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Expert systems for knowledge management: crossing the chasm between information processing and sense making

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Abstract

Based on insights from research in information systems, information science, business strategy and organization science, this paper develops the bases for advancing the paradigm of AI and expert systems technologies to account for two related issues: (a) dynamic radical discontinuous change impacting organizational performance; and (b) human sense-making processes that can complement the machine learning capabilities for designing and implementing more effective knowledge management systems.

Keywords: Expert systems; Artificial intelligence; Knowledge management; Information systems; Information science; Business strategy; Discontinuous change; Sense making; Information processing

"There has been an over-concentration on Shannon's definition of information in terms of uncertainty (a very good definition for the original purposes) with little attempt to understand how MEANING directs a message in a network. This, combined with a concentration on end-points (equilibria) rather than properties of the trajectory (move sequence) in games has lead to a very unsatisfactory treatment of the dynamics of organizations." — John H. Holland (personal communication, June 21, 1995)[1]

1. Introduction

The narrative cited above as an observation by the noted psychologist and computer scientist John Holland was in response to my query to him regarding the possibility of using intelligent information technologies for devising self-adaptive organizations. As meaning seems to be a crucial construct in understanding how humans convert *information* into *action* [and consequently *performance*], it is evident that information-processing based fields of artificial intelligence and expert systems could benefit from understanding how humans translate *information* into *meanings* that guide their *actions*. In essence, this issue is relevant to the design of both human- and machine-based knowledge management systems. Most such systems had been traditionally based on consensus and convergence-oriented information processing systems, often based on mathematical and computation models. Increasing radical discontinuous change (cf. Huber & Glick, 1993; Nadler, Shaw, & Walton, 1995) that characterizes business environments of today and tomorrow, however, requires systems that are capable of multiple — complementary and contradictory — interpretations.

Despite observations made by Churchman (1971) and Mason and Mitroff (1973), the paradigm of information systems, artificial intelligence (AI) and expert systems have yet to address the needs posed by *wicked environments* that defy the logic of pre-determination, prediction and pre-specification of information, control and performance systems (cf. Malhotra, 1997). Wicked

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[1] Considering organizational adaptation for survival and competence as the key driver for most organizational information and knowledge processes (cf. Malhotra, 2000a,b,c), it seemed logical to develop the model of IT-enabled self-adaptive organizations based upon technologies that are often considered as a benchmark for self-adaptive behavior. In this context, genetic algorithms (also referred to as adaptive computation) offer the closest archetype for devising technology-enabled organizations that could possibly exhibit self-adaptive behavior given the dynamically changing environment. By offering the basis for evolution of solutions to particular problems, controlling the generation, variation, adaptation and selection of possible solutions using genetically based processes, it seemed probable that genetic algorithms could offer the basis for self-adaptive *evolution* of organizations. As solutions alter and combine, the worst ones are discarded and the better ones survive to go on and produce even better solutions. Thus, genetic algorithms *breed* programs that solve problems even when no person can fully understand their structure.

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business environments — characterized by radical discontinuous change — impose upon organizations the need for capabilities for developing multiple meanings or interpretations and continuously renewing those meanings given the changing dynamics of the environment. Scholars in business strategy have advocated human and social processes such as 'creative abrasion' and 'creative conflict' (cf. Eisenhardt, Kahwajy, & Bourgeois, 1997; Leonard, 1997) for enabling the *interpretive flexibility* (Nonaka & Takeuchi, 1995) of the organization.

It is also evident that there is an imperative need for relating the *static* notion of information captured in databases or processed through computing machinery to the *dynamic* notion of human sense making. More importantly, our current understanding of information as the [indirect] enabler of performance can immensely benefit from unraveling the intervening processes of human sense making that are more directly related to action (or inaction) and resulting performance outcomes (or lack thereof).

Based upon a review of the current state of AI and expert systems research and practice in knowledge management, this article develops the bases for AI and expert systems researchers to develop knowledge management systems for addressing the above needs. Section 2 provides an overview of the state-of-the-art expert systems research and practice issues related to knowledge management highlighting key relationships with the key theses of the article. Section 3 offers a more current understanding of knowledge management as it relates to organizational adaptability and sustainability by drawing upon information systems and business strategy research. Section 4 highlights the contrast between the computational model of information processing and human sense making while recognizing both as valid meaning making processes. Finally, sense-making bases of human action and performance are discussed in Section 6, followed by conclusions and recommendations for future research in Section 8.

2. State of related research and practice in AI and expert systems

Faced with uncertain and unpredictable business environments, organizations have been turning to AI and expert systems to develop knowledge management systems that can provide the bases for future sustainability and competence. For instance, faced with competition and uncertainty in the finance industry, banks are using neural networks to make better sense of a plethora of data for functions such as asset management, trading, credit card fraud detection and portfolio management (Young, 1999). Similarly, insurance and underwriting industries are relying upon knowledge management and AI technologies to offer multiple channels for rapid response to customers (Rabkin & Tingley, 1999). Many such knowledge management implementations using AI and expert systems rely upon the meaning making and sense-making capabilities of AI and expert systems technologies and humans using them.

In recent years, there have been significant advances in endowing inanimate objects with limited sense-making capabilities characteristic of self-adaptive behavior of humans. For instance, some proponents of 'perceptual intelligence' (cf. Pentland, 2000) have suggested such capabilities derived from a computers' ability to isolate variables of interest by classifying any situation based on categorization heuristics for taking appropriate action. Their suggestion is that once a computer has the perceptual ability to know who, what, when, where and why, then the probabilistic rules derived by statistical learning methods are normally sufficient for the computer to determine a course of action. However, these models, though helpful for procedural decision making, need to advance beyond the static, pre-specified and pre-determined logic to account for dynamically changing environments that may require fundamental and radical redefinition of underlying rules as well as the behavior of the actors.

Similarly, research on 'perceptual interfaces' has been trying to unravel how people experience information that computers deliver (cf. Reeves & Nass, 2000). This stream of research is based on the premise that human experience with information is caused by stimulation of the senses. While paying attention to the chemical senses (taste and olfaction), the cutaneous senses (skin and its receptors), vision and hearing, this research has yet to take into consideration the interpretive, meaning making and sense-making processes that occur at a more cerebral level. The personal constructivist theory discussed in this article could help better relate information to meaning and consequent behavior (or actions) in above cases.

Simultaneously, the state-of-art research and practice in data mining, often described as "knowledge discovery from databases," "advanced data analysis," and machine learning, has been trying to decipher how computers might automatically learn from past experience to *predict* future outcomes (Mitchell, 1999). However, as explained later, current thinking in business strategy is imposing upon the organization the need to move beyond *prediction of future* to *anticipation of surprise* (Malhotra, 2000a,b). The most advanced machine learning capabilities — such as those of the most advanced chess-playing computer (cf. Campbell, 1999) — are still limited by pre-specified, pre-determined definition of problems that are solved based on the pre-specified rules of the game.

Though interesting, such capabilities may have limited use in the emerging game of strategy that is being redefined as it is being played. In such game, all "rules are up for grabs" even though computational machinery has yet to evolve to the stage of sensing changes that it has not been *pre-programmed* to sense and to re-evaluate the rules embedded in the logic devised by human programmers. In contrast to machine learning, humans are endowed with