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Proactive search enabled context-sensitive knowledge supply situated in computer-aided engineering

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ABSTRACT

Processing complex and non-routine tasks, engineers face frequent knowledge shortage. While an expert system requires much effort to develop and a general search engine is blamed for passiveness in meeting people's knowledge demand, we propose in this paper a context-sensitive knowledge supply method which aims at meeting users' unuttered knowledge need bred in computer-aided engineering (CAE) tasks. To this end, concepts involved in a task are extracted and used for perceiving various problematic situations which may occur; and keyword-based search and text parsing techniques are combined to retrieve possible remedies from unstructured knowledge carriers. The proposed method is tested in situation of finite element analysis (FEA), a typical CAE task, where novice engineers receive sentential knowledge recommendations extracted from webpage. Experiment results show that context-sensitive knowledge supply can increase an engineer's knowledge about the current task and make the individual more prepared for future challenges.

1. Introduction

As people who process knowledge-intensive tasks, engineers are in constant need of knowledge to perform planning, judging and diagnosing tasks [1]. Knowledge seeking is an attention-diverting activity as it requires people to suspend their work, conceive the keywords to search with, undergo extensive reading, and eventually recover the previous work. To help engineers concentrate on their creative thinking and improve work efficiency, many expert systems have been built [2–5]. The scope of knowledge-based engineering expert system is illustrated in Fig. 1 by the outmost layer. Built upon encoded task and domain knowledge, an expert system employs various reasoning techniques to infer what the user needs at different task stages, and the guidance provided by it can vary from holistic and abstract to detailed and specific, with respect to which level of knowledge is encoded. However, most of the knowledge-based systems are only suited to specific use [2,3,5,6], for the heterogeneity and immense volume of engineering knowledge impedes the building of knowledge bases that are versatile and scalable at the same time. Hence nowadays, in the engineering design field, a general search engine is still the main tool for engineers to acquire knowledge [7]. Search engine possesses the advantage of not relying on any codification of prior knowledge but, has disadvantage in its passive way to meet user's knowledge demand.

After Internet gained popularity, people began to ask questions on the web when they met difficulties in work or daily life. As time went on, web questions have accumulated to a countless number, mentioning countless problematic situations in every knowledge domain. Chance is that if we could continuously compare an engineer's ongoing task with related problematic situations described on the web, we can make a guess of what he/she need to know and get the required material ready in advance. Context-sensitive knowledge supply, our proposal, is shown by the middle layer of Fig. 1. By employing information extraction and filtering techniques which are less human-involving than knowledge engineering, we want to walk a new way between the powerful yet expensive expert system and the free but low efficient file search method in providing detailed level knowledge support for computer-aided engineering.

The paper is organized as follow. We will survey some literature with similar purpose in Section 2. Through comparison with these works our motivation and novelty will be further explained. Section 3 proposes the framework of our knowledge supply method. The two principal features of our research, knowledge need perception and knowledge item selection, will be detailed in Section 4. In Section 5 we give a knowledge supply scenario and present the experimental evaluation of our method. We conclude our study and point out the future research direction in the last section.

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2. Related works

2.1. Knowledge reuse in engineering process

Enterprises manufacturing complex products cherish their veteran employees' well practiced knowledge. To reuse this knowledge, two directions of endeavor can be identified. The first is to integrate knowledge with process, which emphasizes the driver role of engineering process in the reuse of knowledge [8]. As the author of [9] puts it, the design reuse tools should support the design process either through guidance to reapply knowledge at the most effective time or through the capture and application of knowledge embedded in the process itself. His work comprises a Process Model constructed using Design Roadmap Framework for index and retrieval of information, a Product Model combining product data and ontology, and a Process Logic Engine which interacts with the Process Model and serves as a trigger for the use of product data. Similar structures can also be found in some process-oriented decision support systems [10,11]. Different from above studies which have maintained the accessibility of archived knowledge for general users, expert systems and knowledge-based systems (KBS) make deeper integration of knowledge and process – the knowledge desired by a task is embed into the task process itself and invisible to the user. Such a close combination of knowledge and engineering processes can provide powerful functions, e.g., alerting users to potential error and defects [4], automating the part modeling process [3], and suggesting them the best action route and parameter settings [2,5]. However, building systems of this kind requires a thorough understanding of the task detail and a lot of domain knowledge, whose consequence is that the overhead of knowledge elicitation and codification is considerable [12]. In fact, applied expert systems are plenty in number but usually they are meant for specific product kinds [6], and those general knowledge reuse methodologies are not in a ready-to-use state if without prior knowledge encoding work [13–16].

