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Consumer driven product technology function deployment using social media and patent mining

Amy J.C. Trappey[a], Charles V. Trappey[b], Chin-Yuan Fan[c,*], Ian J.Y. Lee[a]

[a] Department of Industrial Engineering and Engineering Management, National Tsing Hua University, Taiwan
[b] Department of Management Science, National Chiao Tung University, Taiwan
[c] Science and Technology Policy and Information Center, National Applied Research Laboratory, Taiwan

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ABSTRACT

The capability of identifying real-time customer needs is critical for manufacturers that provide short life cycle consumer products such as smart phones. Companies need to form research and development (R&D) strategies to improve key functional features for short lifespan products to reflect the adoption of innovative technologies and changing customer expectations. With the pervasive use of the Internet, this research crawls and analyzes the online voice of customers (VoC), overcoming the time lag of offline surveys, to identify and prioritize product functions for deployment using extended quality function deployment (eQFD) models. In this research, the novel analytics of the manufacturer's patent portfolio is added as an additional eQFD dimension to map ranked functional improvements to a manufacturer's R&D capabilities. Thus, a computer supported eQFD system is developed to perform the unique mappings and gap analyses between the VoC, the prioritized product functions, and the manufacturer's patent portfolio. The newly developed eQFD methodology and its novel discoveries are demonstrated in detail using a case study of three smart phones launched during the same time frame. The products include the Samsung Galaxy S7, the Huawei Honor 5X, and the ASUS Zenfone 3. The newly developed methodology is generally applicable to support VoC-centric product function deployment and R&D strategic planning in other domains.

1. Introduction

The ability to measure market demand accurately is critical for manufacturers that provide short life cycle consumer products such as smartphones and smart watches. Enterprises that successfully improve product functions according to consumer preferences are better able to maintain global and sustainable competitive advantages. The users of the Internet account for more than 48 percent of the world's population [1], which has stimulated the growth of new e-commerce models to procure products or services online. The Internet also enables customers to express their post-purchase experiences, quantifiable satisfaction feedback, and perceptions through online social media at any time from a multitude of touch-points such as mobile phones, computers, social forums, and direct company contact. The comments written by customers are spontaneous and provide critical references for manufacturers to develop R&D strategies to improve product functions.

The Quality function deployment (QFD) approach was developed to improve product R&D strategies considering the relationship between customer demand and product features [2]. The intellectual property (IP) of the process is a critical intangible asset for enterprises with products embedded with advanced technologies. Patent documents are rich in technical knowledge which record these advanced technical claims and create a monopoly for their use in product development and sales.

This research proposes a computer supported approach based on technical function deployment (TFD) and an extended QFD approach (eQFD) to analyze R&D priorities based on consumer demand (VoC). R&D strategies are recommended to close gaps between the prioritized function improvement and patented technologies. Three cases of VoC-driven strategic deployment for improving smartphone technical functions provide details to explain the proposed methodology. There are four sections of this research. Section 2 discusses the literature related to patent analysis, latent semantic analysis, and quality function deployment. Section 3 describes the proposed approaches, including data collection, ontology construction, TFD construction, and results interpretation using case examples. Conclusions are provided in the last section.

* Corresponding author.
E-mail address: cyfan@stpi.narl.org.tw (C.-Y. Fan).

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2. Literature review

In this section, the literature related to methods, deployed and extended in this research, are reviewed. The main objective of the research is to improve product designs using IT and knowledge engineering approaches which are reviewed in Section 2.1. Section 2.2 reviews customers' demands through smart content (VoC) analysis and literature related to latent semantic analysis (LSA) for document similarity analysis. The recent developments using QFD methods for prioritizing product improvement are reviewed in Section 2.3. Finally, the research in the area of patent analysis for strategic R&D support are reviewed in Section 2.4.

