INTEGRATING ARTIFICIAL INTELLIGENCE INTO ORGANIZATIONAL INTELLIGENCE

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Abstract: *Organizational intelligence is the capability of an organization to create knowledge and to use it in order to strategically adapt to its environment. Intelligence of an organization is more than the aggregated intelligence of its members – it is an emergent property of the complex interactions of its subsystems and the way they are aggregated. Processes analyse related to organizational intelligence can be achieved by means of agent-based simulations. Distributed artificial intelligence addresses the study and design of systems composed of several interacting entities, which are distributed from the logical and often spatial point of view, considered in a certain sense autonomous and intelligent. An intelligent agent is a hardware or (especially) software system that is autonomous and situated in its environment and enjoys the following properties: autonomy, reactivity, pro-activeness and social ability. Organizational intelligence can be improved by extracting aggregated information about past experience which can be analysed and used in current situations. This helps organizations to understand past tendencies respectively outcomes and to anticipate future trends by applying previous patterns from organizational data.*

Key words: organizational intelligence, intelligent agents, computational organization theory, knowledge management, data mining.

1. Intelligence and organizational intelligence

Organizational intelligence is the capacity of an organization to create knowledge and use it to strategically adapt to its environment or marketplace. It is similar to and individual IQ, but generalized at an organizational level. The capacity for human problem solving is composed of several facets, such as "emotional intelligence" coupled with the more traditional form of "rational intelligence". In a similar way, organizational intelligence is defined as the problem-solving capacity of an organization created by various subsystems (Halal,1997). In everyday life, we recognize people as intelligent by the way they speak and the way they act. For example, an intelligent person may be characterized by an exceptional ability to extract complex information from the outside world, an exceptional ability to respond appropriately to this information, or an ability to learn quickly. Intelligence can be divided into five specific abilities (Veryard, 2000):

- *Perception:* the ability to make complex observations about the environment.
- *Information processing:* the ability to handle and transform information, all forms of reasoning.
- *Memory:* the ability to store and reuse information.

- *Learning:* the ability to develop new knowledge and capabilities and use the accumulated experience.
- *Adaptability:* the ability to flexibly adapt one's behaviour to the current situations.

Similar to human beings, an organization may behave in intelligent or non-intelligent ways. Also, there is often no relevant relationship between the collective intelligence of the organization and the individual intelligence of the people in the organization. An organization is a socio-technical system, and may be composed of many inter-operating systems, each endowed with some form of intelligence. The human intelligence of many employees is combined with the artificial intelligence of machines, contained in intelligent buildings and distributed through intelligent cyberspace.

However, many of the intelligent components do not add up to an intelligent organization. To make an intelligent organization, it is not enough to recruit the brightest people, locate them in state of the art office buildings, and provide them with the smartest computer tools and fastest networks. Very intelligent individuals are often poor at talking to one another and sharing knowledge, or coordinating their work effectively. Each individual may only make a given mistake once, but if the people do not communicate to each other, the same mistake can be repeated many times without any organizational learning. Even if an organization is collectively ignoring major threats and opportunities in its environment, this does not mean that the individual employees are unaware of these threats and opportunities. Intelligent people get very frustrated and unmotivated in unintelligent organizations, because they can see what is happening, and more than that they can often see what needs to be done. The frustration is even much more bigger than, because but they do not have adequate channels of communication or action. Organizational intelligence is what systems theory calls an *emergent property*, an attribute of the whole system, not of the individual parts. The most important is the way in which the parts of the organization are combined.

2. Intelligent agents for the study of organizational intelligence

Knowledge-based society sustained by knowledge-based economy signifies a new era for education, information, and the correlation of economic data in complex contexts. In this framework, knowledge becomes increasingly important for economic power and social cohesion, as well as for the increase in people living standard. The social transformations cause a new perspective over education with the purpose of reducing the risks associated with informational gaps and social isolation (Sampson, Karagiannidis and Kinshuk, 2002).

