whole. Therefore, a rational intelligent system cannot be considered "smart" while not aspiring to be faithful and simultaneously representative of human thought and feeling. In this sense, although the agent technology has been widely used in various fields of interest, the use of emotional artificial agents is incipient. Thus, the criteria that agents use in their internal decisions are purely rational and simultaneously restricted. Incidentally, it is important to have an agent system that considers both perspectives in the decision-making process, technical criteria and emotional criteria.

The novelties of this work are that it (1) proposes an autonomous decision-making system on the basis of artificial emotions,

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http://dx.doi.org/10.1016/j.eswa.2015.05.004
0957-4174/

obtaining an adaptive mechanism to stock market conditions (2) defines a test scenario using official data of the New York Stock Exchange Market, and (3) obtains promising experimental results.

Our proposal does not correspond to an optimization technique; the underlying problem of stock exchange market is closer to decision-making, and the future profitability or risk of a stock cannot be optimized. On the other hand, our proposal does not correspond to a forecasting technique because the use of artificial emotions does not allow to make predictions about future stock prices. However, the inclusion of an affective dimension into an autonomous decision-making system allows for the incorporation of additional criteria into the rational decision criteria usually used, with the aim to strengthen its autonomy in decision making by better adapting to the market environment conditions. The standard automated platforms to support stock exchange market operations (e.g., Acuity Trading Platform, 2015; Cobra Trading, 2015; MetaTrader 5 Platform, 2015; ZuluTrade Platform, 2015) use strongly analytical key indicators in their internal processes, and all investment operations performed by these platforms are necessarily predefined by a human investor. In other words, the current stock exchange platforms do not have a sufficient degree of autonomy to make investment decisions without the permanent intervention of humans, as the environment conditions (stock exchange market) change. This occurs because automated platforms generate several types of market indicators, but the degree of confidence regarding indicator values and, in general, regarding the future behaviour of the stock market always lies in human investors. The incorporation of an affective dimension allows the system to configure its own degree of confidence along trading periods without human intervention. To achieve the above, the autonomous decision-making system needs to permanently update its internal emotional states, always according to the market behaviour. Thus, the emotional states of the autonomous system have a direct influence on each investment decision made by the system, and in turn, the market behaviour has a direct influence in each emotional state of the autonomous system observed in each trading period, in the same manner that the market behaviour influences human emotional states. As result, the overall system adapts its behaviour to the changing market conditions.

The remainder of this work is organized as follows: Section 2 presents related literature. Section 3 describes different essential aspects in the design of an emotional decision-making system for stock exchange markets. Section 4 includes details of the emotional decision-making system as objective criteria and functions to update emotional states. Section 5 presents the application of an emotional decision-making system in a stock exchange environment, comparing the effectiveness of rational and emotional investors. Section 6 presents a discussion of the obtained results, and finally, Section 7 presents conclusions of the work done and future work.

2. Related work

It is possible to observe several research lines in the stock exchange market domain. First, one important body of research corresponds to forecasting, for example, the use of a set of machine-learning techniques applied in the Indian Stock Market (Patel et al., 2015), using a hybrid model in the high frequency of transactions for the Brazilian Stock Market (Araújo et al., 2015) or making predictions about stock prices summarizing news in the Hong Kong Stock Exchange Market (Li et al., 2015). Because our work does not pretend to predict future stock prices, there is no point of comparison between the forecasting proposals and our work. On the other hand, regarding recommender systems for stock exchange markets, Geva and Zahavi (2015) presented a recommender system that suggests decisions in intervals of five minutes using analytical and textual data. The textual data analysis is performed with the aim to detect positive or negative market news, which is included in the model along with economic indicators. The recommender system generates buy signals using a scoring mechanism, and the signals are verified by an economic evaluation module. It is important to mention that the decision model used to make recommendations does not use the investor's perceptions related to the market news, nor does it consider the confidence indicators of investors who use the system. The final verification of each buying recommendation is evaluated only from an economic perspective. If the system had the autonomy to make decisions for investors, it could consider only a technical-economic perspective.

Gottschlich & Hinz (2014) presented the design of a DSS for investment decisions using crowd votes obtained from an investment community. The system uses stock prices and ratings of stocks based on votes, which can suggest buying or selling a stock for a specific period. The system allows for defining investment strategies (for example, selecting the best ranked stock from three different industries). The idea to consider a community perception of stocks is interesting because it allows for extending the typical use of analytical indicators; however, the perceptions of the investment community cannot always be profitable for an individual investor. In the same sense, the proposed system does not have autonomy in its investment decisions because the degree of confidence in each recommendation always falls to the investors.

Zhao, Wu, Liu, Ge, & Chen (2014) presented an investment recommender system based on P2P lending. Investors can request lending to buy stocks. The stock profiles are defined by returns and risk, and investors' profiles are defined by return expectations and risk preferences. The candidate lists of stocks are generated on the basis of the similarity of the investors. In any case, all investment indicators are analytical, and it is not possible to observe repercussions in investors according to the market behaviour and their investment portfolios.

Other stock exchange market research suggests trading on the basis of seasonality strategies (Eilers, Dunis, Mettenheim, and Breitner, 2014), studies the effect of the public mood in stock market movements, analyses interactive behaviours of investors in social media (Li et al., 2014; Van de Kauter et al., 2015), composes investment portfolios using technical indicators mixed with an approach of evolutionary algorithms (Silva et al., 2015), uses an intelligent system that implements support vector machines to compose investment portfolios (Silva & Lacerda, 2014), and implements trading agents to make operations in simulated stock exchange scenarios (Cavalcante & Oliveira, 2014; Jabbur et al., 2014; Tirea & Negru, 2014; Cui, Wang, Ye, and Yan, 2012). All works mentioned above consider only technical procedures and an analytical perspective to define investment decision criteria. The affective dimension is not considered one of the criteria for investment decisions.

Regarding the automated commercial platforms to support operations in stock trading, it is possible to observe several proposals available on the market (Acuity Trading Platform, 2015, Cobra Trading, 2015; Colmex Expert, 2015; MetaTrader 5, 2015; VT Trader, 2015; XStation, 2015; ZuluTrade Platform, 2015). The platforms mentioned share several standard characteristics oriented to support trading operations: They provide a real-time connection to global stock data, they maintain an individual register of historical