Requirements of AI Models Applicable to Organizational Learning Theory and Two Related Examples *

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Abstract

This paper discusses the requirements of AI models applicable to organizational learning theory. The discussion focuses on the performance learning via shared knowledge and the interaction among the organizational environments. To validate the requirements, then I examine the principles of two AI systems recently developed in my research projects. The one intends to simulate human articulation processes for making new product concepts from the experience of past-invented products. The other is a simple alife system implemented in an object-oriented architecture, in which an alife partially interacts with the uncertain alife environment.

1 Introduction

The high productivity of Japanese production systems are well-known. Various analyses have been carried out to explain the principles (e.g., [Greene 1990],[Monden 1983]). However, in my opinion, conventional organization and management theory has not succeeded in the explanation. The *theory* should formally explain the mechanisms of such typical activities in Japanese companies as *Kaizen*, *Nemawashi*, and so on. The important but difficult features of these activities are that they heavily rely on informal information processing among members and cannot be quantitatively measured.

The concepts of *organizational learning* (e.g., [Cohen 1991]) or *organizational intelligence* (e.g., [Matsuda 1992]) in organization science certainly give us interesting viewpoints. However, the provided models are simply described in the arguments of papers or books. They are hardly validated by experiments or observations. On the other hand, traditional computer models for understanding organizations ([Cyert 1963]) are too numerical to explain the people's behaviors in the organizational systems.

Recent advances in Artificial Intelligence have made it possible to re-examine Simon's approaches with *physical symbol systems* hypothesis [Simon 1982]. To develop a rigorous theory on organizational learning, therefore, I believe AI *symbolic* approaches are promising because of their descriptive powers and capabilities of computer simulation. In this sense, I fully agree with the statements in [Carley 1992].

In this paper, first, I will discuss the requirements of AI models applicable to organizational learning theory. Second, in order to validate the requirements, I will examine the principles of two AI systems, which have been recently implemented in my research projects, to organizational theory. Unlike systems found in [Masuch 1992], these systems have not originally aimed at developing organization models. Although the limitation, the results can be interpreted by means of organizational learning. Third, some concluding remarks are given for future works referring to Nonaka's interesting theory of organizational knowledge creation [Nonaka 1990].

2 Requirements on AI Models for Organizational Learning

To develop AI models for organizational learning, of course, we must define the strict meanings of the terms: *organization* and *learning*. The essential features of an organization are that it has plural *members* or *agents*, and that it works for *common goals* among the members. By *learning*, I mean both inductive and deductive learning implemented by *symbol processing* functions in usual AI techniques.

Furthermore, we must distinguish the learning by each member and the one by an organization. The former has been studied in the literature of conventional machine learning, however, there have been few researches on the latter themes. The organization, in practice, learns both problem solving and performance improving knowledge for achieving the common goals. This is attained by using the implicit/explicit shared knowledge among the members and the interaction among both the members and their environments.

Based on the discussion, therefore, to analyze the concepts of organizational learning, the requirements on the AI models are summarized in the following:

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(1) **Representing Common Goals**
The common goals or objectives of the learning should be explicitly given in advance. If not, the goals must be emerged from the problem solving through the self organization process of the agents

(2) **Working in a Distributed Environment**
The models must include the concepts of *Distributed Artificial Intelligence*, e.g., distributed problem solving, interaction of intelligent agents and the environments. The models must work in a distributed environment. If the agents do not communicate each other for cooperation, coordination, negotiation, or competition, the learning can be simply explained by conventional learning theories.

(3) **Learning of Organization and Individual Agents**
As is stated above, The models have clear concepts of *learning of organization*. The theory must distinguish the learning of organization and the learning of each agent. The effects of organizational learning may be different from the ones of individual agents.

(4) **Improving Problem Solving Capability**
The models must have the ability of improvements of problem solving capability of both each agent and the organization. By the improvements, we mean both the extension of problem domain and the performance improvement.

