Construction of Models of Monitoring Agents on Several Reference Forms

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Abstract
Various intelligent agents are already being used and studied in the world. Sometimes people may not even realize that they are using smart agents in their life. In our work, we investigated monitoring agents which task is to transform information. One of the areas of use of monitoring agents is the financial exchange, which makes this work interesting for a wide range of people.

Keywords
Intelligent agent, GMDH, stock market

1. Introduction

The use of an agent approach to build monitoring information systems (MIS) is the basis of the concept of intelligent monitoring [7]. MIS agents perform their tasks by processing and transforming the results of observations in order to provide information on decision-making processes in a given area [8]. The results of observations are contained in databases in the form of tables with measured values of the characteristics of the monitored objects. The agent model synthesizer builds a model of the dependence of the state of the object on the signs of external influences. The agent builds its model in the form of a neural network, a polynomial obtained by genetic algorithms, GMDH algorithms [10] or various combinations of these three components [9]. An adequate, accurate and stable model is the solution of one of the typical tasks - grouping, identification, forecasting and others. The content of the task is formed in accordance with the monitoring task of the agent. This paper presents the results of research to improve the method of synthesis of the agent model by the GMDH method [10] in the process of its adaptation to the conditions of financial monitoring of stock indicators.

2. Usage of Agents Models

In modern world, intelligent agents are widely used in various industries, social and political spheres. Agent models are a powerful tool for studying the object of monitoring, which allows to describe complex phenomena through simple objects [6]. According to Kosenko OP [2], in the modern world the monitoring of indicators is ordered and used primarily by users whose activities are related to making specific decisions. With amendments to a specific business, the multi-agent system is able to issue its forecasts at a fairly high level in various areas of economic and industrial activity. This gives us a reason to use in our work agent forecasting model of the agent to provide a potential player in the exchange with reliable data.

Different scientists give different definitions of an agent, but in general, an agent is a stand-alone complex program with a detailed description of its

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behavior, which is able to obtain information from the environment and based on their experience to respond correctly. Very often intellectual agents are closely intertwined in the field of use with artificial intelligence, but there is no complete identity between them [1, 4, 5].

Sometimes, smart agents are considered in combination with other agents. This structure is called a multiagent system. It allows you to solve a problem even more effectively. Agents need to consider interacting with other agents for cooperation or competition. That is, if a goal is unattainable for one agent, then several agents can cope with it, or if each of the agents is developed to solve a specific problem, then the solution is the one that should have the best result [1, 4].

The most famous examples of intelligent agents in the world are Alexa (from Amazon), and Siri (from Apple). They process the user's request, collect data from the Internet and provide a response. They are often used to obtain information about the weather or weather forecast.

Professor Russell identified the following main characteristics of the agent: survivability (code works constantly and decides when to take action), autonomy (the agent makes decisions without human intervention), social behavior (they can be involved through other components) and reactivity (perceive and respond on the context in which they are) [5].

There are two reasons that led to the development of intelligent agents. The first is the use of computer science. There are more and more different technical devices in the world, such as computers, servers, mobile phones, tablets, which in turn can be connected to the network, and those to the Internet. Previously, the number of connection points was less than the number of users, but today each of us can have several different devices. Computing resources are improving day by day, but the amount of data is growing even faster. All this contributes to the complexity of systems and their algorithms. To facilitate data handling, systems are divided into smaller subsystems. It is to solve such problems that there are intelligent agents who study them at a high level of abstraction. The second reason is the development of society. Clever agents play a significant role in analyzing patterns of human interaction in different situations. People can independently predict the behavior of other people, conduct negotiations and discussions, resolve conflicts, form organizational structures. All this can also be analyzed and used by a smart system. This is done by an intelligent agent who can make decisions or execute assignments based on experience, nested data and environment. They can also be used to collect real-time information [4].

The purpose of creating an agent model and the process of building it depends on the order of the decision maker. This order can be executed by agents of several types. Today, intelligent agents are divided into the following types [2]:

- Reflex agents. The agent responds based on pre-established rules by ignoring the history of previous responses;
- Model-based agents. They respond in the same way as reflexes, but have a fuller view of the environment.
- Goal-based agents extend model-based agents, including information about goals and desired situations.
- Utility-based agents are similar to target agents, but evaluate each possible scenario and select the one that will work best.
- Learning agents are agents who have mechanisms for continuous development and improvement through the processing of results.

Vicent J. presents three works related to agent-oriented programming [6]. The first work shows how accountability plays a central role in the development of MAS. Accountability is a well-known key resource within human organizations, and the idea of this proposal is to offer the design of agent systems where accountability is a property that is guaranteed by design. The authors proposed an interaction protocol called ADOPT, which allows the implementation of accountable organizations MAS. The proposed protocol was implemented using JaCaMo, which allows to demonstrate how to develop agents.

