AUTOMATIC INFORMATION PROCESSING AND UNDERSTANDING IN COGNITIVE BUSINESS SYSTEMS

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Keywords: Automatic understanding systems (AUS), Data analysis, Understanding-based information systems, Cognitive business systems, Cognitive analysis.

Abstract: The concept of new generation in area of information systems is automatic understanding systems (AUS) to the attention of the computer sciences community as a new possibility for the systems analysis and design. The novelty of this new idea is in the previously used method of automatic understanding in the area of medical image analysis, classification and interpretation, to a more general and needed area of systems analysis. The concept of the AUS systems approach is, in essence, different from other approaches such as, for example, those based on neural networks, pattern analysis, image interpretation or machine learning. AUS enables the determination of the meaning of analysed data, both numeric and descriptive. Cognitive methods, on which the AUS concept and construct are based, have roots in the psychological and neurophysiological processes of understanding and describing analysed data as they take place in the human brain.

1 INTRODUCTION

There are more and more intelligent information systems being developed. Such systems, which was evaluated as helpful in years of prosperity, are indispensable in crisis time. Economical competition, always very hard, become fierce in contemporary situation. Therefore new methods of IT-based management improvement tools are today necessary more than whenever. The development time of new information systems – decision support systems is expected to become shorter and shorter despite a growing complexity. Everybody looks for new ideas, because only original methods of successful management can to bear fruit in competition superiority. Information systems designed and developed for the future must have new features and new roles. The are no more only useful calculator, helping in routine management procedures. The information system of the future must be a weapon, revolutionising the way we conduct business nowadays. Such revolutionary idea of the use automatic understanding systems in business practice is presented in this paper. This idea is not mature enough to be introduced to the economical practice nowadays, but it is different from typically used decision support paradigms and therefore can be found interesting.

Modern production, service, trading companies, banks, insurance corporations, and the dispatch industry, rely on information systems, which are highly integrated in an organisation. However, they do not take significant advantage of the most recent advancements in artificial intelligence and cognitive science. This is regretful, since the use of AI and cognitive science could contribute significantly to IT innovations and may constitute a source of competitive advantage.

2 COGNITIVE ANALYSIS BASIC METHODS AND IDEAS

More ambitious tasks, such as a **strategic idea generation,** require a new approach. An AUS is a natural way to go.

Tadeusiewicz R., Ogiela M. and Ogiela L. (2009).
AUTOMATIC INFORMATION PROCESSING AND UNDERSTANDING IN COGNITIVE BUSINESS SYSTEMS.
In *Proceedings of the 11th International Conference on Enterprise Information Systems - Artificial Intelligence and Decision Support Systems*, pages 5-10
DOI: 10.5220/0001844200050010
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However, it is worth noting that we are aiming to develop an IS capable of using both the form and the **content** of business data stored and retrieved for analysis. To manage a business efficiently and, in particular, to find and implement new concepts, it is necessary to **understand** the situation of the business as well as that of the business environment (or of a given market segment). By understanding the micro- and macroeconomic situation well, one can have the basis to propose innovative changes, which may even turn out to be revolutionary in nature. However, the lack of understanding of certain signals and/or data could lead to disaster.

From the viewpoint of psychological sciences, in the process of understanding any information obtained by a man, subject to cognitive analysis, there are three stages:

- Registration, remembering and coding the information obtained.
- Preserving – a latent stage of natural processes.
- Information reproduction – its scope covers the remembering, recognition, understanding and the learning of some skills anew (Ogiela, Tadeusiewicz, 2003; Tadeusiewicz, Ogiela, 2004).

Some features of cognitive processes on which we shall base our AUS information model, the model analysed in this paper, can be associated with the neural network technique, which is quite fashionable nowadays. These networks are capable of registering, remembering, storing and reproducing various signals and other information. Nevertheless the capacity of neural networks is limited by the fact that in order to build them one uses rather small sets of units - learning by processing information (artificial neurons). As a result, within their scope lie only very simplified models of psychological processes - at best connected with the ability to learn simple reflexes or elementary associations. The neurophysiological model of cognitive analysis that we need in this paper is based on the functioning and operation of large brain fragments that can be described by examining (among others) large neural group dynamics attractors (amounting even to millions of neurons), defined in the stimulation area of these neurons (Tadeusiewicz, Ogiela, 2005).

Even though there are no identical states of brain surface (for example examined with EEG), in the dynamics of its activities one can find constant relations between these attractors, i.e. relatively repetitive dynamic neurophysiological states. Appropriately, mathematically interpreted dynamic states of the brain are characterised by some deeper relations, which could have their logical representation. The correspondence between the state of mind and brain does not refer to the electrophysiological surface phenomena of a volatile nature, but it points to some stability of attractor states.

