ONE APPROACH TO EVOLUTIONARY OPTIMIZATION IN DECISION MAKING

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Summary

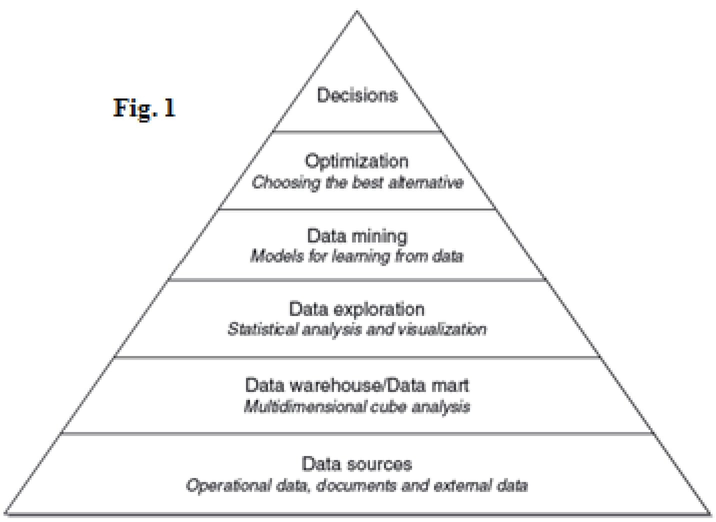
The business intelligence in any organization requires the making of decisions, the coordinating of activities, the handling of people, and the evaluation of performance directed toward group objectives. This problem cannot be solved without system approach, such as synergetic, system modeling and complexity theory. Business intelligence represents the complex iterative and interactive, pyramid-like hierarchical multi-stage process. By moving up one level in the pyramid we find optimization models that allow us to determine the best solution out of a set of alternative actions, which is usually fairly extensive and sometimes even infinite. The top of the pyramid corresponds to the choice and the actual adoption of a specific decision, and in some way represents the natural conclusion of the decision-making process.

In this paper, we present a new approach for a decision making process with respect to the entropy-based evolutionary optimization, that is conditioned by the existence of nonlinear economic or organizational behavioral factors in human society. Originality of this work is in the system model adaptability by structure reconfiguration or self-assembly when multi-agent organization is evolving its way to a better structure. Every found solution can be considered as new knowledge. The knowledge build-up or self-learning process is based upon principle of compatibility between new obtained knowledge and knowledge base as multi-agent model. From the point of view of the knowledge management and learning processes the knowledge complementarity has been discussed.

Keywords: business intelligence. Decision making process. Evolutionary optimization. Entropy.

1. Introduction

Fig. 1



Decision Making in Business Intelligence. *Business Intelligence (BI)* technology, which is the key factor of development and implementation of process change, can be defined as a set of mathematical models and analysis methodologies that exploit the available data to generate information and knowledge useful for complex organizational decision-making processes [1]. The main destinations of business intelligence is effective and timely decisions making process. Business intelligence represents the complex iterative and interactive, pyramid-like hierarchical multi-stage process, where the role of decision making can be considered as one of the most important (Figure 1) [2].

As we progress from the bottom to the top of the pyramid, business intelligence systems offer increasingly more advanced support tools of an active type. Even roles and competencies change. The fourth level includes *active* business intelligence methodologies, whose purpose is the extraction of information and knowledge from data. These include mathematical models for pattern recognition, machine learning and data mining techniques. By moving up one level in the pyramid we find optimization models that allow us to determine the best solution out of a set of alternative actions, which is usually fairly extensive and sometimes even infinite.

Decision support system (DSS). Here we discuss the decision support system, which can be defined as an interactive computer system helping decision makers to combine data and models to solve semi-structured and unstructured problems. The structure of DSS consists of three main elements of a DSS: a database, a repository of mathematical models and a module for handling the dialogue between the system and the users (Figure 2) [3,4].

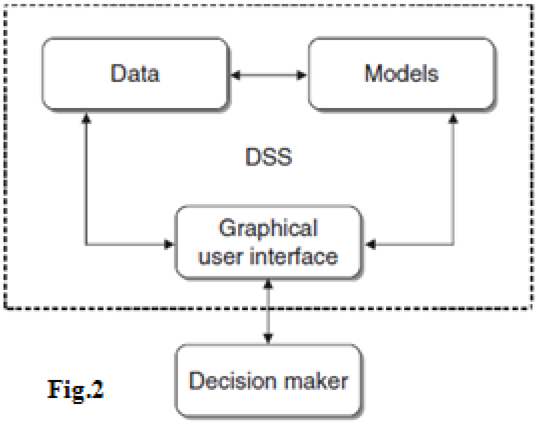


Fig.2

Research on knowledge-based decision-making processes has received increasing attention in the literature during the last decade, reflecting the increasing relevance and importance of computer simulation modeling in business practice.