2.1. Improving product design using information technology

Many researchers use information technology to improve product and service designs based on customer perceptions, such as circulation of complaints and positive evaluations of purchase expectations. Customer perception can be divided into three stages including exposure, attention, and comprehension [3]. The exposure stage describes how consumers react to an external stimulus in the environment. Different products with unique features (e.g., color, shape, texture, or sounds) can enhance memory and expectations. The attention stage refers to the customer's reaction to various stimuli. The customer's comprehension of the message provides meaning to the received information. After information processing, customers will remember to some extent their experiences which may influence future decision making [4]. Horn and Salvendy note that customer perception can be significantly influenced if the product innovation conveys a meaning of importance and novelty [5]. Lee et al. develop an ontology-based intelligent system for automatically classifying customer complaints whereby these systems identify types of customer complaints useful to managers that link operational failures [6]. Effective analysis of customer dialogues demonstrates that using information technology (e.g., text mining, web mining, data mining) is essential to improve customer perceptions of products and services. Product designers use the voice of customer (VoC) for quickly customizing product designs. Tezuka and Tanaka [7] noted that questionnaire surveys for collecting the VoC is a cumbersome, labor-intensive, and subjective process, particularly if person-to-person interviews are used to collect data. Thus, the researchers used web and text mining techniques to extract information expressed by humans and enhance precision and avoid bias [7]. Wang et al. [8] proposed a user requirements oriented knowledge management concept that is based on a four-level hierarchical map which highlights knowledge collaboration and information communication. Chang and Chen [9] proposed a hybrid system that includes data-mining, re-construction, and decision support modules. The research constructs future personal computer (PC) designs and enhances the reliability of concept selection decisions. Tang et al. [10] developed a computational intelligence technique (neural networks) for enhancing mobile phone aesthetics so that the customer's perception is included in the design. In the service industry, Wang et al. [11] used latent semantic analysis (LSA) to identify the key attributes of customer satisfaction and dissatisfaction toward hotel products and services. Qi et al. [12] proposed an automatic filtering model to predict the helpfulness of online reviews from the perspective of the product designer. The research applied KANO to analyze online reviews to derive product improvement strategies.

2.2. Latent semantic analysis (LSA)

In our research, Latent semantic analysis is the most important tool used to derive organize, and analyze the customer voice. In our research, Latent semantic analysis (LSA) identifies semantic correlations and similarities between text sets. LSA uses singular value decomposition and dimension reduction to reduce words that create meaningless noise. The semantic correlations of documents are calculated based on the term frequencies, which reduces the semantic bias of human interpretation [13]. LSA assumes that the meanings of words are determined depending on other words that appear simultaneously in the document. This approach helps prevent the problems caused by synonymy and polysemy [14].

Foltz applied LSA to map the semantic relevance of vocabularies in any text document [15]. Kireyev et al. and Ozsoy et al. use LSA to define semantic spaces and generate summaries of text documents [16,17]. Luh et al. developed a ranking algorithm for estimating search engine efficiency based on LSA genetic algorithms [18]. Jorge-Botana et al. combined LSA and analysis of variance (ANOVA) to explore the LSA parameters for corpora evaluation [19]. Gao et al. proposed two document ranking models based on LSA and statistical translation for information retrieval. The results showed that the performances of the proposed models using LSA are superior [20]. Chan et al. constructed a web service recommender system using a vector space model and LSA [21] which also supports the use of this methodology in a consumer service environment.

2.3. Quality function deployment (QFD)

QFD is a customer-oriented planning tool used to improve customer satisfaction by considering the correlations between customer's voices and engineering functions [22]. In addition to the manufacture industry, QFD has been used in design and service industries [23]. QFD shortens the product and service development and the design and improvement cycle.

QFD has also been combined with fuzzy theory, quantitative analysis, and statistical methods. Raharjo et al. [24] used an AHP-based QFD model to explore the dynamics of the customer's voice by applying time series analysis. Prasad and Chakraborty [25] used QFD to select vehicle materials considering influential factors such as functions, environment, manufacturing processes, and costs. The results show that the QFD-based material selection model is efficient and accurate [25]. Shin et al. [26] combined QFD with a system dynamics approach to construct an energy security management model to help decision makers monitor energy security. Liu [27] combined QFD and KANO for an improved product design process. Singh et al. [28] noted that QFD can be used to improve R&D management. They emphasized that researchers must align dynamic customer preferences with a product's functional and technical deployment to match R&D efforts with market demands. Sularto and Yunitasari [29] applied QFD to study point-of-sale system deployment for improving restaurant service quality.

In addition to improving product design using the voice of customers (VoC), researchers enhanced customer-based product design improvement with patented technology innovations. For example, Jin et al. [30] combined technology road maps (TRM) and QFD to derive competitive business opportunities for new product deployment. Park et al. [31] used function-based patent analysis to identify potential application areas for new technologies which further supports the use of QFD for consumer based applications.

2.4. Patent analysis

Patent analysis is an analytic approach for technology monitoring which can reveal the technical trends of different industries. The World Intellectual Property Organization (WIPO) states that more than 90% of the world's commercially viable R&D results are represented by global patents. WIPO also estimates that time and cost of R&D can be reduced by approximately 40% if researchers properly analyze patent documents of related prior-arts [32]. Patent analysis helps companies avoid intellectual property infringement while developing strategies for product and service design and technical innovation. Many researchers have proposed different patent analytical approaches to explore the technical advances and commercial strategies. In addition to basic