Decision Support System for Industrial Designer Based on Kansei Engineering

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Abstract. A combination of the traditional methodology of Kansei Engineering with the up-to-date Decision Support System (DSS) is developed in this paper. The users who have a little knowledge of information technology can achieve the Kansei Engineering optimal design in a short period of time by using the DSS, which is composed of a friendly human-computer interface, a database management module and a model management section. The introduction of the structure of the DSS is made first and a case study on the flat-panel handset is followed. Through the use of morphological analysis and semantic differential method, many designed samples and Kansei words are stored in the pre-determined database module. Some more consumers' information is required to get the evaluations of the automatic-formed models. Then a combination of BP artificial networks and GA is used to get the final results. The system is developed by the PHP language to make sure that it runs smoothly in a web environment. Finally, a matrix of physical parameters is attained according to the output of the system. A decoding procedure is done to get the real physical design elements of the optimal model of handset, followed by a prototyping method using other software such as UG. The optimal design is shown at last.

Keywords: Kansei Engineering, Decision Support System, flat-panel handset.

1 Introduction

The market is changing so fiercely that it has transformed from the traditional product-oriented one to one where we put more focus on the meeting of the customers' needs, of course, with no except to the handsets market. The product design, which directly or indirectly determines the final purchase behavior, lies in many different factors such as consumer preference [1], texture [2] and interfaces [3]. Recent study has shown that it's really more and more important to consider the inner preference of the customers within the competitive market. How to grasp the authentic preference of the public has become the core tactic of the manufacturing corporation. As a newly emerging methodology of design, Kansei Engineering is described as a useful tool to help the product designer to transform the feelings into the real design elements in physics.

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Kansei Engineering technology can be classified into three types, Type I, Type II and Type III. Type I is a category classification on the new product towards an identification of the design elements. Type II utilizes the current computer technologies such as expert system, neural network model and genetic algorithm. Type III is a modeling using a mathematical structure [4]. We focus our study on Type II in this paper. According to some references, there are usually two types of Kansei Engineering systems, which are developed separately to consumers and designers.

Here lists some articles talking about the consumers'. Nomura, J. details a virtual space decision support system employing Kansei Engineering which is applied for production and sales mainly in the kitchen business [5]. Sato, N. et al extract the features of a movie using factor analysis from data of a Semantic Differential Gauge questionnaire, and then link the viewer's Kansei with the features using multiple linear regression analysis [6].

Some systems on the designers are: Ishihara, S. et al present ART1.5-SSS, a modified version of ART1.5 (Adaptive Resonance Theory) for small sample size clustering. The network used for automatic rule building in our Kansei engineering expert system, instead of statistical analysis [7]. Relevant study has made some progress in the automatic computation of the mental-physical relationship. Ishihara, S et al developed an automatic semantic structure analyzer and a Kansei expert systems builder using self-organizing neural networks [8].

The rapid developing computers with great calculating ability have made it possible to get the conceivable results in a few seconds. Decision Support System, as one of the most powerful tools to solve unstructured or semi-structured problems, has been progressing so rapidly from its born. So many systems dealing with the Kansei Engineering have been developed.

There is some study into the automatic way of implementing Kansei Engineering. But as a useful tool in aiding the evaluator to make decisions, DSS has drawn a lot of attention. The integrated study of KS and DSS is rare. The system in this paper is developed in the web language PHP so that it can make the process of data collecting more smoothly. Many useful mathematical models are provided, with which the potential designers can select freely. A friendly human-computer interface is developed according to the human factors principles. They can help both the consumers and designers to fulfill their tasks well. Finally the optimal design parameters are screened and a decoding operation is made in relevant CAD software such as UG.

In this paper, we develop the logical model of the decision support system for KE design, which consists of tripartite components. A friendly human-computer interface, a database storing the fundamental information of the data flows and a model management component which provides the powerful tools such as BP artificial networks and GA algorithm together make great contributions to the whole system.

In the following case study, the optimization of a flat-panel handset is given. Morphological analysis is used to determine the physical design size. Several semantic words are picked and a Semantic differential method is applied to quantize the feelings of the potential customers. Finally the BP artificial neural network [9] and genetic algorithm, which simulates the cognitive process of the human brain and the natural evolution of the species well, are combined to attain the final solutions.

2 The Basic Structure of the DSS

There seems to be a consensus that a DSS is composed of three interrelated parts: a data management component, a model management component, and a dialogue management [10]. There is no except to the one in this paper. The logical structure of the decision support system which we have developed is shown in Fig.1. The abbreviations are as follows: Inner refers to the datasets stored in the hard disks of the system, while the outer has the opposite meaning, which needs the inputting of the preliminary data, taking the semantic ratings of the Kansei words as an example. DMC and MMC, which respectively represent the data base and model management component, are the most two important components of the DDS. The latter consists of the problem solving tools such as K-means clustering numerical algorithm for the grouping of the representative sample points and Multi-dimension Analysis. Also, it cannot do without GA and BP algorithm.

