*Journal of Software Engineering and Applications*, **2013, 6, 638-644**
Published Online December 2013 (http://www.scirp.org/journal/jsea)
http://dx.doi.org/10.4236/jsea.2013.612076

# Prelude to *Natphoric Kansei* Engineering Framework

**Anitawati Mohd Lokman[1], Mohammad Bakri Che Haron[1], Siti Zaleha Zainal Abidin[1], Noor Elaiza Abd Khalid[1], Shigekazu Ishihara[2]**

[1]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia; [2]Faculty of Psychological Science, Hiroshima International University, Hiroshima, Japan.
Email: anita@tmsk.uitm.edu.my, bakri89@gmail.com, zaleha@tmsk.uitm.edu.my, elaiza@tmsk.uitm.edu.my, i-shige@he.hirokoku-u.ac.jp

Received April 18th, 2013; revised May 18th, 2013; accepted May 26th, 2013



## ABSTRACT

Consumers' emotion has become imperative in product design. In affective design field, *Kansei* Engineering (KE) has been recognized as a technology that enables discovery of consumer's emotion and formulation of guide to design products that win consumers in the competitive market. Albeit powerful technology, there is no rule of thumb in its analysis and interpretation process. KE expertise is required to determine sets of related *Kansei* and the significant concept of emotion. Many research endeavours become handicapped with the limited number of available and accessible KE experts. This work is performed to simulate the role of experts with the use of *Natphoric* algorithm and thus provides solution to the complexity and flexibility in KE. The algorithm is designed to learn the process by implementing training datasets taken from previous KE research works. A framework for automated KE is then designed to realize the development of automated KE system.

**Keywords:** *Kansei* Engineering; Ant Colony Clustering; *Natphoric* Algorithm; Computer-Aided KE

## 1. Introduction

Advancement in production technology and market research has flooded the market with many products with similar design, functions as well as usability. For manufacturers, this means that they are competing in a highly competitive market. They need to make their products appealing to customers so that the production costs can be turned into profits [1]. To compete in this competitive environment, it is very important for the product designers to take into consideration the consumer's impression on their product.

Two methods of product development process are "product-out" and "market-in" philosophies [2]. "Product-out" philosophy or strategy takes place when a product is developed for the market based on the needs of the society. Designers mainly focus on the functional needs, performance and usability. However, this rarely empowers a competitive edge because competitors are quick to catch up [3]. The other way of product development process is "market-in" philosophy. This approach is based on what consumers want, need and their emotional feelings [4]. This kind of strategy attracts them to purchase the product. In 1970's, the "product-out" strategy is very successful because the society hungers for the latest technology are sparse. However, in technology saturated market, society has a variety of product selections, thus shifting their needs to prefering products or goods that have affective and exciting elements which provide value beyond the functional quality [4].

Nagamachi developed a technique called *Kansei* Engineering (KE) as a method to investigate consumers' psychological feelings while interacting with a product and identifying the relationship among these feelings with product characteristics [5]. Research done by [6] found out that many companies are skeptical about the validity of KE results as its main process is hidden by KE designers. Meanwhile, they often complained that they do not have in-house expertise and have to employ experts for consultations. KE was founded in Japan and many experts are from there. In Japan, many actual examples have been developed and have emerged worldwide. The founder himself stated that companies all

over the world had come over all the way to Hiroshima to discuss the actual implementations [7]. Due to this problem, there are countless demands for computer-aided KE. But, not much attempt has been made to develop such system [8,9].

In one of the phases in the KE process, which is the Factor Analysis process, experts are required to find significant factor of emotion from the data obtained. This information is required in order to determine the concept of emotion in the product design. In order to simulate how the experts find the significant factor of emotions, *Natphoric* algorithm will be used. The *Natphoric* algorithm will be able to learn how the process is done by training it with a set of training data collected from previous KE research works.

