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Product concept evaluation and selection using data mining and domain ontology in a crowdsourcing environment

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ABSTRACT

For product design and development, crowdsourcing shows huge potential for fostering creativity and has been regarded as one important approach to acquiring innovative concepts. Nevertheless, prior to the approach could be effectively implemented, the following challenges concerning crowdsourcing should be properly addressed: (1) burdensome concept review process to deal with a large amount of crowd-sourced design concepts; (2) insufficient consideration in integrating design knowledge and principles into existing data processing methods/algorithms for crowdsourcing; and (3) lack of a quantitative decision support process to identify better concepts. To tackle these problems, a product concept evaluation and selection approach, which comprises three modules, is proposed. These modules are respectively: (1) a data mining module to extract meaningful information from online crowd-sourced concepts; (2) a concept re-construction module to organize word tokens into a unified frame using domain ontology and extended design knowledge; and (3) a decision support module to select better concepts in a simplified manner. A pilot study on future PC (personal computer) design was conducted to demonstrate the proposed approach. The results show that the proposed approach is promising and may help to improve the concept review and evaluation efficiency; facilitate data processing using design knowledge; and enhance the reliability of concept selection decisions.

1. Introduction

The term "crowdsourcing" was first coined by Howe [17] and defined as "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call". It is a method to draw upon large numbers of people to contribute their knowledge towards certain functions [1,13]. In recent years, crowdsourcing has been applied widely in various industries, such as medicine, education, and so on [3,2,38]. In product design and development (PDD) realm, crowdsourcing has also been recognized as an effective way to aggregate a crowd's wisdom so as to bring about more chances to achieve better and improved design concepts [41]. Wikipedia[1], Amazon's Mechanical Turk[2] and iStockPhoto.com[3] are good examples of taking advantage of the tremendous number of Internet users to successfully improve their product designs. In addition, Proctor & Gamble uses InnoCentive[4] to deal with the most challenging problems and the problem solving rate has increased to 30%. In another example, Dell has set up an IdeaStorm[5] platform to collect comments and suggestions for all Dell products from Internet users. Therefore, crowdsourcing appears to be a promising way to solicit external resources to improve product competitiveness [9,8]. Actually, a number of research efforts have been devoted to crowdsourcing, the scope of which includes the authentication of crowdsourcing's power in acquiring useful data [2] and the identification of factors which may influence the crowdsourcing effect [39].

For product conceptualization, the applications of crowdsourcing can take multiple forms; for example, new idea and innovation creation [6], design contests, problem solving, new product development and marketing, advertising, and brand building purposes [41]. Through leveraging crowd wisdom in product conceptualization, the potential of crowdsourcing for facilitating concept generation has been further recognized; as a result, more and more research attention has been placed on the exploration of crowdsourcing methods to support the creation of better and innovative design concepts.

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[1] https://en.wikipedia.org/wiki/Main_Page.
[2] https://www.mturk.com/mturk/welcome.
[3] http://www.istockphoto.com.
[4] http://www.innocentive.com.
[5] http://www.ideastorm.com/.

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1474-0346/

Nevertheless, problems are emerging along with the increasing applications of crowdsourcing in PDD. For example, it is actually very challenging to deal with a large amount of crowdsourcing results efficiently. Traditionally, firms rely on their internal R&D to screen and evaluate design concepts; however, this method is inapplicable for crowdsourcing due to the workload might be extremely heavy. In addition, there is a lack of consideration of integrating design knowledge and principles into current data processing methods/algorithms for crowdsourcing. Furthermore, evaluation results often rely on designers' personal knowledge and experience, which may suggest that an assistive quantitative decision making is needed to enhance the identification of the best concepts.

Based on the analysis of current crowdsourcing studies, the need of an efficient and effective concept evaluation and selection approach in a crowdsourcing environment especially for tackling the problems identified as abovementioned is emerged. Accordingly, based on previous work of Chang and Chen [5] which aims to explore improved effective concept evaluation and selection in a crowdsourcing environment, an approach built on data mining and domain ontology is proposed in this study to: (1) facilitate concept review and evaluation; (2) enhance crowdsourcing data processing methods/algorithms through embedding design knowledge and principles to it; and (3) support the decision making process to identify better concepts in a simplified and systematic manner.

