Agent Systems as Modern methods in the Simulation Tools

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Modern computer simulation tools are based on different mathematical models. The simplest of these models are rank as rigid computational methods like statistics or probability mathematics. To flexible, more complex computational methods we can classify artificial neural systems, genetic algorithm or fuzzy sets. Without doubt usage of this second group of models are becoming more universal. They are classified as methods of artificial intelligence. With regard to their mechanisms of teaching, neural systems are used for the purpose of optimization. They allow to describe different non-linear structure of the data and to classify them in the appropriate way. Statistic methods do not show optimum results in the non-linear spaces and spaces that are dimensionally complex. Agent methods that are used in the intelligent systems make possible to precisely simulate reality. Reality with huge amount of objects that are on the different level of abstraction. They are used for example in rout planning by means of GPS system, in the planning different logistic processes, in the economics, in the forecasting of meteorological phenomenons etc. Common feature of all forecasting methods are mistakes connected with discrepancy of simulation results and real value. In the literature there is no researches in mentioned discipline. Results of optimization presented in the article are obtained using agent systems. These results refer to finding the shortest way to the defined extreme by studying level of route complexity (multiple, amount of extremes), time of studying, mistakes of defining appropriate extreme. To authenticate results in case of different tools to simulation, researches have been conducted with five different simulation computer programs.
Keywords: agent systems, simulation.

1. INTRODUCTION

In the modern economy computer simulations are of greater importance. At present there is a lot of IT tools that support different decision-making processes as GPS, SIT, CIL, IS, MIS, MRP/ERP, etc. However they are not adjusted to conduct sophisticated simulations. Systems of MRP/ERP class are based mainly on simple Holt's and Winters' methods of forecasting [2]. More and more frequently in the MRP/ERP systems for the purpose of optimization genetic algorithms and neural systems are used. All algorithms these simple called statistic and algorithms which are based on artificial intelligence methods define factors that have influence on the object.

We reach out for the sophisticated techniques of simulation at the time when creating of complete model and its implementation without additional simulation would be too risky. When it would endanger enterprise to big costs. Simulation models are used in many disciplines as: medicine, economics, logistics, etc. Their main advantage is the fact that because of right parameterized virtual model we are able to define behavior of the object. We can do it in dangerous situations and when there is no possibilities to personally investigate particular phenomenon. To the most popular computer simulation tools we can classify Arena, Anylogic, Igrafix, Promodel, Flaxsim, VenSim, PowerSim, iThink, etc.

Among different simulation programs that are available on the global market we can distinguish discreet methods [3]. Such models are used mainly in tactical and operational actions where described objects are characterized by large number of details.

Very often for example in forecasting problems continuous models are used [3]. Their main advantage is the fact that they can be used in planning of tactical and strategic actions. These models are the most often models that we meet with. Moreover we can distinguish models that are used apart from those which were mentioned:

- deterministic models;
- stochastic models;
- probability mathematics models;
- statistic models;
- dynamic models;
- causal models;
- correlation model;
- binary models;
- integer models;
- systems with sophisticated parameters;

With regard to sophisticated structure of elaborating methods, what has influence on the computational complexity of creating simulation models, in analysis numerical techniques are used. The conceptual construction of such numerical simulator is presented on the figure below.

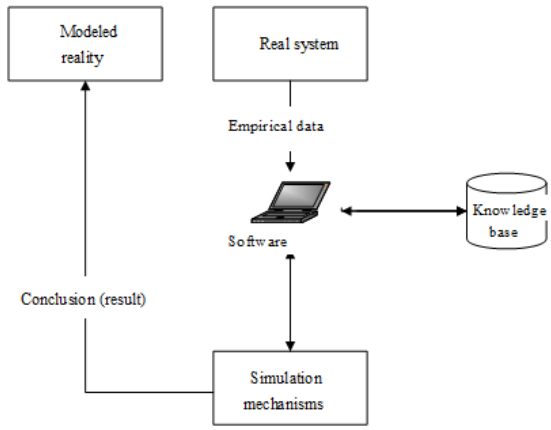

Illustration 1. Block diagram presenting mechanism which simulates reality.

The fact which results from figure 1 is that software integrates shaped realistic system with simulation mechanisms. Important feature is a base of knowledge, which is essential repository needed to modeling part of reality.

