Use of Genetic Algorithms in Economic Decision Making Processes

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Abstract: *The article deals with the use of genetic algorithms in economic decision-making processes and focuses on the system of designing an investment portfolio. The application part shows a case study in which an investment portfolio is designed focusing on intraday speculations on the world currency market. The solution to the case study used the MatLab system enhanced by financial toolboxes. The conclusion summarizes the methods used for the realization of the case study in general.*

Key Words: Genetic algorithms, decision-making system, decision-making process, information system, MatLab, investment portfolio

1. Introduction

Original theories and models used in financial market or capital markets work with simplified conditions, which in reality may cause serious problems. These markets can be regarded as complex systems, whose behaviour involves regularity and randomness that is different from stochastic vagueness, which most AI technologies respect. Nowadays data mining on capital markets utilize neural networks, genetic algorithms, technologies with fuzzy logic, etc.

This is an ideal area for the use of artificial intelligence. There is a range of programmes allowing for the use of artificial intelligence technology, this article will, however, look at the MatLab system. MatLab is a high-performance language for technical computing. Although MatLab stands for MATrix LABoratory, it is well suited to handle most mathematical needs, not just matrix manipulation. Furthermore, MatLab features a set of add-on application - specific solutions called toolboxes. Toolboxes are comprehensive collections of MatLab functions that extend the MatLab environment to solve particular classes of problems such as signal processing, control systems, neural networks, genetic algorithms and many others.

2. The grand of the theory

Genetic algorithms are unconventional search algorithms or optimizing algorithms inspired by processes observed in natural evolution. The aim of the algorithm is to create, in the population of individuals, increasingly better individuals by evaluating their "quality" which must be represented by a function, usually called fitness function. This quality makes the algorithm a perfect tool to deal with optimizing problems, i.e. problems where the best of all possible solutions to the problem is being sought.

The principle of evaluating (also special-purpose or fitness) function can be found, among others, in genetic algorithms [1], [3], [4], or systems based on evolutionary programming [2].

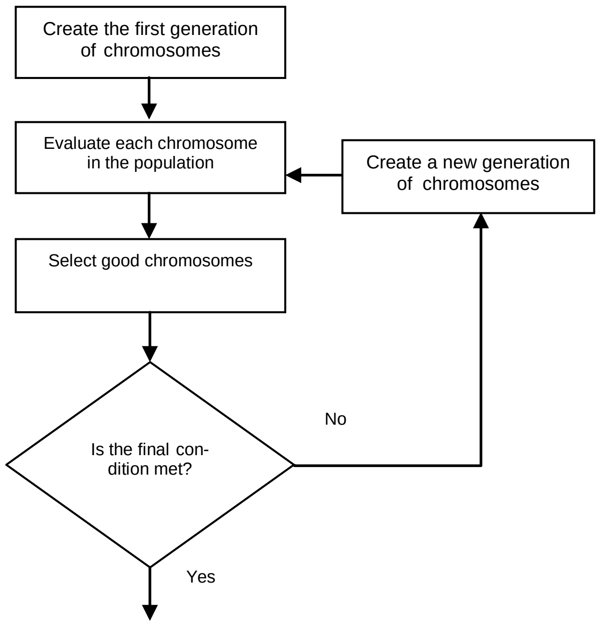

Fig. 1: Diagram of a genetic algorithm

An advantage of an algorithm is that when dealing with a problem it only works with strings of digits 0 and 1 and quality of strings. The quality is shown when the function is being decoded. The algorithm aims to achieve the best possible strings. Only three operators are used in an algorithm – reproduction, transposition and mutation. Reproduction means copying string from the old generation into a new generation, transposition lies in exchanging information between strings, and mutation causes random changes in a string.

Plenty of various implementations of the basic design of genetic algorithms are employed in practice.

2.1 Studies, comparisons and expertises

Genetic algorithms can be successfully used in a range of areas, such as robotics, optimizing in engineering, automated proposal, optimizing of electric circuits and also in economics. Author of [5] presents an overview of the field of genetic algorithms, pioneered in the field of natural adaptive systems and simulated in software. In economics genetic algorithms can be used to optimize asset allocation or to assess outcome of neural networks. We shall consider some applications more closely.

Dostál in [7] shows an example of optimizing a portfolio of American shares as well as a portfolio of Czech shares. Results in [6] shed light on the superior performance of GA when it is applied to the two tick-by-tick time series of foreign exchange rates: EUR/USD and USD/JPY.

The system supporting the creation of investment portfolio is designed in MatLab software which contains functions facilitating work with financial time series. Financial time series are processed by “financial” and “financial derivatives” toolboxes with special functions for financial calculations. Graphic output is secured by functions implemented in order to be able to display stock exchange data (bar, candle, highlow), technical indicators can also be computed using functions (rsindex, willprct, macd, bollinger). Also more sophisticated functions can be used of expected maximum fall in capital based on Brownian motion (emaxdrawdown). The Load function was implemented to facilitate work with the input data – the command load ('gbpusdall/GU07.csv') reads the input data file which includes records of price changes for the given financial instrument in a matrix.

