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ADVANCES IN COMPUTER AND INFORMATION SCIENCES

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ABSTRACT
Value of the contributions of the scientists to 15 consecutive ISCIS (International Symposium on Computer and Information Sciences) is recognized. The shift of paradigm emphasizing ability to process knowledge is stressed. A taxonomy of knowledge processing tools, machines, or systems is offered. Major possibilities for future achievements that the author would like to underline are listed with emphasis on agent technology, agent-directed simulation, and contribution of system theories for cognitive abilities in computerization.

Keywords: computer science, shift of paradigm, taxonomy, system theories, agents, holons, agent-directed simulation, holon simulation

1. INTRODUCTION

It is a great source of pride and joy for all the contributing scientists coming from several countries as well as for their Turkish counterparts to be part of the 15th annual ISCIS (International Symposium on Computer and Information Sciences). The ever increasing care and the quality of the organization of ISCIS over the years continues to attract the best of the scientists in the field. An aphorism states: "One can be part of civilization to the extent one contributes to its advancement and not by procuring and using/consuming its products and/or services alone." A cumulative bibliography of the ISCIS Proceedings (Diri 2000) reflects the international efforts for the accumulation of advanced knowledge on Computer and Information Sciences and hence testifies the ISCIS' contributions to the advancement of contemporary civilization.

2. KNOWLEDGE, KNOWLEDGE PROCESSING, AND THE SHIFT OF PARADIGM

For a long time in the history of civilization, being knowledgeable was an important asset. Information age realities provide tools to store and interactively access a vast amount of knowledge. Hence, they challenge the value of being knowledgeable (in the sense of storing in his/her brain a vast amount of facts, alone). For example, almost half of the books I have in my private library are on a single CD-ROM (Corel

1995). It contains over 3500 classical books that are searchable interactively. Recent announcements of some encyclopedia include, for example, Encyclopédie Hachette 2001 which comes in three CD-ROM or one single DVD-ROM (Hachette 2000). Similarly, Encyclopedia Universalis, planned for release at the end of October 2000, will come in five CD-ROM or in one single DVD-ROM (Universalis 2000). In the beginning of the advent of notebook computers, we had a transition period during which the volume of the documentation of the software loaded on the computer was much larger than the volume of the computer itself. Nowadays, the documentation resides on the hard disk. Similarly, all the knowledge we get through formal education can reside on a single CD-ROM where the knowledge can be stored for interactive seearch without any loss. Libraries were places to work as repositories of human knowledge. Now, information technology shrinks drastically the storage requirements and offers interactive search capabilities. Furthermore, with Internet geography became history.

Independent of the medium on which knowledge resides, paper, CD-ROM, DVD-ROM, or hard disk, information age has brought its own shift of paradigm: knowledge processing ability became more important than knowledge itself. Indeed, knowledge is necessary but not sufficient to solve problems. For example, no library or no CD-ROM can solve a problem. Therefore, knowledge processing and especially cognitive knowledge processing have to be explored to get the benefits of computerization. A taxonomy of over 500 types of knowledge and knowledge processing knowledge was given by Ören (1990).

3. KNOWLEDGE PROCESSING EVERYWHERE

Knowledge processing is done by two types of machines or systems: machines for knowledge processing and machines with knowledge processing abilities. Each group can further be divided into three categories, namely, fixed-wired tools or machines, variably-wired tools or machines, and stored-program tools or machines.

3.1 Machines for Knowledge Processing

These types of tools or machines are built for the sole reason of knowledge processing.

Fixed-wired tools or machines for knowledge processing have existed for a long time and the archtype, the abacus still exists. The relationship of the elements are fixed. As an abacus would inspire, they are indeed fixed-wired tools. Some other examples of fixed-wired knowledge processing tools are: astrolabe (Nasr 1976), Al-Biruni's gear calendar computer and hodometer (Price 1984), and bar-linkage computers (Svoboda 1965).

Variably-wired tools or machines for knowledge processing include unit record machines (also called punched card machines), analog computers, and hybrid computers (de Beauclair 1968). When I started to work for a computer company in Turkey in 1963, unit record machines were in use as there was only one computer in the country at the time.

Stored-program tools or machines for knowledge processing are basically digital computers with all the variants: personal computers, notebook computers, digital assistants, palm computers, and wearable computers. Paraphrasing Kay (1984) who stated "Computers are to computing as instruments are to music," we can define a computer as an instrument to execute programs. Computers are already used extensively. But it seems this is only the beginning. (Ören 1990, Denning and Metcalfe 1997).