To realize the development of computer-aided KE system, a framework for automated KE will be designed. Suitable *Natphoric* algorithm will be incorporated into the framework as a suitable development tool for the complex and flexible requirement of KE. The framework includes step-by-step technique of the use of KE Type 1 and will automate the word classification process that normally requires KE expert.

## 2. *Kansei* Engineering

According to [10], *Kansei* is an individual subjective impression from certain artifact, environment or situation using all natural human senses such as sight, hearing, smell, taste and balance as well as recognition. For example, customers who want to purchase a product or service will invoke emotional desire such as "elegant, feminine and inexpensive" [11].

*Kansei* is an internal sensation, but at present, can only be quantified using methods based on externalization. Therefore, [12] developed a series of standard measurement methods. The most common method of measuring *Kansei* is through classifying and quantifying meaning in words used to describe and differentiate each psychological and emotional need [13]. This reflects a person's mind and act as an external description for each elements of *Kansei* [13].

KE is a product development methodology which translates customers' impressions, emotions, feelings and demands of existing product or concepts into concrete design parameters [14]. This methodology integrates effective elements that are already presented during the development process [10].

It is important for manufacturers to also satisfy customers' psychological needs in addition to the product physical qualities which are defined objectively [15-18]. The KE objective is to develop products that satisfy the individual physical, psychological and emotional needs [2]. This will create a sense of endearment with the product [19,20].

For example, before purchasing a car, an individual will imagine a car with "beautiful and premium exterior", "powerful engine", "easy operation", "cool and relaxed interior" and so forth. These words express the *Kansei* of the consumers' desire towards the kind of vehicle that would satisfy their needs. These needs can be transformed and realized by through product design and development by manufacturers which in turn satisfy the customers need. Presently, KE have been successfully applied in areas such as home appliances, packaging design, work equipment or architecture [21,22].

## 3. Process of *Kansei* Engineering

KE methodology embeds tacit knowledge which has been deeply rooted in Japanese culture making it unique [4,23]. The objectives of KE are to translate *Kansei* into product properties and used as a basis to build and validate a prediction model [24].

Since KE is flexible in nature, variety of techniques can be deployed depending on the type of KE. The process of *Kansei* measurement and its underlying procedures may differ accordingly. Nonetheless, the fundamental structure contains basically the same standard procedure [14,15].

There are at least eight types of KE [4,7,15-17] which are:

1) Type 1—Category Classification
2) Type 2—*Kansei* Engineering System
3) Type 3—Hybrid Engineering System
4) Type 4—*Kansei* Engineering Modelling
5) Type 5—Virtual *Kansei* Engineering
6) Type 6—Collaborative KE Design
7) Type 7—Concurrent KE
8) Type 8—RoughSet KE

However, this study will only concentrate on Type I which is the simplest method of *Kansei* analysis and has proven track record in industry [25]. A popular car maker, Mazda, for example is using this type to design their cars and one of their popular products as a result of this method is Mazda Miata [7,14,20].

The most critical part that requires KE expert is the "Interpretation of the analyzed data" phase. In this phase, a set of *Kansei* Words that have most significant effect on each emotion are selected based on statistical analysis result. To date there are no hard and fast syntax rules. Thus, the development of an automatic *Kansei* word analysis system will significantly provide a faster way of analysis and interpretation of the *Kansei* words.

## 4. Framework Design for Computer-Aided System

Computer-aided system is defined as advanced computing technologies that access various models to provide

specific information when requested by user input [26].

The system has three primary elements which are:

1) An interface with the user.

2) A reasoning element that triggers system action.

3) A knowledge element in the form of databases, knowledge bases, and modeling modules that provides the information and analyses to be applied.

Various traditional and manual systems have migrated to computer-aided system. Some examples of those migrations are [27-29].

In these systems, the critical part of the process which traditionally done manually is converted to a computer-aided system. The process is thoroughly studied and a computer system is built to simulate the process. The advantage of a computer system is that it reduces human workload, dependent on experts and human errors.

