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A novel integrated knowledge support system based on ontology learning: Model specification and a case study

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ABSTRACT

Semantic engineering is currently being adopted to support the knowledge-management processes needed by organizational users for decision-making and task-intensive knowledge activities. Such optional engineering strategies consider that some systems, such as the *Knowledge Support System (KSS)* fulfill the needs of the knowledge user, by providing the services and management qualities they require. Some key features of the KSS have been analyzed to identify their main characteristics or system components according to the most recent trends. Lately, some solutions have been proposed to develop this type of knowledge system based on the approaches, Ontology Development and *Ontology Learning (OL)*. In this paper, a novel model of an *Ontology-Learning Knowledge Support System (OLeKSS)* is proposed to keep these KSSs updated. The proposal applies concepts and methodologies of system modeling as well as a wide selection of OL processes from heterogeneous knowledge sources (ontologies, texts, and databases), in order to improve KSS's semantic product through a process of periodic knowledge updating. An application of a *Systemic Methodology for OL (SMOL)* in an academic Case Study illustrates the enhancement of the associated ontologies through process of population and enrichment.

1. Introduction

Some Knowledge Systems are oriented toward the support of users' requirements in organizational knowledge processing. These systems may be an alternate way of increasing the efficiency of Knowledge Management (KM) through semantic learning [1–3].

According to Venzin et al. [4], knowledge is important for the theoretical reality of strategic management, basically because knowledge simplifies sustainable, heterogeneous resource distribution, knowledge changes the nature of investment decisions, knowledge changes the nature of work and property and knowledge emphasizes the social context. This last point reinforces the twofold concept of KM systems as capable of managing individual and group knowledge, according to the following definition of KM given in [3].

"KM is a systematic method for managing individual, group, and organizational knowledge using the appropriate means and technology. At its root, it deals with managing people, what they know, their social interactions in performing tasks, their decision making, the way information flows, and the enterprise work culture."

For our proposal, we concentrate on the three most relevant aspects of KM:

(1) *the perspective of collectivist knowledge* -the social aspect of the interchange of knowledge (groups, communities, networks, and organization units) is considered, rather than the individualist aspect [5];
(2) *the reusability of the properties of knowledge* -the capability of knowledge to generate new information as a product of the intervention and processing carried out by users, the implicit and explicit quality features and the possibility of converting from the former to the later [6];
(3) *knowledge as a competitive resource from diverse knowledge sources (KSOs)*-an assessment for the support of decision/task/recommendation management, knowledge can be used as technical representation method (e.g., ontologies), and different KSOs can be recovered and discovered through diverse Methodological Resources (MRs) [7].

In the framework of KM, Decision Support Systems (DSS) are comprised of *Knowledge-based Systems (KBSs)* and the *Knowledge Support Systems (KSSs)* [8–10]. The KBS can be better qualified as software developed to satisfy specific user's needs, usually as an application for expert decision-making. They include expert systems, intelligent decision support systems or specialized data

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bases systems used to store experiences, lesson learned, know-how, and best practices, as well as technical solutions [11,12].

In KSS, they are oriented to help both knowledge activities, such as organizational practices and routines (e.g., document management), knowledge distribution (e.g., groupware), for the purpose of knowledge adoption (new products and new markets), and so on [13]. Keeping our work in a generic perspective, as proposed by Gaines [14], the term KSS "..*is used to encompass all systems (computer-based) whose primary function is to support knowledge processes in the society*". As the same author's state "..*the term is deliberately left unqualified -open- to encompass non-computer-based systems supporting knowledge processes*". Some details about this view of KSS are described in SubSection 2.1.

Our premise is that new knowledge is required for the continuous process of KSS updating in order to keep organizations updated, and this associated knowledge is usually represented as ontologies in the new trends of KSS. However, diverse KSOs are overlooked as key features for the updating of the KSSs. We suggest an OL process for Knowledge Acquisition (KA) as a useful option to extend the life-cycle of these KSSs. OL, from different KSOs, can improve KSS through the growth of the knowledge, and through processes of comparison and restructuring of the knowledge structures in their knowledge-bases.

To deal with this problem, we have focused on a systemic approach in order to include the necessary learning faculties of OL, considering it to be another KSS key component that can guarantee the continuous updating and enrichment of the organizational knowledge. In particular, we propose an appropriate ontology-based KSS architecture that is designed to meet the users' requirements, related to their KM-updating activities.