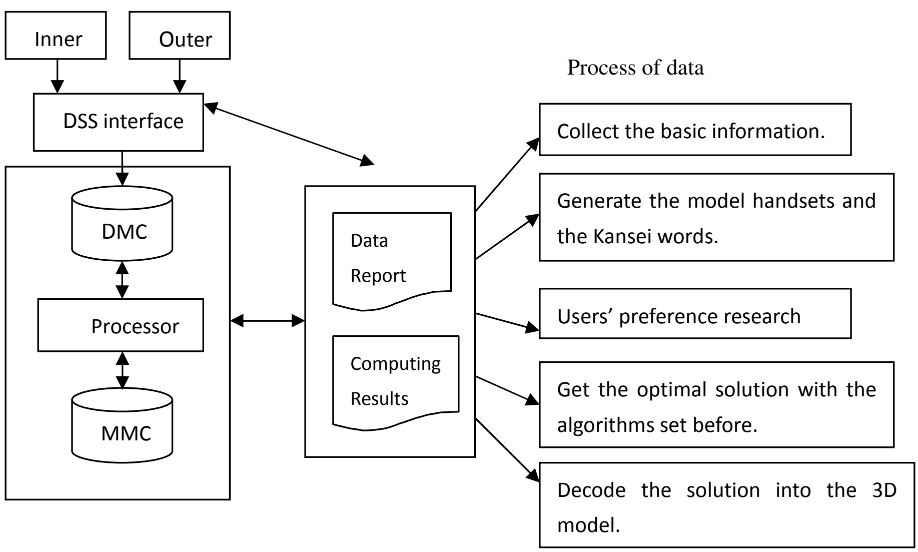

Fig. 1. Basic Structure of the DSS

2.1 Inner and Outer Data flows

As one of the main sources of the datasets, the Inner refers to the ones storing in the hardware of the system originally. It consists of selected primal models varying according to the graduation of the physical variables. Adversely, the Outer, which comes out from the exterior source, gathers the evaluations from the potential consumers. The results are made of two parts. The former comes from the groupings of the primal models, while the latter gathers the rating of the selected handsets after clustering method.

2.2 DSS Interface

The human-computer interface is what enables the learner to communicate with the computer and the computer to communicate with the learner [11]. The interface which provides a smooth channel between the human and the machine is so important that many usability problems occur if not taken seriously. Different traditional products such as the ovens or TVs which have an instruction solve the problems well. The software interface lacks this function. In this way, the interface of the DSS shows a significant role in supporting the users to achieve the goal.

2.3 Data Management Component (DMC)

Constitute of the database part and the management component, which runs its role of both reading and writing the data flows, the DMC acts an important part in pulling the job off. A special data structure is designed to memory different kinds of records such as numerical values and sample pictures. It provides the consumers who are requested to rate the phone model with the inner data and make a copy of the feedback. Without the DMC, it's like to draw a triangle with two sides left, which does not make sense.

2.4 Model Management Component (MMC)

As same as the DMC shown above, it is also composed of two distinguishing parts, which are the model base and the module of the data processing. Model base is dissimilar based on the problem you facing with. In this paper, some multivariate statistical models are added to the model base so that it can show the special characteristics of the datasets collected. Many other instruments including MLP, BP artificial neural network and GA are provided for the solution of the problem. In this system, a combination method of BP and GA is used to get the best design which in some way attracts the largest number of the consumers. It's a more advanced when compared to the previous study which only take the simple assembly of the design elements into consideration.

2.5 Processor

Being a linkage between DMC and MMC, processor makes the running of the data flow of the system more smoothly. Data is processed in batch to get the reports which will be shown on the screen. Some computations of the mathematical models with the original data are running here. It saves lots of time and money because an integrated and repetitive calculating is made. Human's brain can be liberated from the dull computing to produce more creative work.

2.6 Data Report and Results

Actually, it's a part of the human-computer interface. The final results and medium-term reports are shown within it. The status whether the computer is working now is clear at a glance. A good feedback relationship is built with the support of the data report and results part. We can decide what to do next after reading the system status and statistical results. The final results which include the optimal physical design parameters are shown in the data report. Some further operations which can convert the physical factors into the real appearance of the product can be attained in other CAD software such as UG.

3 Case Study

The consumers' preference is changing so fiercely that Kansei Engineering is put more and more attention. In a high competitive market such as mobile phones, the product designers need to provide the consumers with various styles of products [12]. The product image plays an important role in the consumers' preference and choice of the product [13]. In this paper, we choose the flat-panel handsets to be the expected item for the decision support system. The explicit methods are listed below.