Let us now try to shift these statements to a cognitive IS model, of interest for us and used for business purposes. Its task would be to interpret facts based on the understanding and reasoning conducted in connection with the semantic content of processed data.

3 SEMANTIC ANALYSIS OF THE DATA

Every Information System is supposed to perform a semantic (directed at the meaning) analysis of a selected object, or the basis of the information must contain some **knowledge** necessary to make a correct meaning analysis. Confronting the obtained description of a currently analysed object (e.g. a specified market situation), we obtain the premise to show the real meaning and sense of the said object, that is to **understand it** via its featured characteristics along with its given set of expectations and hypotheses. This is true for every system capable of understanding any data and information. This is due to the fact, that it is always the knowledge held previously, i.e. the basis to generate system expectations, that can constitute the reference point for semantic analysis of features obtained as a result of the conducted analysis of every object, analysed at the system input. As a result of the analysed objects combined features together with the expectations generated, based on the knowledge regarding its semantic content, we find a cognitive resonance phenomenon (figure 1). That is the key to meaning analysis of objects or information.

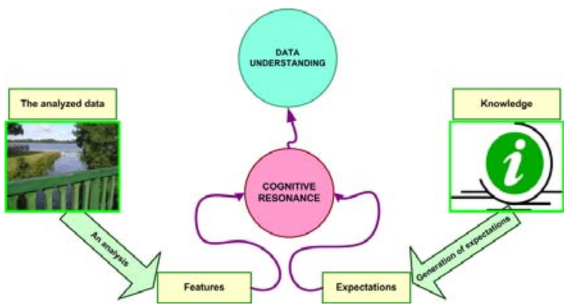

Figure 1: The cognitive resonance phenomenon in the process of the analysed object understanding.

In accordance with the concept developed by the authors over a number of years, cognitive analysis used in IS dedicated to automatic understanding, is based on the syntactic approach. For the purposes of meaning analysis and interpretation of the analysed object it therefore uses a linguistic description (Meystel, Albus, 2002; Tadeusiewicz, Ogiela, 2004).

Further system operations relate to techniques originating from mathematical linguistics. The details of its use can be found in next chapters. Nevertheless due to the fact that we are referring to it for the first time here, it is worth explaining why we decided to use this very tool in our papers. Well, the basic difference one can see between automatic data classification, frequently used in information science, and the automatic understanding of the data is that in the case of classification one knows in advance a certain finite number of classes. The recognition process is only supposed to determine to which class one can include the object analysed at a given time. On the other hand, if one tries to understand the meaning of a specified object, we have no “a priori” known list of possible meanings to choose from. The sense of each data set must be built though from scratch. One can say therefore that the number of possible meanings detected in the automatic understanding process is potentially infinite; this is even true in one given situation when we are dealing only with one determined meaning. For this reason we need such an IT tool that would be capable of generating an infinite number of analysed object descriptors. Due to the implementation possibility the tool itself must be composed of a finite number of elements. Language is such a tool. A natural language enables one to express an infinite variety of moods and content using a finite number of words. On the other hand, artificial languages, for example algorithmic ones, enable, in a similar way, the creation of an infinite number of various software items. In our paper we refer therefore to a formalised term of data description language and to mathematical methods and to the rules governing the processing of it. This is to create the basis for the automatic generation of (potentially) an infinite number of various meanings using just a small set of elements, formal rules (enabling computer application) and axioms; these would form the grounds for an automatic understanding system (Skomorowski, 2000).

4 NEW OBJECT REPRESENTATION

As a result of the implementation of the pre-processing stages described above as well as with reference to mathematical linguistics, it is possible to obtain a new object representation in the form of hierarchic semantic tree structures and the subsequent steps deriving this representation from the start symbol of the grammar used. An intelligent, cognitive IS, at the stage of pre-processing, must in most cases decompose the analysed data to a lower level of instance, identify primitive components and determine the relationships between them. An appropriate classification makes it possible to find out whether the representation of a given object belongs to a class of objects generated by a formal language defined by a possible grammar defining formal languages (i.e. sequential, tree or graph languages). A recognition with their use takes place in the course of syntactic and semantic analysis performed by the system.

5 AUS-TYPE INFORMATION SYSTEM: A WHOLE CONCEPT

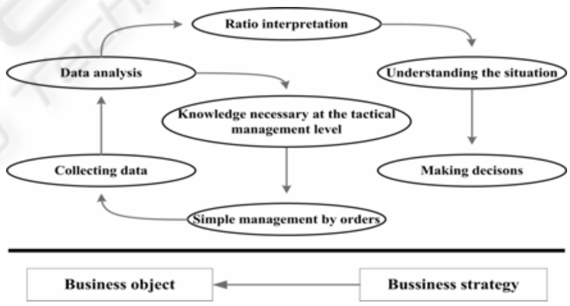

Figure 2: Division of functions between people and computers in a traditional IS supporting business decision-making.

