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A Decision Support System for market-driven product positioning and design

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ABSTRACT

This paper presents a Decision Support System (DSS) for market-driven product positioning and design, based on market data and design parameters. The proposed DSS determines market segments for new products using Principal Component Analysis (PCA), K-means, and AdaBoost classification. The system combines the data integrity, security, and reliability of a database with the unparalleled analytical capability of the Matlab tool suite through an intuitive Graphical User Interface (GUI). This GUI allows users to explore and evaluate alternative scenarios during product development. To demonstrate the usefulness of the proposed system, we conducted a case study using US automotive market data. For this case study, the proposed DSS achieved classification accuracies in a range from 76.1% to 93.5% for different scenarios. These high accuracy levels make us confident that the DSS can benefit enterprise decision makers by providing an objective second opinion on the question: To which market segment does a new product design belong? Having information about the market segment implies that the competition is known and marketing can position the product accurately. Furthermore, the design parameters can be adjusted such that (a) the new product fits this market segment better or (b) the new product is relocated to a different market segment. Therefore, the proposed system enables enterprises to make better informed decisions for market-driven product positioning and design.

1. Introduction

To maintain and enhance the level of profitability in an increasingly competitive and transparent market place, a firm must continuously reposition and redesign its existing products or introduce new products to specific market segments [1]. Decisions on product positioning and design are crucial for managers to meet diverse customer needs and achieve the firm's goals. The company has to establish its market and subsequently subdivide this market so that it can address the needs, posed by a particular market segment, with specific products. Hence, commercial organizations are continuously monitoring their target market segments by gathering data from both consumers and competitors [2]. This data forms the basis for market segmentation, product positioning and design. As a consequence, there is an urgent need for efficient access to and information extraction from this data, as well as the prediction of future trends.

Since the early 1960s, market segmentation is widely considered to be a key marketing concept and a significant amount of marketing research literature focused on this topic [3]. A variety of Data Mining (DM) algorithms have been proposed to automate or at least to support market segmentation and product design [4,5]. DM algorithms can be used to extract static data patterns and discover dynamic trends. The trends reflect customer interest shifts, technology development, and the response to marketing strategies [6]. Plank observed that management decisions were affected by the availability and use of market data [7]. However, many companies lack both data and expertise to harvest useful information which helps them to make informed decisions and act on them [8]. Therefore, making market data directly accessible to decision makers is essential for the success of a company [9]. This access must be as barrier free as possible to ensure usability and to create a positive impact on management decisions about targeting specific market segments and product offerings. However, the goal for strategic marketing extends beyond the mere selection of desirable market segments, it has to build and maintain a sustainable advantage over the competition [10]. In order to achieve this goal, information, on the requirements for each market segment and the subsequent product positioning strategies, must be processed while the design evolves concurrently [11]. One of the key factors for a successful implementation of this concurrent strategy is combining DM techniques with advanced decision making tools [12].

This paper presents a Decision Support System (DSS) for market-driven product positioning and design. The proposed system is based on the proposition that DM and decision support tools make relevant market data directly available to decision makers. We achieve this goal by integrating powerful data management with robust analytical methods into an intuitive Graphical User Interface (GUI), which ensures barrier free access to decision support information. On the methodology

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side, our core idea revolves around the fact that we interpret the result of clustering algorithms on market data as market segmentation. Based on the market segmentation, we use machine learning to provide decision support on product positioning and design. These two concepts objectify both market segmentation and design decisions. To demonstrate the usefulness of the proposed DSS for market-driven product positioning and design, we present a case study based on the US automotive market in 2010.

The rest of the paper is organized as follows: Section 2 reviews the relevant literature for DSSs in product development. Section 3 introduces the proposed DSS. Section 4 provides a case study that is used to test the DSS for market-driven product positioning and design. Section 5 discusses the case study results in detail. Conclusions and further work are presented in Section 6.

2. Literature review

Product positioning aims to establish the properties of products a firm should offer to customers in specific market segments. Product design is concerned with establishing the physical product characteristics [13]. Both product positioning and product design are non-stationary processes, i.e. they change over time and they influence each other in complex ways. Therefore, decision makers have to concurrently consider, which (a) market segments to serve, (b) competitors to challenge, and (c) product characteristics to select [10]. DM techniques, that assimilate training sets, based upon available data, help us to identify market segments, but these techniques are unlikely to provide support for decision problems in the area of product positioning and design. The knowledge discovery for the design intentions and marketing strategies should be modeled, such that they can be retained throughout the product development process [14]. This requires clear modeling techniques, which incorporate advanced decision making tools and utilities for early design stage decision making [12].

