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Decisional DNA: A multi-technology shareable knowledge structure for decisional experience

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ABSTRACT

Knowledge representation and engineering techniques are becoming useful and popular components of hybrid integrated systems used to solve complicated practical problems in different disciplines. These techniques offer features such as: learning from experience, handling noisy and incomplete data, helping with decision making, and predicting capabilities. In this paper, we present a multi-domain knowledge representation structure called Decisional DNA that can be implemented and shared for the exploitation of embedded knowledge in multiple technologies. Decisional DNA, as a knowledge representation structure, offers great possibilities on gathering explicit knowledge of formal decision events as well as a tool for decision making processes. Its applicability is shown in this paper when applied to different decisional technologies. The main advantages of using the Decisional DNA rely on: (i) versatility and dynamicity of the knowledge structure, (ii) storage of day-to-day explicit experience in a single structure, (iii) transportability and shareability of the knowledge, and (iv) predicting capabilities based on the collected experience. Thus, after analysis and results, we conclude that the Decisional DNA, as a unique multi-domain structure, can be applied and shared among multiple technologies while enhancing them with predicting capabilities and facilitating knowledge engineering processes inside decision making systems.

1. Introduction

Now-a-days, engineering systems are established on evolving paradigms; knowledge and users' experience take a big role in today's applications as we have now the computational potential of modeling such paradigms. The term knowledge engineering (KE) has been defined as a discipline that aims to offering solutions for complex problems by the means of integrating knowledge into computer systems [1]. It involves the use and application of several computer science domains such as artificial intelligence, knowledge representation, databases, and decision support systems, among others. Knowledge engineering technologies make use of the synergism of hybrid systems to produce better, powerful, more efficient and effective computer systems. Among the features associated with knowledge engineering systems are human intelligence capabilities such as learning, reasoning and forecasting from current knowledge or experience. From an application point of view, different research projects have been presented by the scientific community involving knowledge representation and decision making technologies to extend the user's understanding; however, to our acquaintance, most of these approaches miss the potential of using knowledge based theories that might enhance the user's experience and at the same time creating his/her decisional fingerprints.

In our case, we propose experience as the main and most appropriate source of knowledge and its use leads to useful systems with improved performance. Multiple applications perform decisions, and most of the decisions are taken in a structured and formal way, this is what we call formal decision events. All these formal decision events are usually disregarded once the decision is made, or even worst, if the system is queried again, the decision has to be repeated. What to do with the experience gained on taking such decisions relies on our proposed knowledge representation structure. We propose the Decisional DNA as a unique and single structure for capturing, storing, improving and reusing decisional experience. Besides, we make use of the Set of Experience (SOE) as part of the Decisional DNA which allows the acquisition and storage of formal decision events in a knowledge-explicit form. It comprises variables, functions, constraints and rules associated in a DNA shape allowing the construction of the Decisional DNA of an organization. Having a powerful knowledge

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structure such as the Set of Experience Knowledge Structure (SOEKS) within the Decisional DNA can enrich and develop any decisional system based upon previous experience.

This paper presents the Decisional DNA as a multi-domain knowledge structure that provides additional support by constructing a decisional repository, i.e., decisional fingerprints. Additionally, such decisional repository, since it is multi-technology applicable, can be shared and distributed enhancing the user's decisional experience. We present its application into four technologies: Decisional DNA Ontology-based knowledge Structure, Reflexive Ontologies, Embedded Systems, and Decision Support Medical Systems. We have chosen these technologies due to their noticeable advantages of being wide spread technologies that are developing the Artificial Intelligence (AI) scientific field. This paper is organized as follows: In Section 2, an overview of the conceptual basis is presented. In Section 3, we introduce four technologies implementing the Decisional DNA knowledge structure. And in Sections 4 and 5, we present our conclusions and lines for future work.

2. Conceptual basis and background

Humanity has always being accompanied by knowledge. Both have grown together to construct what we understand now as society and civilization. Hence, humankind has been trying to make knowledge part of its assets. Knowledge seems to be a valuable possession of incalculable worth and it has been considered as the only true source of a nation's economic and military strength as well as, the key source of competitive advantage of a company [2]. Thus, humankind in general and, more specifically, managers have turned to knowledge administration. They want technologies that facilitate control of all forms of knowledge because such technologies can be considered as the key for the success or failure of an organization, and subsequently, knowledge society. Knowledge itself appears as a human being attribute and can be defined as [3]: *(i)* theoretical or practical expertise and skills gained by a person through experience or education, or *(ii)* familiarity gained by experience of a fact or situation.