The second paper proposes a new methodology for developing MAS work in semantic web environments. The proposed methodology is based on a specific area. A modeling language called the Agent Semantic Web Language. The training was demonstrated through a case study conducted using the well-known JACK platform. The proposed example consists of a set of agents who exchange services or goods of the owners according to their preferences, without using any currency.

Finally, the third work presented the structure of agent development for mobile devices. The proposed structure allows users to create intelligent agents with typical agent-oriented attributes of social abilities, reactivity, proactivity and autonomy. In fact, the main contribution is the related support of the data framework. Supporting related data corresponds to the ability to convey the beliefs of the agent related data environment and use these beliefs during the planning process [6].

Previously, the effectiveness of the procedures for reducing the compatibility of signals due to the use of models of several reference forms on each row of selection of a polynomial model was proved [3]. As a result, the simulation error is reduced by 11.5% compared to the better model obtained by the traditional multi-row GMDH algorithm [3]. There is an increase in the diversity of the agent synthesizer due to the increasing adaptability of the synthesis process of agent models to changes in the properties of the input data arrays.

3. Statement of the Research Task

In the process of using the described technologies to build a forecast model of the monitoring agent, it turned out that there are cases when the variety of proposed methods of model synthesis is not enough to adequately describe the processes of price changes on the stock exchange. Therefore, there is a need for additional research on the processes of synthesis of agent models with several reference forms for their adaptation to the conditions of a given subject area.

At the beginning of the synthesis of the model, the results of observations of the price of gold bonds at the close of trading on the stock exchange are known, where z_t – the price of a gold bond at the time of the last observation, t – the value of the time of the last observation during the historical period;

which are recorded over a discrete period of time in one day:

$$\Delta_t = t - t_{-1} = t_{-1} - t_{-2} = 1. \quad (1)$$

During historical period *T:*

$$T = \{t, t_{-1}, t_{-2}, \ldots, t_{-m}\}. \quad (2)$$

A predefined list of features of influencing factors that are used as independent variables.

$$X = \{x_1, x_2, \ldots, x_n\}, \quad (3)$$

where n – the number of signs of influencing factors.

It is necessary to build a forecast model

$$Z_{t+1} = f(X, T, \Delta_t) \quad (4)$$

4. Research and Results

We propose to improve the method of model synthesis using several reference forms in agent synthesizers. The main task of the agent is to transform information from a matrix of numerical characteristics into the form of a model. Depending on the simulation results, the system issues a status change message. At the input, the system adopts a multi-row GMDH algorithm and a method of model synthesis, according to which, with each row of selections, models with several reference forms are generated and then the best ones are selected. In the course of the research we determined that, in contrast to the existing method, where models of 6 reference forms were generated on each row of selection [3], for the best result of forecasting the value of gold bonds we should use models of two reference forms given in Table 1.

Table 1
Reference model forms

Reference form 1	$A_0 + A_1 * X_0 + A_2 * X_1 + A_3 * X_0 * X_1 + A_4 * X_0^2 + A_5 * X_1^2 + A_6 * X_0^2 * X_1 + A_7 * X_0 * X_1^2 + A_8 * X_0^2 * X_1^2$
Reference form 2	$A_0 + A_1 * X_0 + A_2 * X_1 + A_3 * X_0 * X_1 + A_4 * X_0^2 + A_5 * X_1^2$

Data for the array of observation results were taken from financial exchange reports on the Yahoo website [11] from 2016 to 2021. An array of 1260 observation points was fed to the input of the agent synthesizer. A fragment of this array is presented in table 2.

As a simulated feature (dependent variable) used prices at the time of closing the exchange. The following were used as influential features (independent variables):

- the stock index, the basket of which includes the US joint stock companies with the largest capitalization,
- price of Australian dollar,
- exchange-traded investment fund specializing in treasury forms under fixed-term contracts of 7-10 years,

- exchange-traded investment fund specializing in treasury forms under fixed-term contracts of 1-3 years,
- the price of the Canadian dollar,
- international treasury bonds, a stock exchange investment fund that monitors the market consolidated index of fixed income securities,
- US dollar index