3.2 Machines with Knowledge Processing Abilities

Primary goal for machines with knowledge processing abilities is not knowledge processing; however, with their knowledge processing ability they can perform their task much better.

Fixed-wired tools or machines with knowledge processing abilities include several types of historic automata (al-Jazari 1205). Akman (1976) re-introduced Turks to the works of al-Jazari.

The archtypical example to *variably-wired tools or machines with knowledge processing abilities* is the Jacquard loom. The machine under the control of punched 'cards' could weave different patterns. Furthermore, the punched cards used by the Jacquard looms were the inspiration for the punched card knowledge processing machines: first the unit records and afterwards the punched card computers.

Stored-program tools or machines with knowledge processing abilities are the most important applications. They can be computer-embedded machines (CEM) or computer-embedded systems (CES). When the emphasis is on the computer, they can be referred to as embedded systems. CEMs or CESs are the essence of intelligent machines (Kurtzweil 1990) and can automate functions at different degree of sophistication:

1. In some systems, parameters and some other values can be set based on some automatically measured/computed values (e.g., in a camera, to set film speed, to measure and set distance, to measure light and to set the lens aperture and shutter speed, and to automatically fire the flash); another example is reprogrammable pacemakers that existed since a long time as a forerunner of implantable computers.

2. Intelligent cars, utilities, and buildings can have several functions performed by the embedded computers.

3. Optimizing systems such as a tracking missile can perform its mission with a high degree of effectiveness.

4. Knowledge-based, rule-based, or agent-directed systems can benefit from their advanced knowledge processing abilities.

5. Simulative systems can evaluate, via embedded simulation ability, the outcome of different alternatives and can automatically select most desirable one.

4. WHAT'S NEXT?

Computers are still very young. They are younger than myself, for example. We can expect to have advancements on many fronts. An excellent book prepared on the 50th anniversary of the field of computing provides a review of past achievements and future projections (Denning and Metcalfe 1997). Major possibilities for future achievements that I would like to underline are:

1. Software *agents* provide a solid computational paradigm to implement software assistants working (quasi-) autonomously and having perception abilities to observe the existence or lack of some characteristics or events and other abilities to affect their environments. Furthermore, they can process goals and can perform goal-directed knowledge processing.

2. *Mobile agents* and distributed computing extend the concept of computational platform to whole or part of the net on intranets and on the Internet.

3. System theories provide strong backgrounds for cognitive, i.e., intelligent, computerization. For example, systems with *understanding* abilities (Ören 2000), systems with *learning* abilities (Osherson et al. 1986), systems with *adaptation* abilities, and systems with *anticipation* abilities (Dubois 2000) would provide bases for cognitive knowledge processing. Agents are natural candidates for the implementation of systems with cognitive abilities.

4. *Cooperation* is becoming an important paradigm for both civilian and military applications. Holonic systems are excellent candidates to conceive, model, control, and manage dynamically organizing cooperative systems. A *holonic system* is composed of autonomous entities (called *holon*s) that can deliberately reduce their autonomy, when need arise, to collectively achieve a goal. A *holonic agent* is a multi-agent system where each agent (called a holon) acts with deliberately reduced autonomy to assure harmony in its cooperation in order to collectively achieve a common goal.

5. *Agent-directed simulation* is very promising and consists of agent simulation, agent-based simulation, and agent-supported simulation. *Agent simulation* allows simulation of natural or engineered entities with cognitive abilities. Therefore, agent simulation is very appropriate for the simulation of intelligent entities. *Agent-based simulation* is use of agent technology to generate behavior of models. (Parallels with AI-based simulation are knowledge-based simulation, qualitative simulation, and rule-based simulation.) *Agent-supported simulation* is use of agent technology to support simulation activities; they comprise front-end and back-end activities of a modelling and simulation environment, agent-supported validation and verification, as well as agent-supported program generation, program

integration (as it would be the case in the formation of federations using HLA), and program understanding for documentation and/or maintenance purposes.

6. *Holonic agent simulation* or *holon simulation*, in short, is an important type of agent simulation where agents represent holons. Some military application include use of simulation for preparedness for conflict management including conflict avoidance and conflict resolution.

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