In KE, consumers' *Kansei* is mapped into design elements. Meanwhile, the requirement for seeking more accurate mapping relationship never stops. Previous research works proposes mapping schemes, such as grey theory [30], neural network [31], fuzzy logic [9], and linear regression [32]. However, these models have their own deficits, limitations and are not accurate enough [33]. Therefore, this study only focuses on automating KE expertise using intelligent approach. Evident from past literature show no attempts have been made to employ this technique in computer-aided KE.

## 5. Multivariate Statistical Analysis Phase in KE

In KE Type I, *Kansei*, data can be obtained from *Kansei* survey. The data are analyzed using multivariate statistical method. The result of this process will be further analyzed by experts in order to determine significant *Kansei* words. **Figure 1** shows the process of KE Type I with the "Interpretation of the analyzed data" phase highlighted.

There are a variety of statistical methods that are commonly used in the multivariate statistical analysis process. The statistical methods that are commonly used are Correlation Coefficient Analysis (CCA), Principal Component Analysis (PCA), Factor Analysis (FA), Conjoint Analysis and Quantification Theory Type I (QT1). KE researchers either use one or combinations of these statistical methods. However, using the methods requires a certain level of expertise. This is one of the problems of introducing KE in the industry. Experts in the area of statistics, cognitive ergonomics and product development are the main requirement [6]. For any of the statistical methods, experts are required to analyze the result of the statistical analysis to select significant elements. The significant elements can be factors or set of *Kansei* words. The selection is based on the score of the statistical analysis and kansei expert knowledge.

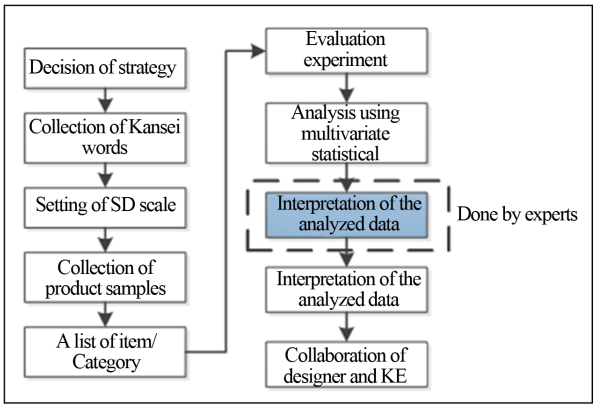


**Figure 1. KE Type I process.**

[4] states that the most important results are derived from Factor Analysis. The result of Factor Analysis eases the process of identifying design elements. So, this study will be focusing on Factor Analysis and identifying methods to aid the analysis process. The objective of Factor Analysis is to classify large number of variables into groups, called factors. Mathematical relations between these factors can also be calculated. This analysis can be used in order to understand the relationship between low level *Kansei* words and high level *Kansei* words. The result of this process is a matrix where the *Kansei* words are grouped into factors that reveal the relationship between the words. **Table 1** shows a fraction of Factor Analysis from a study on website design using *KE* [20].

For instance in **Table 1**, the website emotion is structured into five factors. The first factor consists of "Mystic", "Futuristic", "Masculine", "Luxury", "Sophisticated", "Surreal", "Impressive", "Gorgeous", "Cool" and "Professional". The research classifies this factor of emotion to represent the concept of "Exclusiveness". In classifying each factor group, the research followed the common practice performed in KE, to select representative words that can effectively describe the factor group [7]. The output of this Factor Analysis will be used in the next phase of *Kansei* Engineering to find the relationships between those emotions with the product properties.

In order to enable users with only basic knowledge of KE to execute the KE process, the system must act as the expert to aid users during *Kansei* words selection process. This project proposes using intelligent algorithm to simulate the experts. A collection of *Kansei* words needs to be collected and their similarities in term of meanings need to be identified to ensure proper selection of *Kansei* words can be programmed into the system using results obtained from the Factor Analysis. Intelligence property of *Natphoric* algorithm is suitable for simulating this task.

