Fuzzy Expert System for a Stock Trading Process

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Abstract

The goal of this study was to build and to evaluate a human skill based fuzzy expert system for a decision making support in stock trading process. Our focus was concentrated on computer software that is capable to reproduce the knowledge from the skilled stock trader. Using classical technique and soft computing methods the expert system STRASS (Stock TRAding Support System) was developed. The proposed system was tested for the historical collection of NASDAQ, NYSE and AMAX stock records. At present, it is being tested by "KOLEGU" mutual fund in a real stock trading process.
Key words –fuzzy expert systems, stock trading process, evolutionary programming

1.Introduction

The financial and economic applications of soft computing methods have attracted a lot of interest in past years. It had become clear to many financial market observers that soft computing and computer science tools, especially those from the fields of fuzzy systems and neurocomputing were frequently finding relevance in the financial markets [1]. In the stock markets, the relationships between process variables are generally too complex to make grounded decisions using classical system theory.

The goal of this study was to build and evaluate a human skill based decision support system for a stock trading process using classical and soft computing methods. The essence of soft computing is that unlike the traditional, hard computing, it is aimed at an accommodation with the imprecision of the real world, like stock trading process. Thus the guiding principle of soft computing is: exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, low-solution cost, and better rapport with reality [2]. Soft computing is based on fuzzy logic methods, neurocomputing, evolutionary programming and parts of machine-learning theory [3,4].

For the decision support system development we have used so called "hybrid system approach". The most important stock's financial indicators were used to form the data basis for the decision support system and the information fusion and decision-making algorithm was developed using fuzzy technique and knowledge from experienced stock trading experts. Then the evolutionary programming methods were used for the further improvement of the fuzzy expert system.

The data transfer and preprocessing algorithms, also realization of fuzzy algorithms and membership function tuning algorithms were merged to the software packet ***STRASS*** (**S**tock **TRA**ding **S**upport **S**ystem, Windovs95, MATLAB 5.2). The proposed expert system yielded about 26 % annual "paper profit" for the historical collection of NASDAQ, NYSE and AMAX stocks records. At present, it is being tested by ***"KOLEGU"*** mutual fund in a real stock trading process.

2. Elements of decision support system

2.1 Formation of data basis

The data basis for the decision support system contains information on selected NYSE, NASDAQ and AMEX stocks. The information was obtained using *StockQuest* software (http://www.marketguide.com). By selection of stocks the special rules were applied:

The first critical rule for stock selection was the annual growth rate of earnings per share *(EPS)* over the last 3 years. Earnings per share were calculated by dividing the company's total after tax profits by the company's number of common shares outstanding. Only the stocks with the *EPS* growth rate over 50% was picked out for the next selection step. *StockQuest* search engine was used during processing this rule. About 600 stock-candidates from 9200 companies were selected for the next exploration step.

In the second step the multi-linear regression between input variables (rolling *EPS*, growth rate of *EPS*) and output variable (stock price) was identified (data records

from the last three years). Then the "fair" price of the stock was estimated using this regression model. The stock was selected for the next exploration step, if the "fair " price was at minimum 10% larger that the actual price.

In the third step the recommendations of Wall Street's Experts were taken into account (http://quote.yahoo.com/). Only the stocks with the quality index QI<3.0 (range 1-5, strong buy=1,strong sell=5) was picked out for the next selection step.

During the forth selection step the following formal constraints were applied for analyzed stocks: Price/Earning ratio < 100, Price>10 $, Average Daily Volume >15000. At the end of this selection procedure about 70-80 stocks were selected for the expert system data basis. This selection procedure has to be repeated every month.

Additionally, the data basis was extended using data on recent general stock market direction and actual 'stock price moving' direction. For the characterization of general market direction the S&P500 index was used. Last 30 S&P index values were fitted using linear regression technique and slope of this curve was used for the characterization of general stock market direction. Actual 'stock price moving' direction was estimated using stock price for last five trading days. The relative stock price values were fitted using linear regression technique and this slope value was used then as a fuzzy expert system input.