2. Overall approach

Fig. 1 shows an overall framework of the proposed product concept evaluation and selection (ProCES) approach in a crowdsourcing environment. The ProCES comprises three modules; each of these modules deals with one of the three problems identified in Section 1.

In **Module 1**, data mining technique is deployed to perform preliminary analysis on the large number of crowd-sourced concepts. In particular, web mining is applied to crawl on web logs and extract meaningful contents from the initial online crowd-sourced concepts. Afterward, text mining is applied to discover textual patterns and further analyze the textual information in a quantitative manner. The main objective of this module is information extraction from crowdsourcing platform.

In **Module 2**, concepts are re-structured using design knowledge and domain ontology. For this purpose, the connections between different word tokens extracted from crowd-sourced concepts are explored, and particularly, two kinds of connections are focused: (1) design relation and (2) semantic relation. Respectively, concept development hierarchy offers the base structure to re-construct crowd-sourced concepts and leverages design knowledge and principles in building design relations; and domain ontology provides semantic and lexical reference to bridge separate individual tokens and leverages textual analysis in building semantic relations. The main objective of this module is to transform design concepts into a unified structure in order to facilitate the subsequent processing.

In **Module 3**, concepts are clustered based on the unified concept structure; thereby, concept selection can be simplified into the comparison between clusters rather than between individual concepts. Through a multi-attribute and multi-criteria decision making process, the clusters with better overall design quality can be identified. Due to the integrated consideration of design and semantics issues, the identified better clusters might be more promising with higher potential to contain excellent concepts. The objective of this module is to identify the best concepts through a simplified way.

In a nutshell, the proposed method is expected to: (1) reduce the burden of designers in reviewing crowd-sourced concepts; (2) leverage design knowledge in crowdsourcing data processing; and (3) assist in achieving better concepts through a simplified and reliable decision making process.

3. Information extraction from crowd-sourced product concepts using data mining technique

In a standard scheme of product conceptualization via crowdsourcing, a design project is posted online, and Internet users who are interested in this project can contribute their ideas. Normally, the number of crowdsourcing responses is huge. To deal with large crowd-sourced concepts, data mining as a powerful data processing tool to manage large data is adopted in this work.

3.1. A brief review of data mining in product conceptualization

For information extraction, data mining is an important tool to discover knowledge from a large amount of data and it has been widely applied in various industries.

Basically, data mining is a generic term that covers such techniques as clustering [27,43], association rule generation [23] and neural network [4,7,29,33]. Clustering is mainly used for classification based on distances (similarities) between different concepts or designs. Association rule generation is employed to find regularities between products in large-scale transaction data. It is possible to cope with both numerical data and textual information. Neural network consists of an interconnected group of artificial neurons

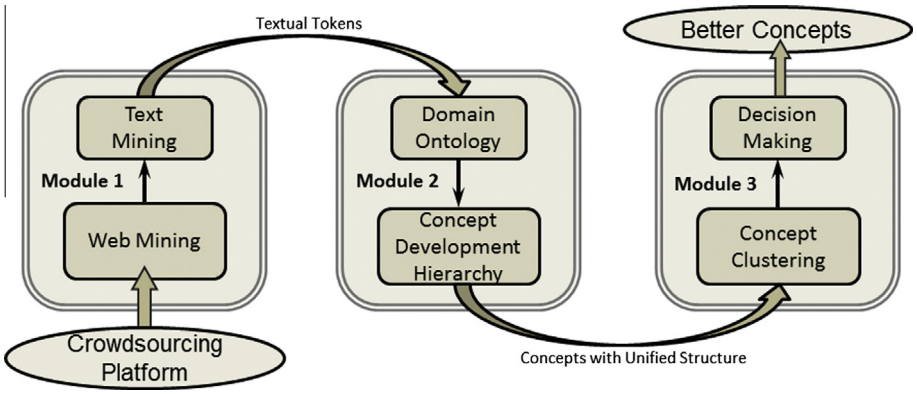

Fig. 1. Overall structure of the proposed ProCES approach.