**Table 1. Factor Analysis table example [20].**

| | | | | | |
|---|---|---|---|---|---|
| Creative | 0.777329 | Lively | 0.67778 | Comfortable | 0.194254 |
| Classic | 0.794316 | Appealing | 0.682461 | Refreshing | 0.204197 |
| Professional | 0.805803 | Pretty | 0.689458 | Sexy | 0.272922 |
| Cool | 0.811333 | Lovely | 0.690027 | Classic | 0.275441 |
| Gorgeous | 0.812754 | Elegant | 0.703414 | Boring | 0.308598 |
| Impressive | 0.822734 | Adorable | 0.713039 | Light | 0.313839 |
| Surreal | 0.846445 | Charming | 0.763686 | Neat | 0.319281 |
| Sophisticated | 0.848426 | Sexy | 0.787619 | Calm | 0.339163 |
| Luxury | 0.878831 | Cute | 0.794058 | Relaxing | 0.348516 |
| Masculine | 0.899118 | Beautiful | 0.816958 | Natural | 0.474887 |
| Futuristic | 0.913165 | Chic | 0.93916 | Plain | 0.839005 |
| Mystic | 0.941857 | Feminine | 0.948707 | Simple | 0.9241 |

## 6. *Natphoric* Algorithm

Traditional artificial intelligence (AI) mainly concerned with reproducing the abilities of human brain, but the newer approaches is simulated based on inspiration from biological structures and behavior that are capable of autonomous self-organization. *Natphoric* algorithm is a new approach of AI which comes from the idea that intelligence not only appears in evolution, development and learning, but also appears as much in cells, bodies and characterization of societies [34].

Algorithm that is needed in this project is the one that can store and cluster a collection of *Kansei* words based on their similarities. The algorithm also needs to be flexible and dynamic, which can learn and adaptively updates its databases when new words are added.

In this project, the collection and grouping of *Kansei* words is a data clustering problem. The flexible, robust, decentralized and self-organized property of Swarm Intelligence (SI) is suitable for solving complex problems such as data clustering [35].

[36] defines SI as any attempt to design algorithms or distributed problem-solving devices based on the collective behavior of social insect colonies or other animals. The characteristics of their behaviors such as social interactions and attraction among similar groups (swarm) have inspired the designing of several types of optimization algorithms [34,37].

*Natphoric* algorithms have been applied and found to be very successful in many applications such as business, engineering, space exploration and many others [38]. In this study, the ability of *Natphoric* algorithm in data classification and clustering will be used to collect and process *Kansei* words. Successful applications of *Natphoric* algorithm for similar purpose are [39-41]. Such success stories prompt this study to formulate ant-based clustering *Natphoric* algorithms to develop an intelligent repository of *Kansei* words that can be used by automated KE system in aiding the analysis and interpretation process.

Ant Colony Optimization (ACO) algorithm has the potential of simulating the process of interpreting Factor Analysis result. The ACO algorithm can be used to store the relationships between *Kansei* words by classification and clustering which aid the analysis process in Factor Analysis used to select *Kansei* words in representing each factor. Which *Kansei* words to choose and what words to represent each group can then be identified based on the relation in ACO.

## 7. Automated KE Framework

To realize the development of computer-aided KE system, a framework for automated KE will be designed. **Figure 2** depicts the automated *Natphoric* KE Framework.

The explanations of the phases in the framework are as follows.

**Phase 1: Identification of domain and *Kansei* words.**

**Step 1:** User will need to specify the product domain.

**Step 2:** Automatic suggestion of *Kansei* words by the system database based on the domain. The set of Kansei Words are collected from previous research works based on their domain and stored into a database.

**Step 3:** User will then finalize the suggested new words, whether to add new *Kansei* words or remove any from the list.

**Phase 2: Specification of design elements.**

**Step 1:** The design elements or specification of the product need to be specified. For example color, shape, size, etc.