2. THE ROLE OF AGENT SYSTEMS IN MODERN SIMULATION TOOLS

With regard to sophisticated decision-making problems, their optimization is essential. Using statistic or probability mathematics methods of simulation we are dealing with a phenomenon of over-learning. Over-learning is connected with excessive adaptation to studying data, which causes lack of possibilities reliable generalization of the case for example to general population. This fact causes necessity of using solutions that are based on artificial intelligence methods which very god cope with such problems. Neural systems are used mainly to find the best solution according to defined criterion of optimization.

The common feature of different simulation programs is the fact that they have system which is based on the knowledge [1]. Such system stores up symbolic model of the surroundings and it makes some decisions using symbolic reasoning. Such system based on the knowledge is called agent system. Thanks to their unique properties it links continuous and discreet models. The characteristic feature in agent models is the fact that they have some patterns of behaviors. Such agents create different multiagent structures by mutual relations among themselves.

On this stage we can propose some conclusion: good simulation tool should be equipped in the legible interface, graphic realization of simulation, mechanisms which allow to built hybrid simulation models based on agent systems.

Main adaptations of agent systems in simulation methods are:

- planning of road transport;
- planning of different logistic processes, including optimization of whole supply chain;
- economics;
- medicine;
- meteorological forecasting;

Common problem of all simulation tools dedicated science is mistake of simulation results

In terms of the actual state. Next point of this article presents results of the copyright researches which relates to discrepancy between simulation and real state of the object.

During the logistic systems designing process very rare simulation methods are applied. There are few advanced simulators on the World. Although the most advanced are in Frankhofer in Madgeburg (Germany) their range of application is limited to subjects visualization without possibility of planning and forecasting of the most possible scenario. The own, authors method of extreme determination is define by the equation *E(A)*:

$$\forall D \quad E(A)=\frac{\sum_{o=1}^{W}\sum_{k=1}^{n}\min\sup_{R_{k,o}}\{\mu(R_{k,o})\}\cdot\max_{1<k<M}\mu(R_{k,o}))-0{,}1*\left|\sup_{R_{k,o}}\{\mu(R_{k,o})\}\cdot\max_{1<k<M}\mu(R_{k,o})\right|}{\sum_{k=1}^{d}t_{k,o}}$$

Where: $\mu(R_{k,o})$ is diffused value of traces of the k –agent searching solution in o – cycle, in *M* number of possible steps.

$t_{k,o}$ - is a function determines number of agent steps to achieving the best solution (local extreme of implicit function).

3. COMPARISON OF THE ACCURACY OF THE SIMULATION TO THE REAL DATA

In order to verify the accuracy of the simulation compared to the real data, has been used five simulation programs that use the agent system as the tools for optimalization available in Polish market. Due to the fact that the permission to public names of these programs were not allowed, such names are not mentioned. Results received by estimated error variance of results that were obtained with the use of such tools can be generalized to the general population of all the simulators that use agent systems. In those researches assumed a problem, which is to find the shortest way to a local maximum of function. In that case, in the input of the model, two values are given: number of variabilities and number of local extremes of particular space of such area, was illustrated on figure 2. Purpose of the agenda system is not only to find a local extremum but also to nominate the shortest path that leads to it, where the start of searching has been settled at random boarder of space area.

The study assumes that the number of extrema and the number of variables will be varied from 1-100. Measuring accuracy of optimalization there were assumed various combination of quality of variables and extrema. Accepted that percentage value will differ to the accuracy level of nominating the shortest path number of steps by agents of the system. Lets *X* to nominate the lowest number of steps that are necessary to overcome the path from point of initialization to the local extreme. Lets *Y* to be the optimal path received by the agent's system in the Simulator. Therefore the accuracy of *D* result received Turing the simulation is the ratio of the real optimal length of path *X* to the local extremum to optimize that path obtained in the simulation of *Y*, which describes the following formula (1):

$$\forall X <= Y \qquad D=\frac{X}{Y}\cdot 100\% \qquad (1)$$

In the base on a set of measurements, results received from five simulation programs were averaged and the solution of optimalization problems were received. We can see it in the illustration below [3].

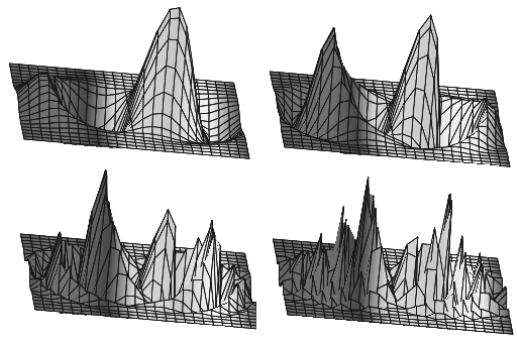

Illustration 2. Examples of function Z=f(x,y) having more complex surface In terms of number of local extremes.