One theory suggests that situation assessments are the base for experienced decision-makers when taking decisions [4]. Decision-makers principally use experience for their decisions, i.e., when a decision event emerges, managers select actions that have worked well in previous similar situations. Then, in a brain process that is not well understood yet, managers extract the most significant characteristics from the current circumstances, and relate them to similar situations and actions that have worked well in the past. Therefore, this theory suggests that any mechanism that supports the process of storing previous decisions would improve the decision maker's job; and as such, it is related to a process of storing knowledge and experience.

Since this paper tackles problems in the engineering and computer fields, we concentrate on the concept knowledge engineering (KE). According to Feigenbaum [1], "Knowledge Engineering (KE) is an engineering discipline that involves integrating Knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise". Two main movements surround KE, they are: the transfer movement and the modeling movement. The transfer movement aims for techniques to transfer human knowledge into the artificial intelligent systems. The modeling movement aims for modeling the knowledge and problem solving techniques of the domain expert into the artificial intelligent system. Our research concentrates on the modeling trend which requires the areas of knowledge representation (KR) and knowledge modeling. Therefore, KE [5] depends on computer science in general, trying to mimic knowledge in a certain domain and within the scope of an artificial system. This definition involves not only the need for specific technologies, but also the need to overcome related implementation issues.

From a mechanistic point of view, reasoning in machines is a computational process. This computational process, to be feasible, definitely needs systemic techniques and data structures, and in consequence, several techniques have been developed trying to represent and acquire knowledge. These kinds of technologies try to collect and administer knowledge in some manner. Although these technologies work with decision-making in some way, they lack of keeping structured knowledge of the formal decision events they participate on [6]; they do not use their experience. We formally define a *Formal Decision Event as a choice [decision] made or a commitment to act that was the result [consequence] of a series of repeatable actions performed in a structured manner.*

For us, any technology able to capture and store formal decision events as explicit knowledge will improve the decision-making process. Such technology will help by reducing decision time, as well as avoiding repetition and duplication in the process.

Unfortunately, computers are not as clever as to form internal representations of the world, and even simpler, representations of just formal decision events. Instead of gathering knowledge for themselves, computers must rely on people to place knowledge directly into their memories. This problem suggests deciding on ways to represent information and knowledge inside computers.

A Knowledge Representation (KR) is fundamentally a replacement, a substitute for the thing itself. KR is an element of intelligent reasoning, a medium for organizing information to facilitate making inferences and recommendations, and a set of ontological commitments, i.e., an answer of how to interpret the world [7]. KR has been involved in several science fields; however, its main roots come from three specific areas: logic, rules, and frames. They appear as the most generalized techniques, and symbolize the kinds of things that are important in the world; even though developed systems can use exclusively one of the techniques, their hybridization is a common element. Logic implicates understanding the world in terms of individual entities and associations between them. Rule-based systems view the world in terms of attribute-object-value and the rules that connect them. Frames, on the other hand, comprise thinking about the world in terms of prototypical concepts. Hence, each of these representation techniques supplies its own view of what is important to focus on, and suggests that anything out of this focus may be ignored [7]. Recent advances in the field of KR have converged on constructing a Semantic Web, an extension of the current World Wide Web, looking for publishing information in a form that is easily inferable to both humans and machines. Current progresses have led to the standardization of the Web Ontology Language (OWL) by the World Wide Web Consortium (W3C). OWL provides the means for specifying and defining ontologies, that is, collections of descriptions of concepts in a domain (classes), properties of classes, and limitations on properties. OWL can be seen as an extension from the frame based approach to knowledge representation, and a division of logic called Description Logics (DL) [8].

These KR techniques have been implemented with different data structures creating a universe of knowledge as big as the number of applications researchers and IT companies have developed. These technologies have been developed to make useful huge quantities of stored information by modeling knowledge in some way; however, none of them keep an explicit record of the decision events they participate on. Hence, it is necessary to define a multi-domain shareable knowledge structure able to be adaptable and versatile as to capture all these different decision events from the day-to-day operation, to store proper