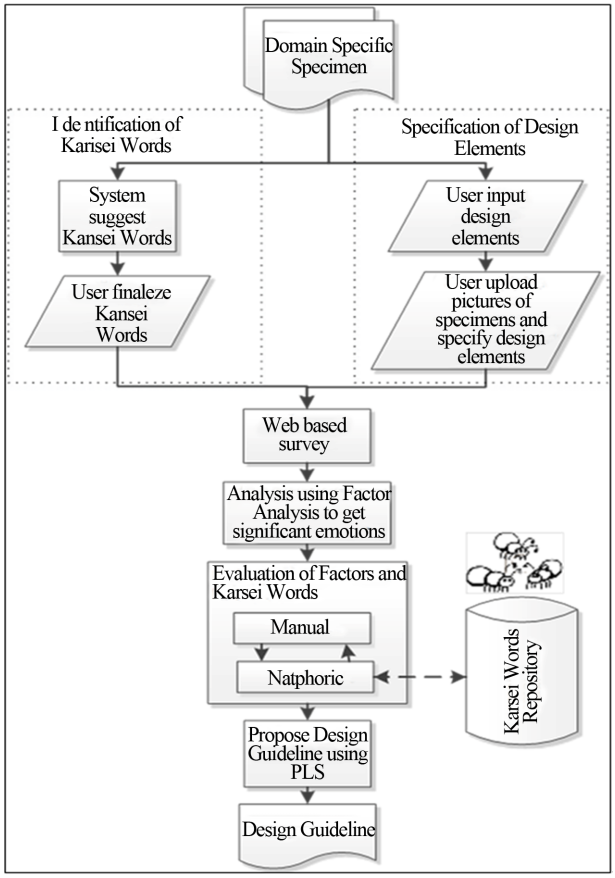


**Figure 2. Proposed Automated *Natphoric* KE framework.**

**Step 2:** After specifying all these information, about 30 to 40 product specimens are uploaded into the system. These specimens consist of products from the company and other makers that will be used during the survey. For each specimen, user needs to define design elements according to that have been specified earlier. For example, for color element, user can define blue, red, white, or any color.

**Phase 3: Web-based survey.**

**Step 1:** Construction of web-based survey pages. The system will be able to generate a link to the survey page that can be used by test subjects to do the evaluation.

**Step 2:** Conduct the survey. The evaluation experiment is done on a number of subjects. They will record their feeling on the SD scale sheet on the website with the *Kansei* words specified earlier as shown in **Figure 3**.

**Phase 4: Factor Analysis.**

**Step 1:** Data that is collected from the survey will then be analyzed using Factor Analysis (FA) to identify significant factors of emotion. FA detailed out the structure of emotion, where it determines significant factors of emotion [20].

**Step 2:** *Kansei* words that contribute to the factors that have been selected will be identified from the Factor

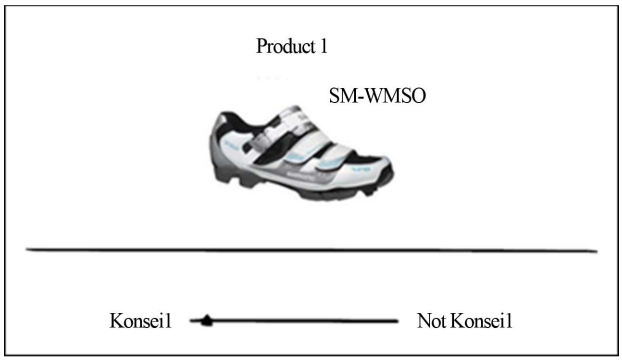


**Figure 3. Web-based survey.**

Analysis result table. In the table, the *Kansei* words are sorted in increasing order of factor value.

**Phase 5: Evaluation done manually by expert and automatic *natphoric* evaluation system.**

In a normal KE process, experts will select representative words which they could effectively describe the factor group [7]. There is no specific formula or rules to make the selection.