(5) **Inductive and Deductive Learning**
The model makes clear the difference of organizational learning between the increases of knowledge by inductive learning and the performance improvements by deductive learning.

3 Two AI Systems Related to Organizational Learning

In this section, I will examine the applicability of two recent results of my research projects from the viewpoints of performance learning via shared knowledge and the interaction among the organizational environments. The one intends to simulate human articulation processes for making new product concepts based on the experience of past invented products [Kudou 1993]. The other is a simple alife (artificial life) system implemented in an object-oriented architecture [Kunigita 1993].

3.1 Role of Analogical Reasoning in Organizational Product Design

In the research, we have developed an analogical reasoning system for making new product concepts. When the key concepts of a past-invented product is given, the system will generate new concepts for other products similar to the given one as is shown in Figure 1. This is attained by the technique of *Purpose-Directed Analogy* (PDA) [Kedar-Cabelli 1988].

The system has the following two components:

1) **Instance Level Analogical Component**
Using the technique of PDA, the system generates a new product concept similar to the given product with some epoch making concepts.

2) **Concept Level Analogical Component** Using analogical reasoning on the concept level of the given product, the system expands the applicability of the concept of new product generated in the first component.

The analogical reasoning is useful for finding the similarity of the purpose of past and new products. The results of the analogical reasoning rely on the purpose and the rich domain theories.

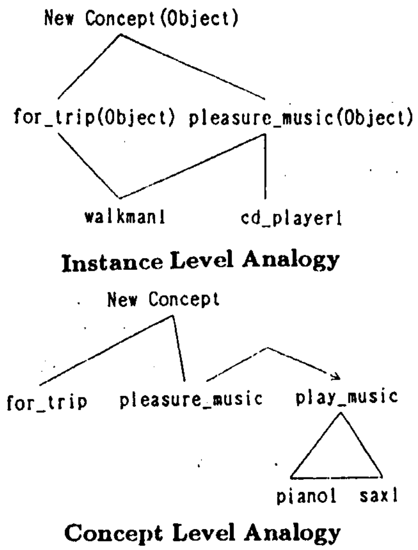

Figure 1. Analogical Reasoning for Making New Product Concepts

In this system, the goals or the purposes are given in advance. Therefore, requirement (1) in the above section is satisfied. As the system uses rich domain theories to invent new concepts, it satisfies the requirements (4) and (5). Furthermore, to satisfy the requirements (2) and (3), we can extend the system in the following way. To extend the system, we assume that the process of organizational product design depends on the ability of organizational learning, and that a new product is designed and improved through the communication between the members,

- The initial design goal or the purpose of the product is broadcasted to the members of the organization;
- Using the problem solving capability of each member, which depends on the domain knowledge of each member, some of them can develop new product concepts.
- The product concepts are evaluated by the other members based on the purpose of the product. The member can communicate each other to interchange their problem solving (intermediate) results in order to evaluate them.

3.2 Interactions with Environments for Problem Solving with Uncertainty

In the research, we have proposed a simple reinforcement learning algorithm for an alife , which solves moving target problems [Ishida 1991] under an uncertain artificial environment.