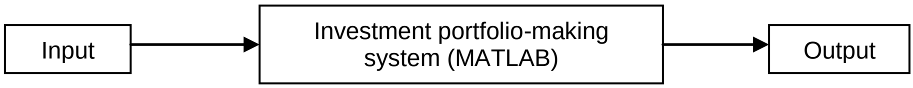

Fig. 2: General scheme of the System of an investment portfolio design

Input: The input of the investment portfolio design is an analysis of an investor’s profile generated by fuzzy system, time series and a priori knowledge of the financial expert.

Investment portfolio-making system: A series of processes aiming at a successful investment portfolio design and implementing genetic algorithms and expert knowledge in financial decision-making. The system je generated by means of sophisticated software MatLab using financial and fuzzy toolboxes.

Output: Output of structuring the investment portfolio, optimization and filtration of the output represented by a matrix of relevant data.

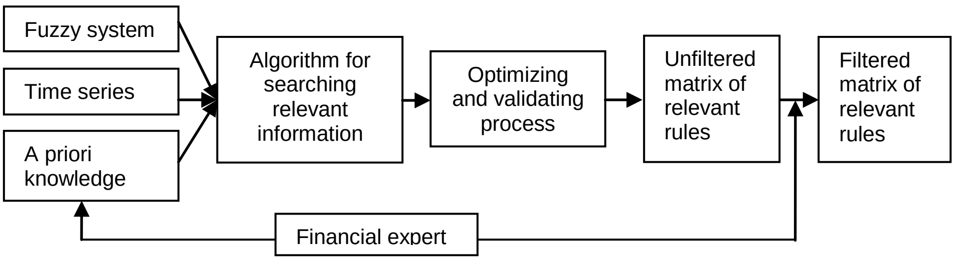

Fig. 3: Detailed illustration of the System of an investment portfolio design

Fuzzy system: A part of the investment portfolio design which, using the theory of fuzzy logic helps to adapt the designed portfolio. The goal is to determine a prospective investor’s profile, their attitude towards risks, and investment possibilities. This information plays an important role in the process of investment portfolio design and is taken into account in considering money management and risk management.

Time series: A part of the investment portfolio design represented by time series of financial instruments. Model creation, optimizing and validating are carried out for these input time series. Typical financial instruments for investment portfolio design, using this system, are currency rates, stocks titles, commodity contracts, ETF's contracts.
A priori knowledge: A priori knowledge represented by the know-how of a financial decision-making expert. It is the key part of the investment portfolio design, which brings the investor a statistic advantage and forms the basis of investment decision-making.
Financial expert: An expert for financial decision-making externally involved in the investment portfolio design. At the beginning the financial expert defines a priori knowledge which brings know-how into the system. While the portfolio is being created the expert enters the system during the final filtration of the matrix of relevant information that has been found and carries out the final completion and portfolio design.
Optimizing and validating process: A process searching the optimum setting of money management and the stability of the portfolio designed using sophisticated verification methods.
Unfiltered matrix of relevant rules: Matrix of relevant information found before the filtration carried out by a financial expert.
Filtered matrix of relevant rules: Matrix of relevant information found after the filtration carried out by a financial expert.

3. Application

The system made in order to search relevant rules and to create an investment portfolio only works with one of many feasible strategies for designing portfolios while applying genetic algorithms in the process of seeking the best solution.
The case study shows an investment portfolio design focusing on intraday speculations on the world currencies markets. The system designed an investment plan for cross currency pairs GPB.USD and USD.JPY traded on the Forex market using financial leverage.
The necessity to diversify the risks led to the portfolio being designed for the two mentioned currency pairs. The relevance of the diversification is testified by the correlation coefficient of profit and loss distribution of individual currency pairs which ranges between -0.13 and 0.08 over the period of designing and application.
The portfolio was designed in 2007 and 2008. Its application was carried out from 2009 to 2010.

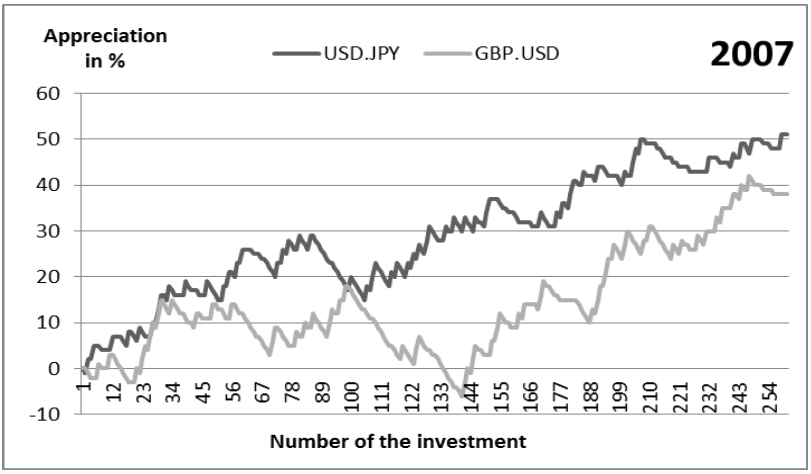

Fig. 4: Accumulation of profits and losses carried out according to investment portfolio rules in 2007, GBP.USD and USD.JPY – portfolio design