2.2 Linguistic variables and terms

Experienced stock trading experts are able to keep the trading process in such a manner that their profits are significantly better than those of other traders. In this study our focus was concentrated at first on computer software that is capable to extract the knowledge from a skilled stock trader. An expert knowledge about the stock trading process was formulated in terms of fuzzy variables and rules and mounted into the fuzzy expert system. We use the following linguistic variables to describe decision support system inputs and output.

Input variables:

- Price Error Factor, PEF, (fair/actual price ratio), with descriptive terms BIG (B), MEDIUM (M), SMALL (S).
- Expert Opinion, EO, with terms STRONG BUY (SB), BUY (B), NEUTRAL (NE).
- General Market Direction, GMD, with terms POSITIVE (P), NEUTRAL (NE), NEGATIVE (NG).
- Stock Price Moving direction, SPM, with terms POSITIVE (P), NEUTRAL (NE), NEGATIVE (NG).

The output variable of the expert system is the Buy Sell Recommendation, BSR, with terms STRONG BUY (SB), BUY (B), HOLD (H), SELL (S) and STRONG SELL (SS).

2.3 Fuzzy rules and inference mechanism

The knowledge from the skilled stock trader was converted to a set of fuzzy rules, which can be regarded and processed with computer. Thus, the starting point of this construction is a representation of process input/output relationships by mean of fuzzy 'IF - THEN '-rules, formulated by stock trading expert. The *l-th* of *M*-rules may be written as follows:

$R^{(l)}$: **IF** x_1 is F_1^l **AND** ..., **AND** x_n is F_n^l
THEN y is G^l,

where F_i^l are the fuzzy sets (terms) of the fuzzy input vector $x = [x_1, x_2, ..., x_n]$. We consider rule systems with a single fuzzy output variable y only (buy-sell recommendations), its terms are denoted by G^l. To define the input/output membership functions we used Gaussian bell-shaped function [5]. It should be mentioned that the membership functions are normalized to a unit maximum. In order to process the set of fuzzy rules an appropriate inference mechanism and a defuzzification technique must be chosen. In the case of the learning procedure to be applied to the system of rules, the product inference rule proved to be convenient [5]. As an improved defuzzification technique, the 'modified center average technique' has been applied. The knowledge from the skilled stock trader was represented by 81 rules, which have the following form:

IF *PEF* is *BIG* **AND** *EO* is *SB* **AND** *GMD* is *P* **AND** *SPM* is *P* **THEN** *BSR* is *SB*.

2.4 STRASS software

The proposed decision support system was realized on PC/Windovs95 using MATLAB 5.2 and Personal Stock Monitor as a basic software. (http://www.personaltools.com/psm/). The data transfer and preprocessing algorithms, also realization of fuzzy algorithms and membership function tuning algorithms were merged to the software packet ***STRASS*** (Stock **TRA**ding **S**upport **S**ystem). The packet has a user friendly GUI and can be used by people from financial institution, that haven't special education in programming languages.

3. Application of decision support system

The key steps by real application of expert systems are as follows:

- define quasi on-line all input variables for fuzzy expert system using *INTERNET* services, ***STRASS*** software and stock market data,
- determine the output of fuzzy expert system for every selected stock, using preprogrammed inference mechanism and defuzzification technique,
- arrange all stocks according to buy-sell recommendation quantitative value [1,-1],
- if the buy-sell signal value exceeds some threshold value (e.g. >0.7), make recommendation for stock owning,
- if the buy-sell signal value is smaller as some threshold value (e.g. < -0.5) make recommendation for stock selling.

4. Results and conclusions

The quality of the expert system was tested by "paper profit making " process for selected stocks using 6 month historical data records (01.01.1996-30.06.1996) and 10000 $ start capital. The start capital was divided in four equal parts and four different stocks were traded during this time interval. The original expert system was capable to make about 18 % annual profit on start capital (price differences minus commissions, commissions: 10$ pro trade, such a service is provided by e.g. DATEK company, http://www.datek.com). For the improvement of the original decision support system (parameter of the membership functions of linguistic variables) evolutionary programming technique was applied [3,5]. The improved decision support system yielded about 26 % annual "paper profit" for the selected stocks, for the time interval, that was not used in evolutionary programming procedure.

At present, the developed fuzzy expert system is being tested by ***"KOLEGU"*** mutual fund in a real stock trading process. The fund has achieved about 24.5 % annual profit in the year 1998.

5. References

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