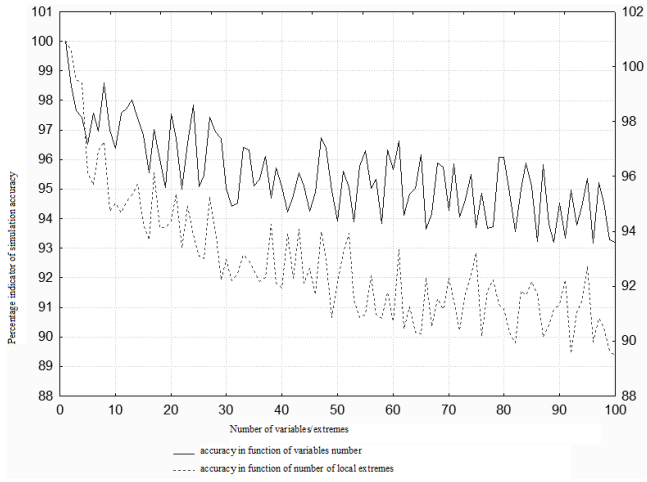

Illustration 3. Averaged simulation results received from five different simulation programs, that measure the discrepancy between real optimal (shortest) path and obtained path with the help of the system.

After performing all researches some conclusions raise. Of the two analized variables, quantity of local extremes have the strongest influence on the accuracy of classification. The more local extremes the more quantity decrease. At about 70 local extremes the quality classification is stabilizing to about 91%+/-1,54%. At about the complexity of the model of 30 variables results are converging to the level 95%+/-1,21%. The converge between different tools used to the simulation averages about 2,54%, that proves consistent results of the optimization. After series of multiple regression and sets of combined analysis for different number of variables and local extremes, the local mathematic model was assigned. Such model allows to measure the accuracy rate of various simulations accordance to these two parameters:

$$Y' = \left(\frac{E^{0,021} + Z^{0,012}}{E^{0,021} \cdot Z^{0,012}} \right) \cdot 50\% \pm 1{,}14\%, \qquad (2)$$

where: Z – number of input variables in the simulation model,

E – number of local extremes of seeking functions.

This formula was obtained by the nonlinear regression made by the neural network.

The resulting factor of determination ($R=0{,}9634$, $R^2=0{,}9282$, $F(2,97)=627{,}5152$, $p<0{,}001$) is statistically significant and very strong. Therefore it can be concluded, that the accuracy of approximation is at the level of 93%. The theoretical characteristic, obtained by the formula (3) is shown in figure 4.

In the researches it was also examined how the complexity of the present space, affects the time to reach the agent system to find the smallest number of steps to the local maximum. The complexity of the present space is associated with the complexity resulting from the interaction of the number of variables and extremes. Received results are illustrated in figure 5. The research of time has been done on a PC with 2 GHz and RAM 1024 MB.

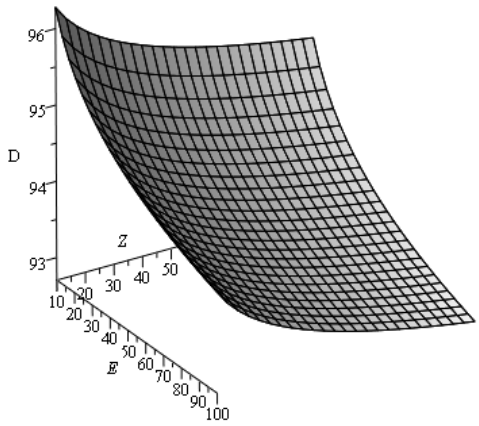

Illustration 4. Characteristic of the accuracy of the simulation seeking for the shortest path to the local extreme with use of the agenda systems based on the number of variables and the number of extremes