2. Entropy Based Evolutionary Approach To Simulation Modeling

Multi-Agent Modeling and Simulation (MAMS) Approach. In this section, we will point out that multi-agent models can be seen as an alternative view on modeling areas. Multi-Agent Systems, also called Swarms of Agents or Societies of Agents, are systems capable of achieving their goals through the interaction of constituent agents. Probably the most important design issue of a multi-agent approach is the modeling of the agents. In the simulation, different agents are used to capture the heterogeneity of restructured environment. An agent is thus a software representation of a decision-making unit. Agents are self-directed objects with specific traits. The agents are specialized and perform diverse tasks using their own decision rules (Figure 3) [5].

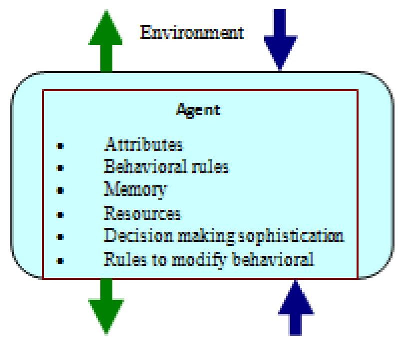


Fig.3

Multi-Agent Modeling and Simulation (MAMS) is a new modeling paradigm and is one of the most exciting practical developments in modeling since the invention of Artificial Adaptive Agents models based on Artificial Intelligence methods [6,7]. The MAMS system provides the ability to the complex relations between Intelligent Agents, which generally are computer programs that are capable of accomplishing their goals under conditions of uncertainty through the interaction with other intelligent agents. The most common applications of MAMS and currently employ learning methods such as Support Vector Machines, Bayesian approaches, Logistic Regression, Artificial Neural Network, Fuzzy Logic and Genetic Algorithms, Expert Systems and Intelligent agents, Ant colony and Particle Swarm Optimization. They are often used in combination with each other.

New vision of entropy. All the system use relate to groups of related entities. Any change or evolution of the system can be described as a transition from one state to another one, which is closely related with the changing of entropy. In thermodynamics, entropy is often associated with the amount of order, disorder, and/or chaos in a thermodynamic system. A property frequently used to characterize self-organization is an increase or decrease of order (disorder) which intuitive notion is to identify it with the entropy. We can imagine disorder as disoriented agent behavioral vectors. To highlight the fact that order and disorder are commonly understood to be measured in terms of entropy, below are current science encyclopedia and science dictionary definitions of entropy as a measure of disorder in the universe or of the availability of the energy in a system to do work [8].

In large scale systems appears to contradict the second law of thermodynamics. This paradox has been explained in terms of a coupling between two cases of dynamics: *chaos* (from Greek chaos = the disordered) or self-organized criticality, where random processes greatly increase entropy, and *cosmos* (from Greek kosmos = the ordered) or creation, when self-organization vs. entropy, i.e. it takes place the reduction of entropy. *One well-known example of chaotic case or self-organized criticality is the experiences in the sandbox (the Bak-Tang-Wiesenfeld sandpile model)* [9].

The "disorder" and hence the entropy associated with the number of system states as the degree of freedom. On the other hand, we can distinguish also two modes of the dynamics: epistemological i.e. on the same level (because of cluster entropy minimization) and hierarchic (through the evolutionary processing, when the overall system complexity, hence degree of freedom and entropy increase). Any action in characterized by changes (increasing or decreasing) of entropy. It has led to the development of a number of models using entropy, including Shannon information theory, synergetic, and complexity theory. In view of the aforesaid we introduced a new conception of entropy as an internal behavioral incompatibility (resistibility) or antagonism, certain contradiction between disoriented components behavioral vectors [10]. In the given context, the building a model and its optimization is possible by criterion of the entropy minimization. With the viewpoint of optimization it may be convenient to use heuristic algorithms of synergetic graph reconfiguration for the purpose of the entropy minimization. The state of system is conditioned by behavioral vectors of components, which is defined from synergetic connections of every agent.

Synergetic Graph Modeling and Optimization. In this paper, we present a new concept for a formal description of the complexity with respect to the viewpoint of modeling. Particularity of this work is the description of the modeling areas in a form of the synergetic graph, where an agent is represented as the node of graph. Agents interact (communicate, coordinate, negotiate) with each other, and with their environment. We introduced a new conception of entropy as an internal behavioral incompatibility (resistibility) or antagonism between disoriented agents behavioral vectors. In the given context, the criterion of system state is associated with the idea of fitness-function.