Knowledge, intellectual capital, intellectual property tend to replace money as the most important resource of the business environment. The success in the new economy is given by knowledge management, i.e. the ability to retrieve, store, maintain, develop, share and use knowledge. Information cannot be efficiently integrated without an initial knowledge base to allow the interpretation and understanding of new observations. Different persons can interpret the same information in different ways, and can reach different conclusions regarding their significance, based on their own experience. Subjects have personal cognitive filters (Rzevski, 2002) which control the access of information to the secondary processing mental functions (representation, memory, reasoning). The fine tuning of cognitive filters is done by interaction within the group members, which explains why people that belong to the same culture tend to perceive the world in a similar manner. An accelerated fine tuning of these filters can be achieved by education or training. In knowledge-based society and economy, operations such as finding relevant information and aggregating it into pieces of knowledge need to be automated. In a complex, unpredictable environment, intelligent agents are available tools to create, search and structure knowledge.

Analyses of processes related to organizational intelligence can be achieved by *agent-based simulations*. Distributed artificial intelligence refers to the study and design of systems formed of many interacting items, logically and often spacially distributed and that can be considered in a certain sens autonomous and intelligent (Weiß and Sen, 1996). Most classical artificial intelligence systems are static, with a predefined architecture, while agent-based systems can be dynamically modified in time. Distributed artificial intelligence studies the problems related to the design of distributed, interactive systems. An intelligent agent is a hardware or (especially) software system, which exhibits the following properties:

- *Autonomy:* the agent operates as a self-contained process, without direct human intervention and is in control of its own actions and internal state;
- *Situatedness:* the agent has a well defined location within its environment;
- *Reactivity:* the agent perceives its environment (which can be for example the physical world, a user through a graphical interface, a collection of other agents, the Internet etc.) and responds in a timely manner to the changes that take place in that environment;
- *Pro-activeness:* the agent not only reacts to the changes in its environment, but is capable of taking initiative and display a goal-oriented behaviour;
- *Social ability:* the agent can interact with other agents (or with humans) through a certain communication language.

A group of agents can form a system. The group defines the roles, and these define the associated commitments. When a new agent enters into such a system, it enters on a certain role. It autonomously joins the organization, but must accept the constraints

resulted from the commitments of that role. The organizations define the social context where agents interact. Social commitments are the commitments of an agent toward another. They represent a flexible way to contrain the autonomous behaviour. Closely related to them is the concept of social dependency, defined as (Huhns and Stephens, 2000):

$$(SocialDependency\ x\ y\ a\ p) \equiv (Goal\ x\ p) \text{ and } (CanExecute\ x\ a) \text{ and } (CanExecute\ y\ a) \text{ and } ((ExecutedBy\ y\ a) \Rightarrow (Achieve\ p)) \quad (1)$$

Agent x depends on agent y regarding action a to reach goal p, which x cannot achieve, while y can. Cooperation is a form of reciprocal dependency, when x and y depend on each other to achieve different goals: p_x for x and p_y for y:

$$(Cooperation\ x\ y) \equiv \exists p_x\ \exists p_y\ ((SocialDependency\ x\ y\ a_y\ p_x) \text{ and } (SocialDependency\ y\ x\ a_x\ p_y)) \quad (2)$$

Ideally, all the agents that belong to an organization should always cooperate to find optimal or at least acceptable solutions to the problem of fulfilling individual goals. Nevertheless, agents often have opposite goals that can result in a competitive behaviour.

In literature, algorithms such as DFG, Dissolution and Formation of Groups (Weiß, 1994), are described dealing with the ways the groups appear and dissolve in multiagent systems, how agents coordinate their actions and how agents specialize to some roles. These algorithms try to formalize two processes inherent to distributed learning: assigning merit, i.e. the approximation of the relevancy of agent and group activities from the point of view of the whole system goal, and group dynamics, i.e. the formation of new groups and the disappearance of old ones. The goal of the algorithms is to allow the coordination the agent actions in the multiagent system under consideration.

