A Knowledge Extraction and Design Support System for Supporting Industrial and Product Design

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ABSTRACT

Industrial and product design involves a lot of unstructured information for the generation of innovative product design ideas. However, the generation of innovative design concepts is not only time-consuming but also heavily relies on the experience of product designers. Most existing systems focus mainly on the technical aspects of realizing product designs, which are inadequate to support concept generation process at the pre-design stage. In this paper, a knowledge extraction and design support system (KEDSS) is presented. The system aims at extracting key design concepts and depicting the trends of these concepts from the massive amount of unstructured design information in the open domain. A summary report, a related concept list, and concept trend graphs are produced based on the inputs of the designers’ design ideas. A series of experiments have been conducted to measure the performance of the system. Moreover, the system has been successfully trial implemented as part of a public service platform for modern industrial design of injection molding machinery and equipment.

KEYWORDS

Industrial and Product Design, Knowledge Elicitation, Knowledge Management, Knowledge-Based System, Technology Management, Text Mining, Unstructured Information

1. INTRODUCTION

Industrial technology is developing at a fast speed, information of which can be found in abundance from web pages, company portals, patents, and scientific journals, etc. On the other hand, e-business via the internet and mobile devices has become more popular and common. Nowadays, most companies promote their products and services through the internet. However, the huge amount of public data makes it a great challenge to comprehend the content. Existing methods based on reviewing of existing data, brainstorming, benchmarking, ideas campaigns, focus group interviews, and surveys are always costly, time-consuming and heavily relied on the knowledge and experience of the workers. In

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today’s highly competitive market, there is a real need to have a computational system which provides a quick analysis of the massive amount of information so as to reduce the cost and time in eliciting useful knowledge for a specific product technology and design. The current computer aided design (CAD) systems are excellent in visualizing product designs but they are inadequate to support the generation of product design concepts at the early design phase, which is still a largely human centric activity (Soni et al., 2010). This is an important but time consuming process for designers to generate design concepts (Chandrasegaran et al., 2013). Designers need to review lots of information about the development of new technologies or the latest products. The trend of the market and the customer preferences are also changing from time to time. There are some methods and tools that have been developed for translating ideas into products, such as TRIZ and Invention Machine Goldfire. TRIZ is a problem-solving method based on logic and data, which accelerates a project team’s ability to solve problems creatively (Kamarudin et al., 2015). TRIZ research began with the hypothesis that there are universal principles of creativity that are the basis for creative innovation that advances technology. If these principles can be identified and codified, they will be able to be taught to people so as to make the process of creativity more predictable. Invention Machine Goldfire is a purposely built application method focused on the front-end of the product lifecycle as well as in the development of new products. It aims at leveraging the internal and external resources, connecting product development teams, and applying the best possible disciplines and technologies to drive and manage innovation (Li et al., 2014). Most of these tools and methods were focused on finding optimal solutions of well-defined and codified problems.

Comparing with the existing methods and tools, a knowledge extraction and design support system (KEDSS) is presented in this paper. The system supports the generation of new design concepts for designers at the early design phase by providing systemic analysis of unstructured design information. The KEDSS extracts key design concepts and depicts the trends of the concepts. The system assists industrial designers in generation of product design concepts. A prototype was successfully developed, assembled and tested as a part of a public service platform for modern industrial design in a city in China. Encouraging results were obtained based on the feedback from the selected reference sites.

The remaining part of the paper is organized as follows: the next section describes the current studies in unstructured information management and processing. In section 3, we present the framework of our proposed KEDSS. Then, in the fourth part, a case study will be presented by implementing our proposed approach and demonstrating the capability of the method. Finally, in section 5 draws the conclusion and future scope of the application.

2. LITERATURE REVIEW

2.1. Unstructured Information

A number of information management systems have been built and applied in various areas which include production and manufacturing (Vosniakos & Giannakakis, 2013; Silich et al., 2016), medical services (Xu et al., 2014), learning and teaching (Stantchev et al., 2014), transport logistics (Grabara et al., 2014), and many others. Most of them are dealing with structured information, which refers to information that either has a data model or has one that is easily usable by a computer program. On the contrary, unstructured information includes natural language, written documents, speech, audio, still images, and video (Ferrucci & Lally, 2004). It usually refers to computerized information that either does not have a data model nor has one that is not easily usable by a computer program. Many researchers point out that most of all potentially usable information originates in an unstructured form (Manu & Anandakumar, 2015). The term distinguishes unstructured information from the data which is stored in databases or documents with semantic annotations. Unstructured information has an inherent form which can be inferred from the text. For example, this can be done through examining word morphology, sentence syntax, and other small and large-scale patterns.
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