The second direction of knowledge reuse goes to knowledge retrieval, which is to organize the knowledge resources and make them easily acquirable for people. Studies with case-based reasoning (CBR) method may fall to this category [17,18]. The foundation of CBR is case modeling and indexing, which require varied degrees of human intervention. With the increasing complexity of products and the popularity of computer-aided documentation tools, the number of electronic, textual design documents has exploded [19], which proposes a big challenge toward the acquisition and utilization of knowledge from unstructured documents [20]. Efforts in dealing with this challenge include informal information retrieval [21], knowledge extraction from unstructured documents [19,22] and textual case-based reasoning (TCBR) [23–25]. In [21], the author introduced an automatic way to extract domain-specific thesauri by using term vector model and singular value decomposition. The constructed thesauri were then used in query expansion to improve the performance of informal design information retrieval. Domain-specific ontology and shallow natural language processing are used in [19] to obtain semantic and structured design representations from unstructured documents. In the field of TCBR, an exemplary application is an email reuse system proposed in [24] which makes use of antecedent mail content to reply new requests. Word associations such as co-occurrence and translational mapping are exploited to retrieve past cases.

While knowledge retrieval may employ information technology and artificial intelligence to reduce the system implementation overhead, it lacks the activeness in knowledge provision. To draw the advantage of both knowledge integration and knowledge retrieval, we resort to *task context*, which refers to all the information that can be used to characterize the current and history state of an ongoing task. By sensing and using task context, we can detect user's knowledge need instantly or even in advance, giving time for retrieving relevant knowledge with various approaches.

2.2. Contextualized information retrieval

The information retrieval (IR) method behind most popular search engines features the "one size fits all" problem by providing the same results for the same keyword queries even if they are submitted by different users with different intentions [26]. To solve

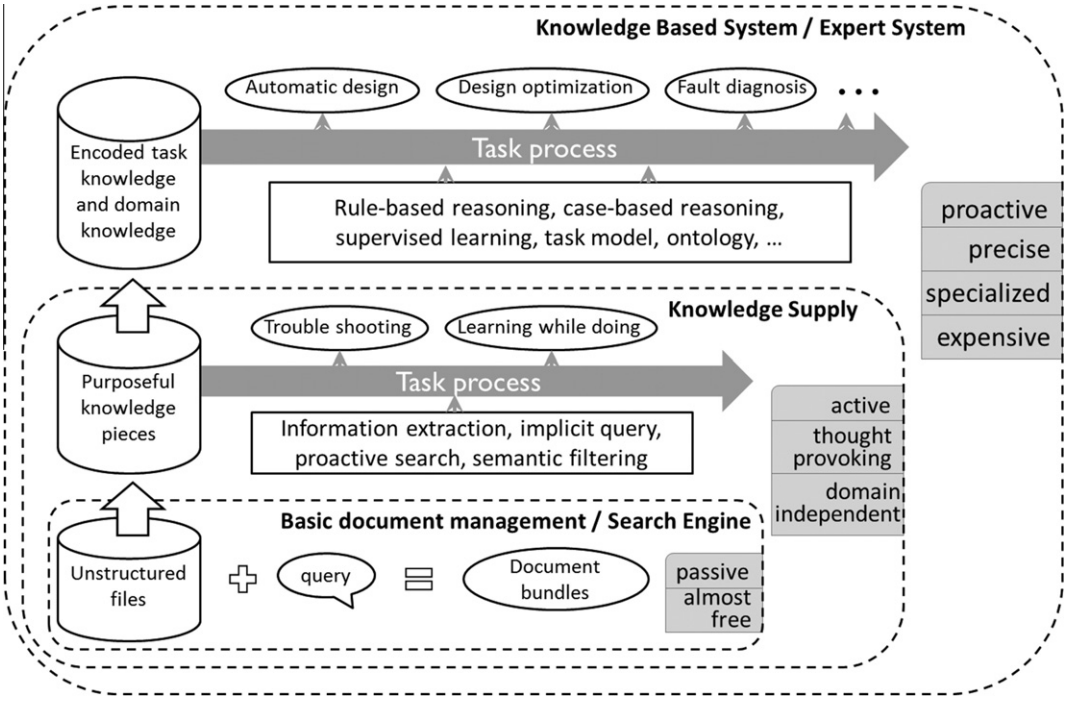

Fig. 1. Scope of knowledge supply.