3. Computational Organization Theory

In general, organizations are characterized as (Carley and Gasser, 2000):

- a paradigm for large-scale problem solving;
- comprised of multiple agents (human, artificial, or both);
- engaged in one or more tasks; organizations are systems of activity;
- goal directed (however, goals can change, may not be communicated properly, and may not be shared by all organizational members);
- able to affect and be affected by their environment;

- having knowledge, culture, memories, history, and capabilities distinct from any single agent;
- having legal standing distinct from that of individual agents.

One rationale for the existence of organizations is that they exist to overcome the limitations of individual agents. From this point of view, there are four basic limitations:

- *Cognitive Limitations: a*gents as boundedly rational actors have cognitive limitations and therefore must join together to achieve higher-levels of performance;
- *Physical Limitations: a*gents are limited physically, both because of their physiology and because of the resources available to them, and therefore must coordinate their actions, e.g. to achieve higher-levels of productivity; all action takes place situated in specific locations, and agents are limited in their access to other locations; this fundamental locality means that distributed action is fundamentally a multiagent, and hence potentially organized, phenomenon;
- *Temporal Limitations:* agents are temporally limited and therefore must join together to achieve goals which transcend the lifetime of any one agent;
- *Institutional Limitations:* agents are legally or politically limited and therefore must attain organizational status to act as a corporate actor rather than as an individual actor.

Researchers in the field of Computational Organization Theory use mathematical and computational methods to study both human and automated organizations as computational entities. Human organizations can be viewed as inherently computational because many of their activities transform information from one form to another, and because organizational activity is frequently information-driven.

Computational Organization Theory attempts to understand and model two distinct but complementary types of organization. The first is the natural or human organization which continually acquires, manipulates, and produces information, and possibly other material goods, through the joint, interlocked activities of people and automated information technologies. Secondly, Computational Organization Theory studies artificial computational organizations generally comprised of multiple distributed agents which exhibit collective organizational properties (such as the need to act collectively, an assignment of tasks, the distribution of knowledge and ability across agents, and constraints on the connections and communication among agents). Researchers use computational analysis to develop a better understanding of the fundamental principles of organizing multiple information processing agents and the

nature of organizations as computational entities. The general aims of research in this area is to build new concepts, theories, and knowledge about organizing and organization in the abstract, to develop tools and procedures for the validation and analysis of computational organizational models, and to reflect these computational abstractions back to actual organizational practice through both tools and knowledge.

The original information processing perspective basically argued simply that agents were boundedly rational, that information is ubiquitous in the organization, and that the organization itself becomes a computational system. Today there is a neo-information processing perspective on organizational behaviour that extends and refines this early view. The basic views of this neo-information processing perspective on organizations are:

- *Bounded rationality:* there are two types of bounds for the organizational agents, limits to capabilities and limits to knowledge; capabilities depend on the agents' cognitive, computational, and physical architecture; knowledge depends on the agents' ability to learn and the agents' experience; the agents' position in an organization influences to which information an agent has access, thus, an agent's knowledge of how to do specific tasks, how its specific organization operates, and how organizations operate in general, is a function of what positions the agent has previously held;
- *Information ubiquity:* within organizations large quantities of information in many different forms are widely distributed across multiple agents; the information may not necessarily be correct;
- *Task orientation:* organizations and the agents within them are continually engaged in performing tasks; the tasks in which an organization and its constituent agents are engaged require these agents to communicate, build on, analyze, adapt or otherwise process organizational information using various technologies, and to search out new information and new solutions;
- *Distributional constraints:* organizational performance is a function of what information is shared by whom, when, and of the process of searching for that information; the culture of an organization is the distribution of the knowledge and processes across the agents within it; this distribution affects the extent and character of socially shared cognition, team mental models, group information processing, and concurrent information analysis;
- *Uncertainty:* uncertainty about task outcomes, environmental conditions, and about many other aspects of organizational life influences organizational activity; distributed computational models such as distributed search or distributed constraint satisfaction pose distribution itself as a source of uncertainty: distribution can render critical uncertainty-

reducing information less available because of the cost of seeking, transmitting, or assimilating it, and because of the overhead of coordinating information needs across agents;

- *Organizational intelligence:* organizational intelligence resides in the distribution of knowledge, processes, procedures across agents and the linkages among agents; organizations redesign themselves and their vision of their environments on the basis of the information available to them, with the aim of enabling them to better search for or process information; such redesign is part of organizational learning processes, can alter the intelligence of an organization, and may or may not improve organizational performance;
- *Irrevocable change (path dependence):* as agents and organizations learn, their intelligence is irrevocably restructured; this one-directional evolution means that the kind and order in which things are learned can have dramatic consequences on future actions;
- *Need of communication:* in order to function as a unit, agents within an organization need to communicate; this communication may take place explicitly by sending and receiving messages or implicitly by perceiving the actions of others.

