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GUEST EDITORIAL

Computational linguistics for design, maintenance, and manufacturing

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1. INTRODUCTION

Although graphic representations have proven to be of value in computer-aided support and have received much attention in both research and practice (Goldschmidt, 1991; Goel, 1995; Achten, 1997; Do, 2002), linguistic representations presently do not significantly contribute to improve the information handling related to the computer support of a design product. During its life cycle, engineers and designers make many representations of a product. The information and knowledge used to create the product are usually represented visually in sketches, models, (technical) drawings, and images. Linguistic information is complementary to graphic information and essential to create the corporate memory of products. Linguistic information (i.e., the use of words, abbreviations, vocal comments, annotations, notes, and reports) creates meaningful information for designers and engineers as well as for computers (Segers, 2004; Juchmes et al., 2005). Captions, plain text, and keyword indexing are now common to support the communication between design actors (Lawson & Loke, 1997; Wong & Kvan, 1999; Heylighen, 2001; Boujut, 2003). Nevertheless, it is currently scarcely used to its full potential in design, maintenance, and manufacturing.

Computational linguistics belongs to both cognitive science and computer science. The added values of applying linguistic information during the life cycle of a product would be substantial. Linguistic information enables user-friendly human–computer interaction that can handle interpretations and manage complexity in content.

A down-to-earth issue is to try to solve the main obstacle in the interaction between human and computer. Many advanced theoretical and applied research projects in design and decision support are based on a user centered point of view (Mase et al., 1998; Aliakseyeu et al., 2001). This approach enables a better analysis of the cognitive mechanisms and the activity schemes, which are involved in design and decision making tasks. It helps define a context driven behavior for software developed to assist all creative and analytical activities.

Although the written and vocal annotation technique is still quite far from natural language, these representations have already shown to be a salient means of expressing intention or concepts (Leclercq & Juchmes, 2002). These allow for spontaneous expression with multiple interpretations in a multimodal way (sketches, gestures, spoken words, and annotations) that could turn the machine into an active partner in design or engineering. Examples of subfields in this area are natural language processing, signal processing (handwriting, speech recognition), translation between representations, (design) process support, planning, information search, data mining, and so forth.

Throughout the whole process of design, maintenance, and manufacturing, people are dealing with increasing complexity in content and management because of a growing number of large bodies of text, combined with a diversity of other information sources (Simoff & Maher, 1998; Heylighen & Neuckermans, 2000). To store, retrieve, and handle all information needed, multiple approaches have been studied as a means to increase usability, accessibility, and efficiency. Indexing with keywords is not sufficient, and more enhanced methods must be employed: semantic models, content or knowledge management, product ontology, multimodal representations, connectivity through linguistic content, flexible information handling, and translation between languages contribute to making the corporate memory truly accessible for artificial intelligence systems.

In this Special Issue of 2007, which is the 20th Anniversary Volume, five authors provide us with their various linguistic approaches on stimulating concept generation, concept selection and improvement, and information retrieval and handling.

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2. CONCEPT GENERATION

Language is important for reasoning in the design process. The ideas that are produced can be expressed through related hierarchical lexical relationships. Can the designer be stimulated by anticipating the relationships between ideas? In "Using Language as Related Stimuli for Concept Generation," Chiu and Shu examine the relationship between language and conceptual design. They wonder if verbs can stimulate concept generation, and why. Through an interesting problem-solving and design experiment, they investigate the use of verbs as stimuli for ideas, and show how the verb chosen as stimulus by the designers can directly affect the success (completeness) and the type of concept they develop. They analyze the results of the experiment and look for the properties of the verbs that provide the best stimulation in terms of abstraction level and transitivity.

3. CONCEPT SELECTION AND IMPROVEMENT

Affective Engineering is increasingly being used to describe consumer reactions to candidate products such as cars, electronics, and food. This approach includes semantic differential experiments using bipolar adjectives to identify correlations between design features and consumer reactions to inform future product developments. In current practice, the adjective selection process is unsystematic, and poor adjective choices can cause potentially key concepts to be missed, can cause confusion through unfamiliar adjectives or adjectives with similar meanings, and can cause misinterpretation in the experiment.

In "Linguistic Support for Concept Selection Decisions," Delin, Sharoff, Lillford, and Barnes propose an AI-supported process that ensures adjectives with appropriate levels of precision and recall. Their method includes a comparison of seed words against a collection of texts from a wide range of sources, designed to represent the use of natural language, statistics, and a set of rules. Their new approach is illustrated by an industrial case study that aims to evaluate different designs of packaging.

4. INFORMATION RETRIEVAL AND HANDLING

The next three articles concentrate on dealing with a large amount of complex information. One critical issue here is the construction of a structured representation for indexing documents to improve information retrieval.

In "Ontology-Based Design Information Extraction and Retrieval," Li and Ramani propose to use shallow natural language processing and a domain-specific design ontology to automatically construct a structured and semantics-based representation model. They show how, based on the linguistic patterns found in unstructured design documents, concepts and relationships can be extracted, joined into a concept graph, and integrated to build a specific design ontology. This structured representation of the corporate document repository is the foundation for the ontology-based query processing they have developed. In an experiment this ontology-based search is compared with keyword-based search. The performance is measured in terms of recall and precision.

When looking for answers to specific questions, people may refer to corporate and individual documents or use search engines with indexing approaches. Kim, Bracewell, and Wallace point out differences and problems in the way people perceive and access the contents of documents. First, the answer to a question people might have may not be found in just one (place in a) document. Second, answers to questions requiring a comparison or integration of information cannot be found by index-based search engines. Third, it is difficult for users to validate the answers because of the absence of supporting context and rationale. The title "Answering Engineers' Questions Using Semantic Annotations" suggests that they do manage to generate coherent answers. Their analysis goes beyond sentence annotations. To demonstrate their ideas, they have developed a prototype based on the Rhetorical Structure Theory.

For product-oriented organizations, a flexible information model for systematic development and deployment of product families during all phases of the product realization process is crucial. For that purpose, Nanda, Thevenot, Simpson, Stone, Bohm, and Shooter propose a flexible Knowledge Management Framework to organize both linguistic and parametric product family design information into a unified network. In "Product Family Design Knowledge Representation, Aggregation, Reuse, and Analysis," the authors show how designers could explore, search, and analyze design information across different phases of product design or across multiple family products. They formulate a schema that allows a relational database to serve as a central design repository of product design knowledge and propose to use it to represent product families. With an example involving a family of one-time-use cameras, they show the promise of ontologies in promoting component sharing, and assisting designers to search, explore and analyze linguistic/parametric product family design information.

5. CONCLUSION

These state-of-the-art articles do not cover the full breadth of the field of computational linguistics. However, such a goal is practically impossible to obtain in one Special Issue. We thank all authors who submitted their work to this Special Issue. We are also grateful to the reviewers and Professor Dave Brown for not only assisting us but also giving us the opportunity to make an interesting Special Issue.

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