The principal focus of this work is:

(1) to study the characteristics of some KSSs, especially those with ontology-based mechanisms to meet diverse users' needs;
(2) to analyze the current characteristics and capabilities of OL methodology, in order to keep the ontology-based KSSs updated;
(3) to review the KSSs in a social perspective and to try to increase the available KSOs, in order to keep them as functional and updated as users require;
(4) to use some MRs for OL from diverse KSOs (such as ontologies, texts, and databases) for the processes of updating and enriching the knowledge processes of the KSS semantic structures (e.g., ontologies).

The main *contributions* in this work are:

(1) to provide a new perspective of KSS, based in OL, from diverse KSOs. The exchange social-relationships between knowledge generation communities (experts) and the communities of users have been considered [14];
(2) to identify the common characteristics of KSSs for functional systems in order to create general system architecture that can be a draft model and can be improved through ontological engineering;
(3) to present a systemic proposal for a KSS model based in OL (*OLeKSS*). A first model approximation can be found in [15];
(4) to apply a *Systemic Methodology for OL (SMOL)* in a specific case study to show how the associated knowledge of this KSS from diverse KSOs during a KA process can be enhanced. A first approach to this proposal for an OL methodology can be found in [16].

This article is structured as follows: a background review about the KSS and OL characteristics and approaches can be found in Section 2; a new view of KSS in a systemic OL perspective is given in Section 3; the novel *OLeKSS* model is described in Section 4; a real application in the form of a Case Study can be found in Section 5; a short discussion is included in Section 6; and finally, the conclusions and proposals for future research are presented in Section 7.

2. Background

The qualities and characteristics of some ontology-based KSSs and the essentials of OL in the methodological perspective are reviewed in this section.

2.1. Knowledge support systems

KSSs are usually qualified as "Knowledge-driven" DSS to support different users' needs for decision-making and task-intensive knowledge activities [17]. They must be specified in terms of their roles in the social knowledge process according to the perspective cited in Gaines [14]. This is in contrast to the practice of specifying them in technical terms or individual cognitive terms, as is currently the common trend. Gaines suggests some important requirements that a KSS must satisfy.

"(1) The social structure usually involves a professional community responsible for managing the processes of knowledge acquisition and dissemination and a client -users- community dependent on the knowledge for its activities. (2) A KSS will not contain all the knowledge relating to the processes in which it is involved, or provide all the facilities required. And, (3) Knowledge processes are intrinsically reflexive, applying to themselves."

Moreover, there are additional capabilities that the KSS must have, such as: being able to explain its decisions/recommendations to users; being portable and flexible; being an understandable representation of its knowledge; providing automatic learning of new information.

Currently, there are many specific KSSs oriented to medicine, KM, farming, industry, the economy, the environment, and so on. Commonly, these KSSs have been developed using technologies to support functionalities related to the sharing, distribution, capturing, codifying, and creating of knowledge [18].

According the technology used for system design and implementation, these KSSs can be classified as *Traditional Systems* and *Intelligent Systems*.

- *Traditional Systems* are comprised of KSSs that employ conventional technologies, such as databases, discussion boards, spreadsheets, and e-mails. Diverse KSSs have been implemented recently using this traditional approach, for example, DSS for cancer treatments [19]; KSS for medical emergency services [20]; DSS for costing job-orders [21]; and, KSS for strategic planning [22].
- *Intelligent Systems* are comprised of KSSs that also employ some MRs of artificial intelligence related to web semantics, ontologies, user-profiles, data- and text-mining, and so on. Because KSS implementation using ontologies is of crucial interest in this work, we have distinguished some KSSs by this criteria. The following non-ontology-based KSSs are illustrative of recent applications: KB-IDSS for diagnosis therapy [23]; KB-DSS for shipboard damage control [24]; KB-SS for sugar mill [25]; and, KB-SS for energy saving [26]. More details about ontology-based KSSs are provided in SubSection 2.2.

Specifically, we have oriented our model proposal with this type of ontology-based KSS. Using representative instances of this type of KSS, we have derived the main *OLeKSS* components in Subsection 2.2.1 through an inductive approach.