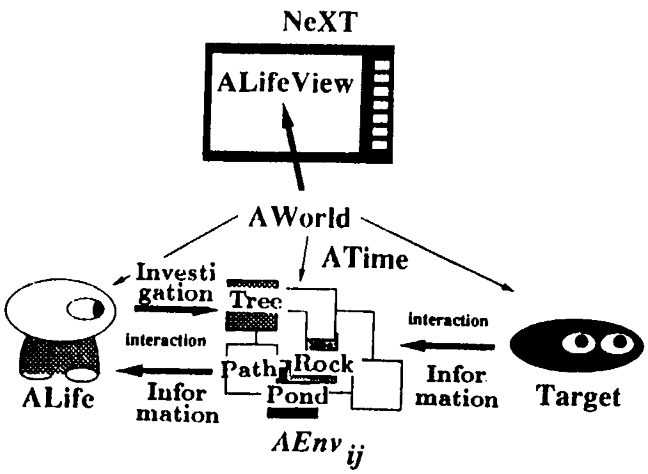

Figure 2. Architecture of the Alife System

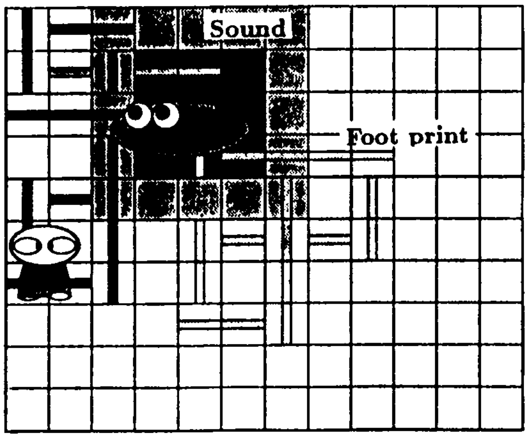

Figure 3. Alife Interacting with the Environment to Catch the Target

In the system, we assume that the alife can only interact with the current environment (cell) which may or maynot have some uncertain information about where the target is (Figure 2 and 3). The alife gradually learns, in a real time situation, which kinds of information in the environment is *important* to catch the target efficiently. The learnability of the alife depends on the biases of the movement of the target and the qualities of traces of the target in the environment.

The functions of the alife system satisfy the requirements of (1), (2), and (4). That is, the alife system can be interpreted as an organizational learning model, if the decision process of an organization has similarities to the alife system:

- the decision must be done based on the interaction with the current environment,
- there exist the uncertainty of the place of the target (e.g., the objective of competitors' strategy),
- the decision maker can utilize only partial information or short perspectives in the current environment (e.g., economical conditions, customers' preference, etc.), and
- the decision maker learns which information is important (e.g., past sales statistics of competitors).

4 Concluding Remarks: Can We Analyze Japanese Firms by AI Models?

This paper has discussed the requirements of AI models applicable to organizational learning theory. To validate the adequacy of the requirements, then the principles of two AI systems have been examined. From the examples, I will suggest that using symbol oriented AI systems, we can simulate and analyze the organizational behaviors of learning.

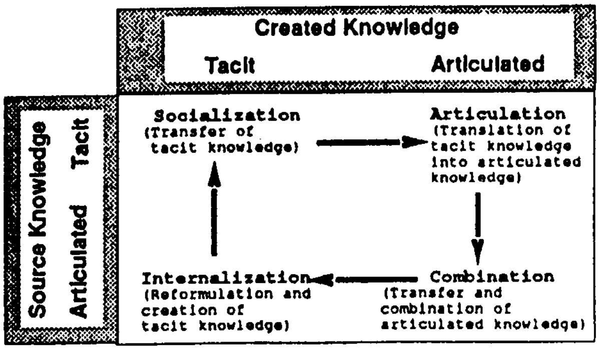

Figure 4. A Cycle of Organizational Knowledge Creation

It is said that the organizational knowledge creation process of Japanese companies is characterized by their bottom-up or middle-up/down approaches of members or agents of the organization [Nonaka 1990] [1]. If it is true, to simulate the behaviors, the agents in distributed environments must be intelligent to be able to communicate with each other and to learn by themselves unlike the conventional distributed AI models of agents [Gasser 1989].

Furthermore, Nonaka argues that there exist tacit and articulated knowledge in an organization and that an organization creates new knowledge through the cycle of (1) socialization, (2) articulation, (3) combination, and (4) internalization (see, Figure 4). Following the arguments of Nonaka's theory, in order to analyze organizational learning processes, we must represent both *articulated* and *tacit* knowledge and implement their uncertain conversion process.

It is a really hard problem to develop such AI models, however, the researches on the model focused on knowledge-intensive learning have just begun in our research group (e.g., [Terano 1993]). I believe that we can answer, at least partially, *YES* to the question in the near future.

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[1] A brief description of Nonaka's theory is found in [Kitano 1992].