We shall now present a proposed structure and operational methods for the previously introduced AUS-type system. First, in order to systematise our considerations and to establish a reference point, let us recall the traditional (nowadays applied in practice) structure of an information system application: computers are, obviously, involved since they are the ones that store and process data as well as analyse data in various ways. Information obtained from such computer systems is entirely sufficient for an effective management of business processes at the tactical level (as marked jokingly on

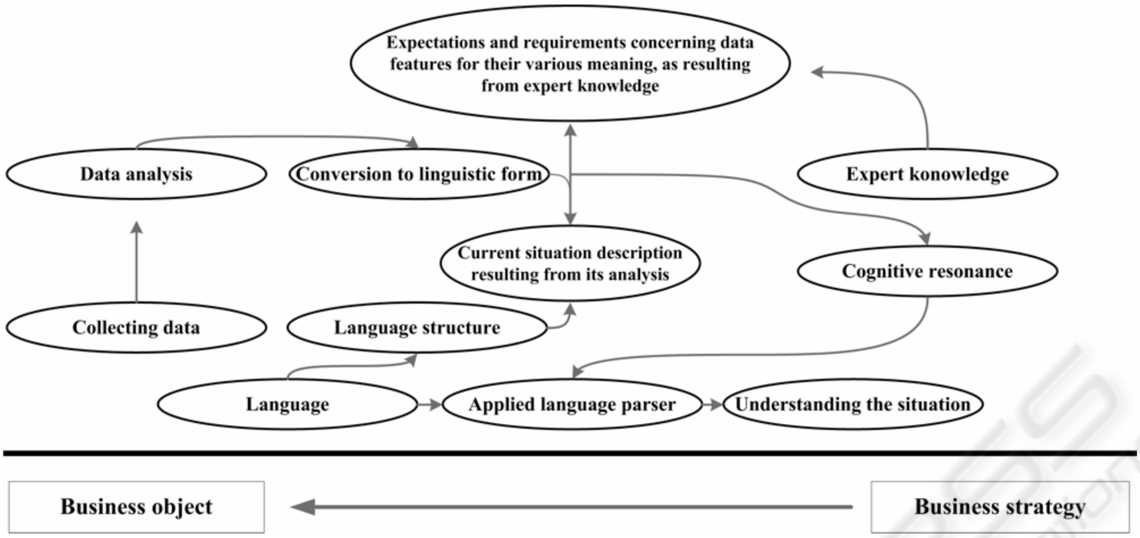

Figure 3: General AUS-type information system structure.

figure 2). On the other hand, if we talk about management at a strategic level, we find out that despite automated data collection, storage and analysis, the task of business meaning understanding of the said data is in traditional systems the unique area of people (experts). So is taking and implementation of strategic decisions: this belongs only to people holding appropriate, high positions. The structure of such traditional IS, as presented on Figure 2, will be the starting point in proposing a general structure of an AUS-type information system.

In such a system, whose structure is presented in figure 3, the initial processes of storing and pre-processing phenomena taking place in the analysed business entity, are analogous to the one we are dealing with in traditional systems. The only difference is that with the perspective of automatic interpretation of data analysis process results, one can compute and collect a larger number of ratios and parameters since the interpreting automaton will not be dazzled or perplexed by an excess of information. This is what happens when people, interpreting situations, are ‘bombed’ with hundreds of ratios among which they can hardly find the important ones and then need to make a huge effort in order to interpret them correctly. There may also be no change to the business process management at the tactical level. This was left out of figure 3 entirely since the AUS information systems concept does not refer to this level at all.

The difference between a traditional system and the AUS becomes visible when the computer independently, and without human participation, attempts to describe the properties and consequences of the ratios computed. The results of automatic interpretation are expressed in the categories of the applied description language for the interpreted data properties. The above-mentioned language is a key element at this stage. It must be designed with great know-how. Its construction must therefore be based on collecting and systematising expert knowledge. Referring to the analogy with medical image automatic understanding systems, which were earlier said to be the area of some fully successful implementations of ideas described here, one could say that just like in medical systems (Ogiela, Tadeusiewicz, 2003) the basis for the development of the language subsequently used for semantic image interpretation (and diagnosing a disease) were some specified changes in the shape of the analysed organs. In the AUS-type information systems the basic constructing units of the developed language should be changes of some specified business indicators.