**Step 1:** The *Natphoric* algorithm is used to replicate the expert knowledge in making the selection. The *Kansei* words will be checked with the *Kansei* words repository that is built using Ant Colony Clustering algorithm. The result of this process is a set of factors and group of *Kansei* words that is contributing to each of the factor.

**Step 2:** Users are able to add more *Kansei* words or remove any of them from the suggestion that they think appropriate. This information will be sent back to the repository so that it can learn from this new relationship.

**Phase 6: Analysis using PLS.**

Partial Least Square (PLS) analysis will then be applied to the result from previous phase in order to identify the relationships between emotion and product design elements. It is used to rate the influence of the design elements in each emotion, the best and worst value for each design elements, and the kind of emotion elicited by each specimen.

**Phase 7: Product design guidelines.**

After all the analyses are done, the system will be able to produce a guideline for designing the product. Results of structure of emotion from FA with *Natphoric* were used to conceptualize emotion, and result from PLS scores were used to compose the design requirement. The design requirements included in the guideline were from the elements that have highest influence in eliciting target emotion.

## 8. Discussion

Evolutions in product design have led to many inventions that allow high quality product being introduced to the market. Consumers have vast choice of products as a re-

sult of a highly competitive market. Hence, producers strive to design products that can stand out and attract consumers. Kansei Engineering (KE) was invented when the founder realized that existing product design method did not take into account the consumers' feeling that enabled their needs to be satisfied, thus capture their attention. KE also helps producers in investigating how design requirements influence consumer's attention.

Even though KE has been proven to be successful in designing a heart winning products in a variety of domains, the process is not simple. Experts on KE and product development are required in the process. Companies are hesitating to adapt the technique because the method is not transparent and the need to hire third party experts.

In order to enable normal users with just a basic knowledge of KE to apply the KE process, steps that require expertise need to be automated. The most crucial part in KE is the analysis phase. The process has a possibility to be automated by applying Artificial Intelligence to it. Studies show that Ant Colony Optimization, one of *Natphoric* algorithm seems promising to be formulated and automate the Factor Analysis process.

## 9. Conclusion

This paper proposes an automated framework for *Kansei* Engineering by incorporating *Natphoric* algorithm in its analysis process. The study focuses on *Kansei* Engineering Type I. The proposed framework will automate the component in KE that requires experts and statistical analysis. Therefore, the analysis process will be performed at a centralized component as opposing to referring to several different statistical tools and software. As a result, the KE process will be more accessible and convenient to use. Furthermore, a person with basic knowledge of KE is able to perform the KE process easily. Thus, the implemented tool will help them design products that will attract customers.

## 10. Acknowledgements

This work is supported by Research Management Institute of Universiti Teknologi MARA, Malaysia and Ministry of Higher Education Malaysia under the Exploratory Research Grant Scheme [Project Code: 600RMI/ERGS 5/3 (32/2012)].

## REFERENCES

[1] J. Rajasekera and S. Dayal, "Using Kansei Engineering with New JIT to Accomplish Cost Advantage," *International Journal of Biometrics*, Vol. 2, No. 2, 2010, pp. 163-172. http://dx.doi.org/10.1504/IJBM.2010.031795

[2] N. Mitsuo, "Perspectives and New Trend of Kansei/Affective Engineering," 1*st European Conference on Affective Design and Kansei Engineering &* 10*th QMOD Conference*, University of Linkoping and Lund University, Helsingborg, 2007.

[3] H. M. Khalid, "Conceptualizing Affective Human Factors Design," *Theoretical Issues in Ergonomics Science*, Vol. 5, No. 1, 2004, pp. 1-3. http://dx.doi.org/10.1080/1463922031000086753

[4] M. Nagamachi, I. Ishihara, A. M. Lokman, T. Nishino, M., Matsubara, T. Tsuchiya, *et al.*, "Kansei/Affective Engineering," Taylor & Francis Group, CRC Press, 2010. http://dx.doi.org/10.1201/EBK1439821336

[5] M. Nagamachi, "Kansei Engineering and Its Method," *Management System*, Vol. 2, No. 2, 1992, pp. 97-105.