In addition to this neo-information-processing view of organizations researchers in this area share a series of implicit background assumptions (Carley and Gasser, 2000). These are:

- *Modelability:* organizational phenomena can be modelled;
- *Performance differential:* it is possible to distinguish differences in organizational performance;
- *Manipulability:* organizations are entities that can be manipulated and transformed;
- *Designability:* organizations can be designed; this is not to say that organizations do not evolve, nor that they cannot be found in nature, for assuredly both events occur, however, they can also be consciously designed and redesigned: organizational transformations can be purposeful and principled;
- *Practicality:* organizational transformations based on the design or manipulation of models can be transferred into and implemented in actual practice;
- *Pragmatism:* the costs of modelling and researching organizations using computational methods are relatively lower than the costs of manipulating or researching similar aspects of actual organizations, and the benefits gained outweigh the costs.

4. Improving organizational intelligence

Organizations facing a flat and unchanging environment may not need much intelligence, but organizations facing diverse and turbulent environments may need much higher degrees of intelligence. To the extent that organizational intelligence costs something to develop and maintain, this investment may be justified in the latter case, but not in the former case. But there is a widespread belief that there is a universal trend away from flat and unchanging environments towards diverse and turbulent ones, and this seems to entail a greater overall need for organizational intelligence.

Improvements in organizational intelligence are generally both possible and desirable. The benefits of such improvements are manifold. The organization is likely to become more successful in the short term, and have greater prospects for survival and growth in the longer term. Staff morale is likely to improve, and the individual employees will themselves have greater opportunities for personal growth and fulfilment. In the broader socio-economic system, intelligent organizations will create more wealth, not merely economic wealth but in human potential. In order to increase intelligence, people should first try to eliminate what hinders the intelligence of an organization. Lack of intelligence is not about making mistakes, but repeating them. Veryard (2004) emphasises the importance of identifying and eliminating the barriers against intelligence and creativity within an organization by using:

- *Communication strategies:* address the extent to which meanings and intentions are successfully shared across the organization, especially between multiple subcultures, address the extent to which the organization is successful in speaking to its stakeholders, and in hearing what its stakeholders are saying to it;
- *Group dynamics:* address how people work together, the psychological structures and processes of the teams and groups making up the organization;
- *Knowledge management:* addresses how ideas, information and intellectual property are developed, disseminated and deployed within the organization;
- *Process improvement:* addresses the congruence or lack of congruence between business processes and the goals and values of the organization, the extent to which business processes improvement is dependent upon external intervention, or whether learning is integrated into the system itself;
- *Risk management:* addresses the extent to which individuals and groups within the organization face up to or retreat from the challenges and uncertainties of the task;

- *Space management:* addresses the physical environment in which the organization lives, the congruence or lack of congruence between business processes and the physical space that contains them;
- *System investment and evaluation:* address how the costs, benefits and risks of new and proposed technologies, systems and environments including physical environments are distributed inside and outside the organization, the congruence or lack of congruence between IT and property investment on the one hand, and the goals and values of the organization on the other;
- *Technology management:* addresses how new technologies and systems are implemented and used by the organization, the congruence or lack of congruence between human systems and technical systems.

5. Data mining techniques for the development of organizational intelligence

Data mining is the process of extracting hidden knowledge from large volumes of raw data. It can also be defined as the process of extracting hidden predictive information from large databases. Organizational intelligence, typically drawn from an enterprise data warehouse, is used to analyze and uncover information about past performance on an aggregate level. Data warehousing and organizational intelligence provide a method for users to anticipate future trends from analyzing past patterns in organizational data. Data mining is more intuitive, allowing for increased insight beyond data warehousing. An implementation of data mining in an organization will serve as a guide to uncovering inherent trends and tendencies in historical information. It will also allow for statistical predictions, groupings and classifications of data.