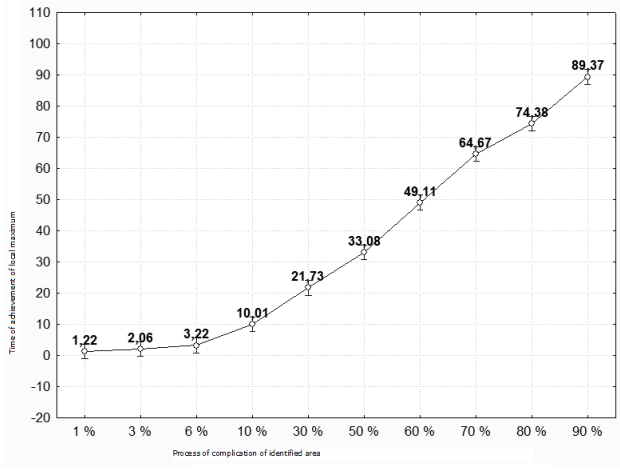

Illustration 5. Figure of time achieving the local maximum in seconds, depending on the complexity of the present space in %.

Obtained results show that complexity of present area approximately 10% followed by significant increase in time to the local maximum. The complexity of the interaction of 10% to 10 variables and 10 local extremes. In these researches adopted only correctly determined extremes by the agent systems. There were made also researches that show the percentage difference between correct and incorrect determination of the local extremum. It turns out that quantity of input variables does not generate the above errors. Such errors are caused by increasing number of extreme. The morel local extrema the more mistakes of adopting extremum by agents system. In this research for the 10 variables generated total of 10000 different spaces. To increase the reliability of the results for each quantity of extreme 1-100

generated 100 different random spaces. Results were averaged and the results were received. Those results show illustration 6.

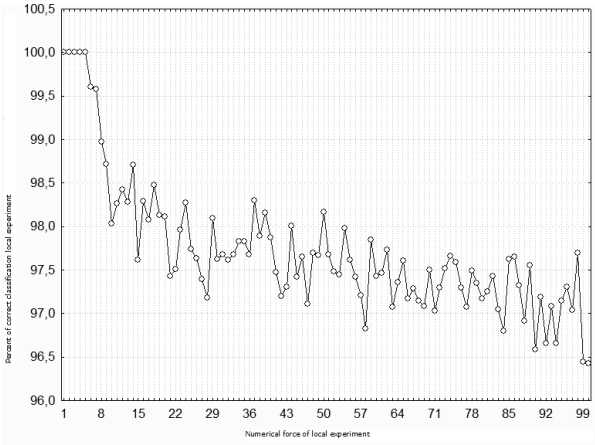

Illustration 6. Figure of the frequency of achieving the correct classification of local extremes, depending on the number of extremes

We can conclude that for agenda systems correctness of finding optimal solutions is very high. Only problem is to find presented above solutions, in the shortest number of steps. That feature is very important. For example, in production it is important to entire correctly the whole process but it is also important to optimize all steps are necessary to receive the final result.

4. SUMMARY

Modern agent system used in simulation tools constitute very good methods of optimization. Above-mentioned systems possess semantics of autonomy, thanks to this semantics agents possessing knowledge about recognized surroundings and using different methods of deduction these agents gain skills to make independent actions through the learning. In the case of simulation usage of multiagent systems causes that simulation of different systems which possess many object on the different level of abstraction is becoming easier. Analysis that were made-up allow to conclude that for quite simple configuration of input variables, simulation (optimization) quality as in finding the shortest way to the local extremes is very high and reaches even about 98%. As it was demonstrated if the configuration is being complicated by adding new variables and by increasing local extremes, the precision of finding the shortest way is decreasing. In the most pessimistic situations it can decrease up to 90%. Elaborated formula (3) based on obtained data allows with a high precision (already in the preparation phase of a priori model) to determine its precision connected with mapping of virtual to real data. In researches there is also demonstrated that right indications of the local extremes in the smallest number of steps depend on time when these steps were reached. (time of studying). In this aspect different simulation tools differ from each other merely about 20+/- 9,62. When configuration is becoming more complex then the time of finding the smallest amount of steps is increasing exponentially. It is evidence of high computational complexity. It is also demonstrated that amount of the local extremes really influences on the correctness of their classification. Even though correctness of classification is decreasing together with the complexity of recognized space it still remains at the very high level of 97-100%.

Researches mentioned above do not deplete analyzed issue. We can determine another criteria associated with estimation of models precision before their implementation. However it succeed to demonstrate that different tools based on agent systems give very comparable results. Faced with the choice of purchase good simulation tool we should take into account obtained results and reflect well on proportion of price to quality. Quality is connected with interface of the usage, simplicity of operation and visualization of simulation (animation). Part of the simulation programs present results in the form of graphs which very often cause difficulties in their interpretation.

LITERATURE

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