As a result of interactions there takes place the merging of agents, creation of a new ensemble (or cluster) that consists of synergetic-entropic union. Every interaction between any clusters recursively form the new entity, the new united cluster, which has mutually modified or provoked redistribution of synergy-entropy, its balance and fitness. Creation occurs when entropy converts into synergy and vice versa, when breaking up synergy converts into entropy]. Entropy-based Optimization (EO) approach, as an evolutionary method, creates an multi agent-based synergetic model, which is populated with thousands of agents each with their own technical trading rule [11]. After every iteration the models configuration evolves through of entropy gradient, i.e. synergetic models structure is transforming from one configuration in others. The main principle and originality of this approach consist in synergetic model evolution by the reconfiguration step-by-step for its improvement without any genetic operation (crossover, mutation and inversion). Reconfigurable model can be compared with self-assembling which is a ubiquitous process in nature when disordered set of pre-existing components autonomously combine into more complex and ordered structures (akin to the supramolecular self-assembling processes or in the brain neural network). We have not yet defined what it means to optimize of the graph by reconfiguration. After randomly formation of initial model, thought the instrumentality of the synergetic connectivity recombination is used to generate new solutions by criterion of the current entire graph entropy minimization or fitness function (synergy) maximization.

Finally, every found decision (or solution) can be considered as new knowledge. The knowledge build-up or self-learning process (and the knowledge complementarity) is based upon principle of compatibility (synergy) between new obtained knowledge and knowledge base as multi-agent model.

2. Conclusion

We conceptually discuss the Decision Support Systems and its taxonomy. We have also discussed the Evolutionary Algorithms as main tools for a decision making process. We introduced a new vision of multi-agent models as an alternative view on modeling areas, where an agent is a software representation of a decision-making unit. Any optimization action of the system can be described as a transition from one state to another one, which is closely related with the changing of entropy. We introduced also a new conception of entropy as an internal behavioral incompatibility (resistibility) or antagonism between disoriented components behavioral vectors. The state of system is conditioned by behavioral vectors of components, which, from one's part, is defined from input-output connections of every agent. Presented a new approach to evolutionary algorithms mimics the mechanism of complicated brain neural network and natural intelligence. The assembling a dynamic model of system and its optimization is possible by synergetic graph reconfiguration for the purpose of the entropy minimization. Entropy-based Optimization algorithm, as distinct from genetic algorithms, doesn't require the randomized initial population and genetic operators. The models configuration evolves through of entropy gradient, i.e. systems structure is transforming from one configuration in others towards the global optimum.

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გადაწყვეტილების მიღებისათვის ევოლუციური ოპტიმიზაციის ზოგიერთი მიდგომა

ბადრი მეფარიშვილი, თინათინ კაიშაური, მაკა ცერცვაძე
საქართველოს ტექნიკური უნივერსიტეტი

რეზიუმე

წარმოდგენილია გადაწყვეტილების მიღების პროცესისადმი ახალი მიდგომა. სისტემის მოდელის ადაპტურობა ხორციელდება მართვის ობიექტის მულტიაგენტური სტრუქტურის რეკონფიგურაციის ან თვითაგების მეშვეობით, როდესაც ორგანიზაციული სტრუქტურა ვითარდება საუკეთესო გზით. ცოდნის მშენებლობის ან თვითგანსწავლის პროცესის ერთ-ერთი პრინციპი არის სწორედ მიღებული ახალი ცოდნისა და უკვე არსებული ცოდნის ბაზების, როგორც მულტიაგენტური მოდელის, ერთგვარი თავსებადობა. ცოდნის მართვისა და განსწავლის პროცესის თვალსაზრისით, ნაშრომში განხილულია აგრეთვე ცოდნის კომპლემენტარულობის საკითხი.

НЕКОТОРЫЕ ПОДХОДЫ ЭВОЛЮЦИОНОЙ ОПТИМИЗАЦИИ ДЛЯ ПРИНЯТИЯ РЕШЕНИЙ

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Резюме

Представлен новый подход к процессу принятия решений. Адаптивность модели системы реализуется посредством реконфигурации или самопостроения мультиагентной структуры объекта управления, когда организационная структура развивается наилучшим образом. Одним из принципов процесса построения знания или самообучения является совместимость полученного нового знания и уже существующих баз знаний в виде мультиагентной модели. С точки зрения управления знанием и процессом самообучения в работе представляется также вопрос комплементарности знания.