Most companies collect, refine and deduce massive quantities of data. Data mining techniques can be implemented rapidly on existing software and hardware platforms to enhance the value of existing information resources, and can be integrated with new products and systems as they become part of the system. When implemented on high performance client/server or parallel processing computers, they can help to analyze massive databases and deliver answers to many different types of predictive questions. Data mining software allows users to analyze large databases to solve organizational decision-making problems. Data mining tools predict future trends and behaviours, allowing organizations to make proactive, knowledge-driven decisions. They can answer organizational questions that traditionally were too time-consuming to resolve. The most commonly used data mining methods are presented as follows:

- *Association:* the capability of identifying nontrivial subsets of simultaneously occurring actions and situations;
- *Classification:* the extraction of data subsets according to some common set of attribute values;

- *Clustering:* the unsupervised grouping of data based on some common features;
- *Prediction:* the possibility to identify the future evolution of an instance based on past recognized behaviour.

Association rule induction is a powerful method, which aims at finding regularities in the trends of the data. With the induction of association rules one tries to find sets of data instances that frequently appear together. Such information is usually expressed in the form of rules. An association rule expresses an association between (sets of) items. However, not every association rule is useful, only those that are expressive and reliable. Therefore, the standard measures to assess association rules are the support and the confidence of a rule, both of which are computed from the support of certain item sets.

Arranging objects into groups is a natural, necessary skill. There are many possible rules that we can use to assign objects to groups, i.e. to classify them. Cluster analysis is a rather loose collection of statistical methods that can be used to assign cases to groups (clusters). Group members will share certain properties in common and it is hoped that the resultant classification will provide some insight into our research topic. The classification has the effect of reducing the dimensionality of a data table by reducing the number of cases. The problem of finding subclasses in a set of examples from a given class is called unsupervised learning. The problem is easier when the feature vectors for objects in a subclass are close together and form a cluster.

Categorization or classification is the process of assigning individuals to classes on the basis of their characteristics. It is one of the most studied reasoning activities, as it is useful for almost every field of human knowledge. Automatic classification techniques developed by machine learning and statistics researchers achieve excellent performance, given sufficient structure in the underlying relationship between characteristics and categories, and given sufficient data describing the relationship. Accurate classification requires prior knowledge as to the relationship between possible categories and the patterns of feature values that will be encountered. The learning phase of classification is concerned with assembling this knowledge. Learning is complicated by the fact that data encoded from a stimulus may be insufficient to fully explain the categorization. There may be missing values or noise in the data, and the categorization may depend on features not encoded, or there may be interactions between features that have been encoded and features that have not. As well, underlying relationships may change over time. Decision problems (in the technical sense) are problems that have a set of instances associated with them with some characteristic size and a binary decision question. Decision tree induction offers a highly practical method for generalizing from instances whose class membership is known. The most common approach to induce a decision tree is to partition the labeled instances recursively until a stopping criterion is met. The partition is defined

by selecting a splitting test in the tree, such that a branch is created for each possible outcome. A useful splitting criterion is the entropy gain that ensures that every time the choice with the highest information value is considered for tree branching. Prediction is straightforward once the data model has been created. If the data mining algorithm is complete, any new instance can be placed in a uniquely defined class.

6. Conclusions

The present paper describes the use of new modern tools of artificial intelligence for the evaluation of organizational intelligence belonging to different layers of contemporary society, from companies to educational organizations such as universities. Since nowadays the most important capital appears to be knowledge, and taking into account that universities are a common place for generating, transferring, and disseminating knowledge, the synthesis presented here will be used for developing a basic methodology of assessment of intellectual capital in higher education institutions. Especially for educational institutions such as universities in a corporate view of the 21st century, the organizational intelligence is in a logical correlation with new social and economical development which assumes new commitment roles in this organization.

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