[6] S. Schutte and J. Eklund, "Rating scales in Kansei Engineering," *Internationcal Conference on Kansei Engineering and Emotion Research* 2010, KEER2011, Paris, 2010, pp. 23-25.

[7] M. Nagamachi and A. M. Lokman, "Innovations of Kansei Engineering. Industrial Innovation Series," Taylor & Francis, Florida, 2010.

[8] L. Lin and C. Xue, "Review of Research and Development Of Computer-Aided Kansei Engineering," *Frontiers of Mechanical Engineering in China*, Springer, 2009.

[9] J. Jiao, Y. Zhang and M. Helander, "A Kansei Minig system for Affective Design," *Journal of Expert Systems with Applications*, Vol. 30, No. 4, 2006, pp. 658-673.

[10] M. Nagamachi, "Workshop 2 on Kansei Engineering," *Proceedings of International Conference on Affective Human Factors Design*, Singapore, 2001.

[11] H. Yanagisawa and S. Fukuda, "Development of Interactive Industrial Design Support System Considering Customer's Evaluation," *JSME International Journal*, Vol. 47, No. 2, 2004, pp. 762-769.

[12] M. Nagamachi, "Kansei Engineering: A Powerful Ergonomic Technology for Product Development," In: *Proceedings of the International Conference on Affective Human Factors Design*, Asean Academic Press, London, 2001, pp. 9-14.

[13] K. M. Nasser and T. Marjan, "Design with Emotional Approach by Implementing Kansei Engineering—Case Study: Design of Kettle," *International Conference on Kansei Engineering and Emotion Research*, KEER2010, Paris, 2010, pp. 625-632.

[14] M. Nagamachi, "Kansei Engineering: The Implication and Applications to Product Development," *IEEE International Conference on SMC*, 1999, pp. 273-278.

[15] A. M. Lokman, "Design & Emotion: The Kansei Engineering Methodology," *Malaysian Journal of Computing*, Vol. 1, No. 1, 2010, pp. 1-11.

[16] A. M. Lokman, "Emotional User Experience in Web Design: The Kansei Engineering Approach," Univerisiti Teknologi MARA, 2009.

[17] A. M. Lokman, N. L. M. Noor and M. Nagamachi, "Expert Kansei Web: A Tool to Design Kansei Website, Enterprise Information Systems," Springer, Berlin, Heidelberg, 2009.

[18] Y. Shimizu, T. Sadoyama, M. Kamijo, S. Hosaya, M. Hashimoto, T. Otani, K. Yokoi, Y. Horiba, M. Taketera,

M. Honywood and S. Inui, "On-Demand Production Systems of Apparel on Basis on Kansei Engineering," *International Journal of Clothing Science and Technology*, Vol. 16, No. 1/2, 2004, pp. 32-42. http://dx.doi.org/10.1108/09556220410520333

[19] R. R. Seva, H. B. Duh and M. G. Helander, "The Marketing Implications of Affective Product Design," *Journal of Applied Ergonomics*, Vol. 38, No. 6, 2007, pp. 723-731.

[20] A. M. Lokman and M. Nagamachi, "Validation of Kansei Engineering Adoption in e-Commerce Web Design," Kansei Engineering International, 2009.

[21] M. Nagamachi, "Kansei Engineering: An Ergonomic technology for a Product Development," *Proceedings of IEA*'94, 1994, pp. 120-122.

[22] T. Childs, A. de Pennington, J. Rait, T. Robins, K. Jones, C. Workman, S. Warren and J. Colwill, "Affective Design (Kansei Engineering) in Japan, Faraday Packaging Partnership," University of Lees, UK, 2001.

[23] A. Lanzotti and P. Tarantino, "Kansei Engineering Approach for Total Quality Design and Continuous Innovation," *The TQM Journal*, Vol. 20, No. 4, 2008, pp. 324-337.