Table 2

Exchange data (gold). A fragment of an array of input data

Date	Open	High	Low	Close	Adj Close	Volume
Mar 18, 2021	161.15	162.82	161.11	162.56	162.56	8,711,100
Mar 17, 2021	162.27	164.15	161.48	161.48	163.51	12,626,700
Mar 16, 2021	162.36	163.20	161.81	162.35	162.35	7,547,400
Mar 15, 2021	162.31	162.55	161.43	162.20	162.20	8,104,500
Mar 12, 2021	159.54	161.69	159.35	161.49	161.49	8,608,500
Mar 11, 2021	161.47	161.98	161.12	161.52	161.52	6,749,200
Mar 10, 2021	161.06	161.78	160.66	161.66	161.66	7,962,000
Mar 09, 2021	160.75	161.25	160.42	160.84	160.84	10,382,600
Mar 08, 2021	158.58	158.74	157.13	157.49	157.49	12,134,900
Mar 05, 2021	159.66	159.82	158.55	159.14	159.14	12,821,600

The last 10 points formed a test sequence. These points did not participate in the creation of the model and were used to calculate the forecasting error.

In fig. 1 presents the test results of agent models.

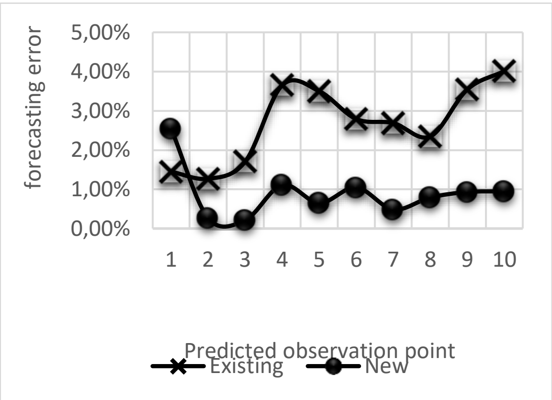

Figure 1: Error in predicting the value of gold at test observation points

The average signal error at the output of the agent model, built on the advanced method, became 0.9%. The error of the model built by the known method was 2.69%. Thus, the use in the synthesis process on each row of selection of models with reference forms, given in table. 1, allowed to reduce the average forecasting error by 10 points by 61.77%.

In addition, we noticed that with a relatively small amount of data, multi-row GMDH can not accurately produce results, in contrast to the algorithm with models of two forms, which even with such a large amount of data could work at standard deviation 2.146009 (see Fig.2).

If you increase the amount of data to 500, the multi-row algorithm starts to work much better (standard deviation - 6.642833), but the proposed algorithm in this case works also good (standard deviation - 5.757732) (see Fig. 3).

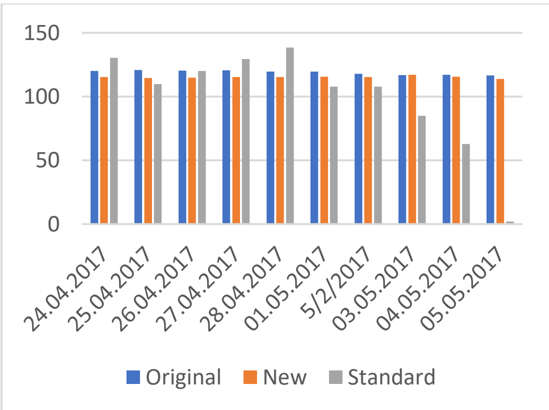

Figure 2: Comparison of GMDH methods with low amount of data

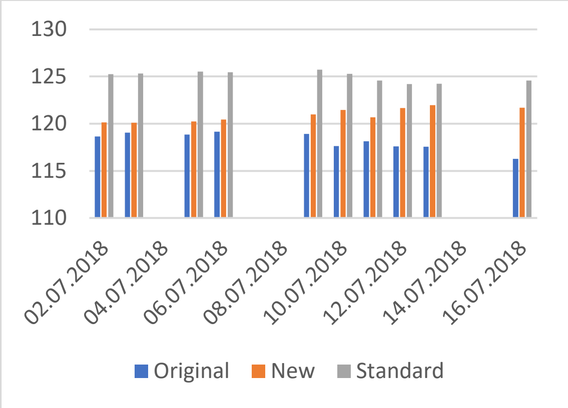

Figure 3: Comparison of GMDH methods with 500 rows of data

5. Conclusions

Generation on each row of selection of models with several reference forms, allows to increase a variety of agent synthesizers. To adapt the processes of model synthesis according to the multi-row GMDH algorithm to the properties of the input data array, it is necessary to optimize the list of reference forms of models. For each input array, the list of reference forms of the models used in each row of selection must be determined separately.

Improving the process of building models with an agent synthesizer can increase the efficiency of the task of the agent as a whole. In addition, it was found that with a small amount of input data, an improved method of synthesis of models with two reference forms is able to build useful models with fewer observation points.

Future research will focus on the study of monitoring agents based on methods based on the combinatorial GMDH algorithm.

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