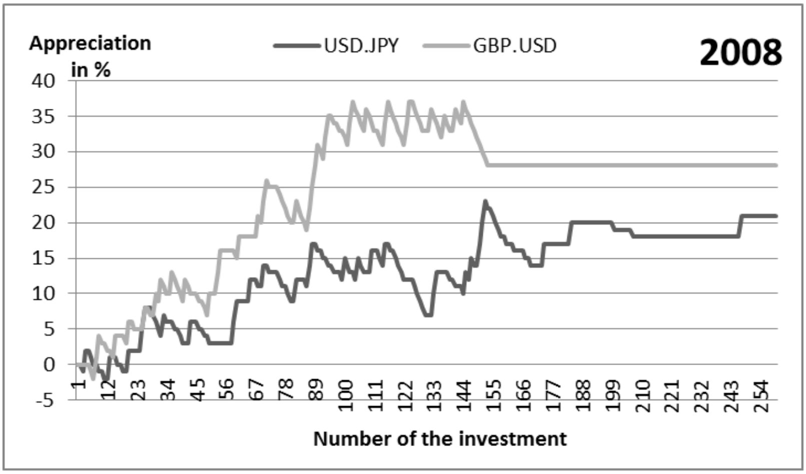

Fig. 5: Accumulation of profits and losses carried out according to investment portfolio rules in 2008, GBP.USD and USD.JPY – portfolio design

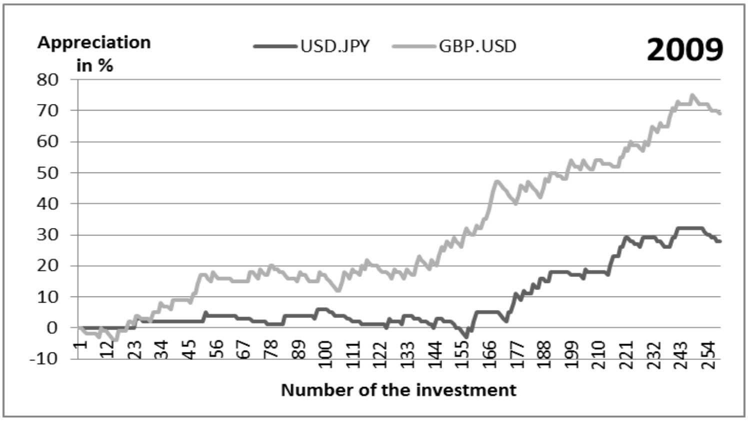

Fig. 6: Accumulation of *profits and losses* carried out according to investment portfolio rules in 2009, GBP.USD and USD.JPY – portfolio application

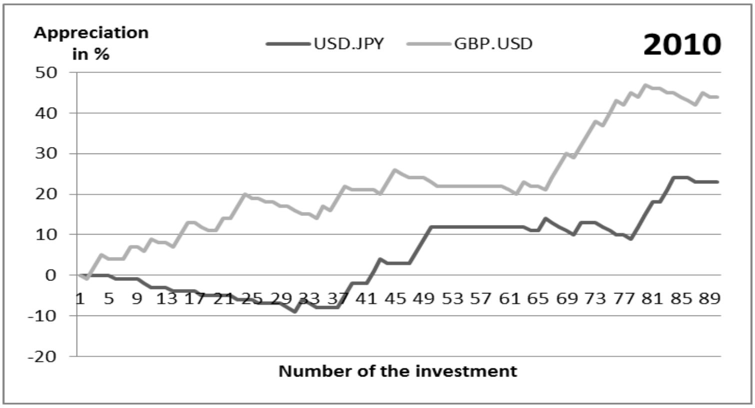

Fig. 7: Accumulation of profits and losses carried out according to investment portfolio rules in 2010, GBP.USD and USD.JPY – portfolio application

3.1 Summary of the application

Year	GBP.USD [%]	USD.JPY [%]	Total [%]
2007	51	38	**89**
2008	21	28	**49**
2009	28	69	**97**
2010	23	44	**67**

Fig. 8: Appreciation results for individual currency pairs of the investment portfolio over the design and application periods

4. Conclusion

Nowadays, financial and capital markets give work to hundreds of thousands specialists. It is taken for granted that computer technology has a strong position in capital market transactions. Computer technology and specialized software in particular makes it possible to work with less known technologies based on artificial intelligence. Applications of artificial intelligence on capital markets are relatively successful, among others thanks to the relative accuracy of the input data and the presence of non-linearity among variables under review.

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