[24] T. Murai, "Large Rough Sets and Modal Logics," *Journal of Japan Society for Fuzzy Theory and Systems*, Vol. 13, No. 5, 2001, pp. 23-32.

[25] L. Hultman and S. Larsson, "Development of a Method for Subjective Expert Evaluation of the Human Driving Geometry," Lulea University of Technology, Lulea, 2005.

[26] N. R. Council, *et al.*, "Council Computer-Aided Materials Selection during Structural Design," The National Academies Press, Washington, DC, 1995.

[27] D. E. Culler and W. Burd, "A Framework for Extending Computer Aided Process Planning to Include Business Activities and Computer Aided Design and Manufacturing (CAD/CAM) Data Retrieval," *Robotics and Computer-Integrated Manufacturing*, Vol. 23, No. 3, 2007, pp. 339-350. http://dx.doi.org/10.1016/j.rcim.2006.02.005

[28] V. Raman and A. Palanissamy, "Computer Aided Legal Support System: An Initial Framework for Retrieving Legal Cases by Case Base Reasoning Approach," *Innovations in Information Technology*, Vol. 2, No. 48, 2008, pp. 317-321.

[29] D. S. Kim, D. H. Baek and W. C. Yoon, "Development and Evaluation of a Computer-Aided System for Analyzing Human Error in Railway Operations," *Reliability Engineering and System Safety*, Vol. 95, No. 2, 2010, pp. 87-98. http://dx.doi.org/10.1016/j.ress.2009.08.005

[30] H. W. Hsiao and E. Liu, "A Neurofuzzy—Evolutionary Approach for Product Design," *Integrated Computer-Aided Engineering*, Vol. 11, No. 4, 2004, pp. 323-338.

[31] H. W. Hsiao and H. C. Tsai, "Applying a Hybrid Approach Based on Fuzzy Neural Network and Genetic Algorithm to Product Form Design," *International Journal of Industrial Ergonomics*, Vol. 35, No. 5, 2005, pp. 411-428.

[32] Y. Kinoshita, S. Ichinohe, Y. Sakakura, E. W. Cooper and K. Kamei, "Kansei Product Design for the Active Senior Generation—A Case Study of Mobile Phone Designs," *International Conference on Kansei Engineering and Emotion Research*, 2007.

[33] K. C. Wang, "A Hybrid Kansei Engineering Design Expert System Based on Grey System Theory and Support Vector Regression," *Expert Systems with Applications*, Vol. 38, No. 7, 2011, pp. 8738-8750. http://dx.doi.org/10.1016/j.eswa.2011.01.083

[34] D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence Theories, Methods and Technologies," MTI Press, 2008.

[35] X. Cui Swarm, "Intelligence in Text Document Clustering," Oak Ridge National Laboratory, 2009.

[36] E. Bonabeau, M. Dorigo and G. Theraulaz, "Swarm intelligence: From natural to artificial intelligence," Oxford University Press, New York, 1999.

[37] G. Martens, C. L. Poppe and R. V. Walle, "Unsupervised Texture Segmentation and Labeling Using Biologically Inspired Features, Multimedia Signal Processing," IEEE 10th Workshop, 2008.

[38] R. Chiong, "Nature-Inspired Informatics for Intelligent Applications and Knowledge Discovery: Implications in Business, Science, and Engineering," 2009. http://dx.doi.org/10.4018/978-1-60566-705-8

[39] N. Tsimboukakis and G. Tambouratzis, "Word Map Systems for Content-Based Document Classification," *IEEE Transactions on Systems, Man & Cybernetics—Part C*, 2011, pp. 662-673.

[40] S. G. Khode and R. Bhatia, "Improving Retrieval Effectiveness Using Ant Colony Optimization," *International Conference on Advances in Computing, Control, & Telecommunication Technologies*, 2009, pp. 737-741.

[41] Z. S. Xu *et al.*, "The Study on Electric Power System Based on Swarm Intelligence," *Advanced Materials Research*, Vol. 442, 2012, pp. 424-429.