6 APPLICATION OF MATHEMATICAL LINGUISTIC APPROACH AS A KEY POINT OF NEW IDEA

Of course, focusing attention on a business index and ratio changes computed in the input part of the analysed AUS-type information system, as only on those elements, which should be the basic components of an artificial language, is just the first step. The listing and appropriate categorisation of changes that should be registered in linguistic business processes corresponded only to the stage at which one defines the alphabet to be later used to build words and sentences, i.e. the language main object. In order to make it possible to create from the elements of this alphabet counterparts of words and sentences for subsequent use by the AUS to describe the states of business process, which require understanding and interpretation, calls for an introduction of additional mechanisms. These mechanisms would enable combining the above-mentioned sentences into larger units. Therefore, at a level superior to the above-described alphabet one must build the entire grammar rules and transformations. This grammar can then be used to create complete languages of description expressing important content, necessary to understand automatically the analysed processes.

In medical image understanding systems we constantly refer to, at our disposal were tools detecting local changes in the shape of some specified internal organs and their morphologic structures (Tadeusiewicz, Ogiela, 2004). These were the above-mentioned ABC-base. To understand the state of a given organ correctly, one needed to add to these graphic primitives their mutual spatial relations and combine them with anatomy elements. Owing to a definition of rules and the grammar constructs connected with them, one could combine for example a graphic category 'change of edge line direction of a specified contour' with a meaning category 'artery stenosis anticipating a heart failure.'

Similarly, by building into the proposed language grammar the ability to associate business changes detected in various parts of the managed company and its environment as well as the possibility to trace and interpret time sequences of these changes and their correlations, it will be possible, for example, to understand what are the real reasons behind poorer sales of goods or services offered. As a result it will be, for example, possible to find out about the fact that this is due to the wrong human resources policy rather than the wrong remuneration (bonus) system.

After the development of an appropriate language which will (automatically!) express semantically oriented descriptions of phenomena and business processes detected in the business unit (e.g. a company) as supervised by the information system, a further AUS information system operation will be very similar to the structure in which function the medical systems previously built by this system authors. The starting point for the business data automatic interpretation process, the process finishing with understanding their business meaning, is the description of the current state proposed in the system. It is expressed as a sentence in this artificial language, built specially for this purpose. Without going into details (described, among others, in earlier publications listed in the bibliography) one can say that the above-mentioned language description for a human being is completely illegible and utterly useless. A typical form of such notation is composed of a chain of automatically generated terminal symbols. Their meaning is well based in the mathematically expressed grammar of the language used. Yet from the human point of view this notation is completely illegible.

7 CONCLUSIONS

This paper presented the problem of divergence of IS to accommodate needs imposed by current changes to business. The disparity between the needs and real capacity of IS can be observed by analysing the computer management support association with a need for making strategic decisions. To make this term clear let us specify that in this paper, we understand that all decisions taken at various levels of company management can be perceived as strategic if they are not limited to a simple regulation of stable business processes but which induce and impose changes. Therefore, strategic decision making cannot be made solely on the basis of information about the current state of affairs in the on-going business processes. Their essence can change the state of affairs. For this reason, current IS, focused mainly on registration and settlement functions are insufficient to support such decision-making processes.

The analysed steering functions, as has been realised, are decisions that go far beyond simple tactic management, and are executed by issuing detailed commands and giving simple tasks whose execution can be assessed based on a small number of well-defined parameters. There are a number of Information Systems that support tactic decisions but for a real support of strategic decisions there are practically no acceptable methods. At the same time, the growing complexity of modern business processes, taking place in the conditions of global economy, results in that more and more people have to make such difficult decisions. Many of the decision makers are not ready prepared for this situation, neither professionally nor mentally.

It makes sense to support their work with IS of the proposed AUS-type information system. The system would be equipped with previously unavailable methods to process of the data semantics for supporting the management in the strategic decision making.

We have outline the concept structure that could be the basis for such an AUS-type system dedicated to the automatic business data understanding. We have tried to demonstrate briefly that a will to build such a system is an objective worth aiming at.

In the most competitive global market, the economy cannot be treated as a "zero-sum" game in which the success of some businesses must necessarily be based on (or depends on) the failure of others.

The economy is not a zero-sum game, which suggests that the success of one particular business does not infer the automatic failure of another business. Quite the contrary, the whole global economy is more and more oriented towards looking for solutions that can be referred to as "win-win solutions", i.e. solutions resulting in success for all participants, although each of them may be active in different fields that have been achieved via different scopes. For such an economy, implementing the innovation based on the AUS concept and on cognitive premises and methods, this should be interpreted not as a source of threat but rather as another factor for global growth and development.

ACKNOWLEDGEMENTS

This work has been supported by the AGH University of Science and Technology under Grant No. 10.10.120.783

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