Step 1: Determine the physical design variables of the handsets through morphological analysis methods in industrial design. Therefore, 21 continuous variables and 5 discrete ones are picked out to represent the whole design. The basic data and original formation of the mobile phones come from a lot of famous handset manufacturer such Nokia and Samsung Corporation.

Step 2: Consolidated the linguistic variables which can represent the consumers' needs. About 100 descriptive words are picked out from relevant magazines and TV programs. Then a sketch survey was done to analyze the main Kansei words with the method of factor analysis. There are 14 image words left, which includes one entry referring to preference. In this step, a fundamental Kansei Engineering method and the basic statistics method are used.

Step 3: With the principle of gradation, 40 typical cells were picked out. 22 potential consumers were asked to participate in the Multidimensional Scaling Analysis (MDS) part. In this study, a 6-dimensinal coordinate system is built according the selection requirements which ask a younger pressure coefficient less than 0.1 and RSQ more than 0.8. Then a K-mean cluster analysis is applied to get the representative samples from the 40 ones. Based on the results of the analysis, 12 representative models get out of the ruck after using the cluster analysis. In the traditional KE study, it's common to deal with the discrete variables. While in this one a combination of both continuous and discrete variables are made.

Step 4: 120 undergraduates (aged from 22-26) were randomly chosen according to their student numbers from the business administration of the Northeastern University to take part in the assessing part. Faced with the computers which we provided for the evaluation, they gave their attitudes on the typical handsets model with a 7 degree Likert Scale (-3-3) under the name of the Kansei words. The preference data is then stored in the Outer source of the database. The human-computer interface is put on display in Fig 2.

Step 5: So many data are collected that it's the high time the data analyze system played a role. Data is extracted from the data management component and corresponding method is elected according to the evaluator's personnel attitude. Of course, several means can be used to get the most precise solution. Because the model base is so powerful that it can support nearly all the numerical algorithms. In this paper a simple combination of BP artificial network and GA are used to ensure the exact results. An optimal was in front with the algorithm pre-compiled.

Step 6: Decode these combinations of categories and display them using 3D imagine and rapid phototyping models. In this study, a method based on the rapid 3D image formation is used. The final design model is listed in Fig 3. Because of some technology problems, the plug-in module of the automatic phototyping has not been set in the system. Further study is going on to solve this problem.

Fig. 2. A Human-computer Interface

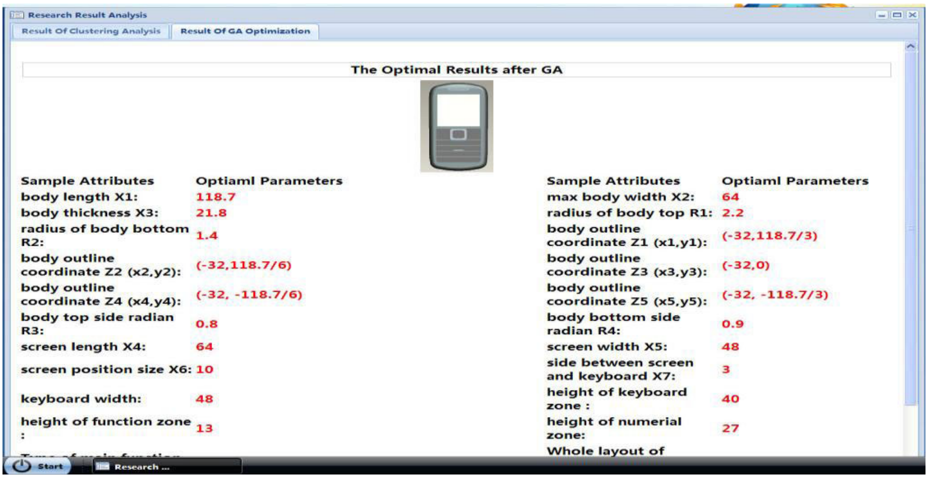

Fig. 3. Optimal Physical Results

4 Discussion

The rapid developing market calls for a higher standard for the design industry. Customers' preference is becoming more and more important under the presumption that there is no obvious difference between two products whose price is much of a size. The one, who can transfer the masses' predilection into the design elements, will beyond no doubts to be the winner in the competitive business world. In this paper, we give a brief introduction to the DSS which is used for the optimization of the physical design sizes of a flat-panel handset. Further study should go on to get more precise result: (1) a larger number of potential consumers should be investigated to assure the precision of the results. (2) Some more mathematical models shall be added to the model base module. Consequently, the evaluator has more choice to determine the analysis of the datasets. (3) The results are decoded into the physical design model in the PROE software. How to have the automatic phototyping module embedded in to the DSS is the biggest problem in the long run.

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