DSS frameworks can provide a modeling strategy by combining knowledge discovery and automated decision making. In the early 1970s, DSSs were developed as a new type of tools which integrate DM with artificial decision making [15]. Power defined a DSS as "an interactive computer-based system or subsystem intended to help decision makers use communication technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions" [16]. In the early product design and development stage, it is difficult to make precise and objective decisions due to a lack of information. For example, Eeckhout and De Bosschere put forward that early design stage decision support tools can provide extremely valuable information for designers and decision makers [17]. Chiu et al. developed a DSS for market segmentation using DM and optimization methods, however, these decision aids stop at the market segmentation step. Besharati et al. proposed a DSS for supporting the product design selection process [18]. Their method was based on purchase or non-purchase decisions from customers and they did not consider competitors' products. Xu et al. provided appropriate evaluation and decision tools for concurrent product development [12]. Their method has value in academic research, but their approach lacks an intuitive user interface, hence applications in an industrial setting are limited. The literature review shows that both DM and decision making algorithms are utilized in many fields of science and engineering. However, there is no dedicated DSS which integrates these algorithms in a meaningful and trustworthy way to support market segmentation and product positioning simultaneously. Therefore, there is a need for DSSs that provide synergy early in the product development stage.

We aim to address this need with the proposed DSS for market-driven product positioning and design. The proposed DSS attempts to mine important information from market data without pre-defined market segments, and to provide decision support for product positioning and design. It contains simulation models that allow decision makers to perform "what if" analysis to (a) evaluate the market segment outputs for different product property combinations, and (b) manipulate properties of a new product to examine its market position. This function enables decision makers to assess the signs and strengths of the relationship between different use cases. We conceal the advanced algorithm structure with an effective interface that provides a simplified and understandable representation of the different decision situations. With the proposed system, the decision makers can focus on the result interpretation rather than spend time on organizing the data. The next section describes the materials and methods that are used to construct the proposed DSS.

3. Materials and methods

This section describes the methods used in the proposed DSS for market-driven product positioning and design. Fig. 1 shows an overview block diagram of the system. It is structured into two phases: I, data preparation; II, decision support with the Decision Support System Database Explorer (DSSDB Explorer). Each of these phases is realized as a separate software program written in Java [19]. On a functional level, the system reads in market data and converts it to entries in database tables. The next step employs Principal Component Analysis (PCA) and K-means clustering to identify the market segments. An AdaBoost classifier is trained on these individual market segments, and subsequently it is used to determine the market segment to which a new product design belongs. The following subsections describe the algorithms and methods used in the implementation.

3.1. Data preparation

Data standardization and accessibility are a prerequisite to realize the promise of DM. In the data preparation phase, the data set, that

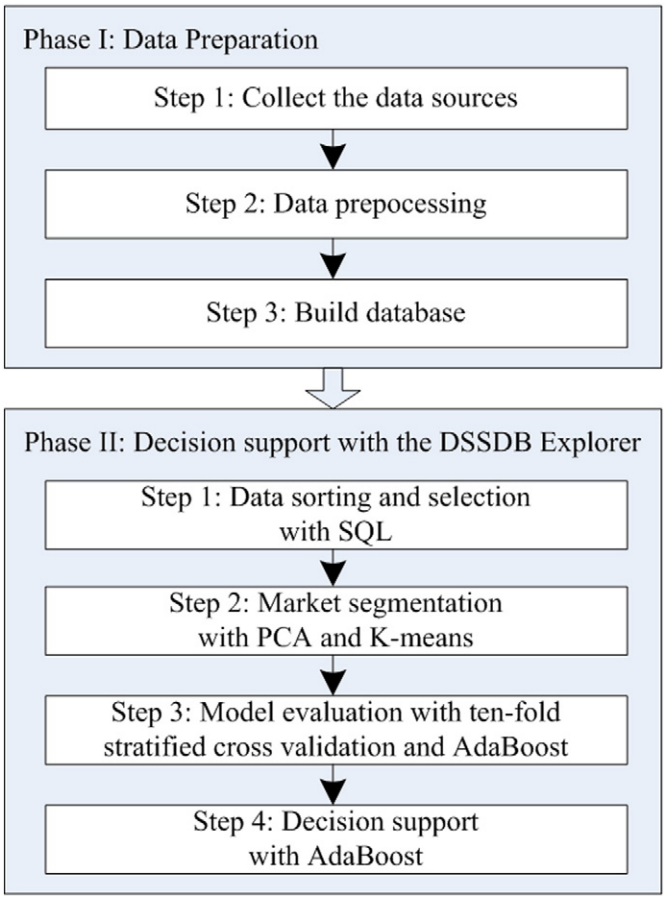

Fig. 1. Overview diagram of the proposed DSS system.