Natphoric Kansei Engineering System (N-KES)

Anitawati Mohd Lokman, Mohammad Bakri Bin Che Haron, Siti Zaleha Zainal Abidin, Noor Elaiza Abd Khalid
Universiti Teknologi MARA (UiTM), Malaysia.
anita@tmsk.uitm.edu.my

***Abstract*—Over recent years, consumers have become sophisticated and desired product that meets their desired emotional connectivity, which stands out in their eyes among the abundance choices they have from the market. Kansei Engineering (KE) has been widely attracting researchers' attention as a technology that enables incorporation of emotion in product design. KE makes it possible to discover relationships between product design and the resulted emotional responses. Among the process in KE implementation, KE analysis is the most crucial part, and it requires a Kansei expert intervention to determine the optimum result. However, there are not many accessible Kansei experts and there is no specific rule of thumb in this process. This research proposed a web-based system comprising of Natphoric algorithm in its engine to simulate the expert intervention in a computer-aided KE implementation. The algorithm is used to imitate the expert activity to find a significant factor of emotion. It learns the process by training with datasets from previous KE research works. The Natphoric algorithm is formulated to handle the complexity in KE, and the N-KES adopted the use of one of the technique in KE Type 1 to automate the Kansei conceptualization process which requires expertise in KE. The developed N-KES has produced similar result with the manual KE implementation. This research outcome will benefit the producers and designers advocates to easily implement KE Type 1, to enable development of new and innovative product design.**

***Index Terms*—Emotion; Kansei; Kansei Engineering (KE); KE Type 1; KE System; Natphoric Algorithm.**

I. Introduction

Over the past decade, the power and effect of emotion in persuasion and acceptance of a product have been increasingly recognized [1-4]. Emotional connectivity to a product has become a requirement for consumers to feel close to the product [4,5]. Henceforth, affective design has been the center of attraction in many manufacturers' Research & Development (R&D) department in building and designing products.

Kansei Engineering (KE) has become widely known and gained attention of many researchers to use this technology in their R&D process to design heart-winning products [6]. They are doing so by translating customers' feelings and emotions into product parameters. The process of interpreting the result of statistical analysis in KE requires expert intervention. In this process, a set of related KWs that are contributing to the factor of emotion need to be selected. There are no exact rules or methods to do the process.

Previous literature has indicated that many companies felt insecure about the validity of KE results, as its vital process is enigmatic, and relying on a 3rd party expert which often need to be employed with a cost. Due to this problem, there are countless demands for a computer-aided KE. But, there is very little attempt exists to develop such system [7,8]. The most crucial part in KE that requires expert input is during the analysis phase. The research contend that the process could be automated by applying Artificial Intelligence. The research has identified the Ant Colony Optimization, one of Natphoric algorithm as promising in assisting the Factor Analysis process in KE.

The proposed system, N-KES, consists of the required statistical modules, so users do not need to convert and transfer data from one tool to the other to do the analysis. It is transparent in which it enables users to view the detail results of each step in the analysis process. Automation of the critical process using Natphoric algorithm is done to simulate how KE experts perform the analysis, and enable novice users with basic knowledge of KE to perform KE process easily. The system can be used by producers and designers advocates to design their products based on a target consumers' emotion.

II. Background Literature

Kansei has been used as a substitute to emotion in many research to represent affect or emotion in response to a product [1-6]. Kansei is seen as sensual intuition providing material for understanding, and through this providing the mental ability to experience affective values such as the psychological feeling, emotion and desire [10].

Among the diverse way of accessing consumer's Kansei, the easiest is by the use of Kansei Words (KW). Two important measuring elements in KE are the synthesizing KW and identification of concepts. The first requires analysis to related sources in the domain, and the latter requires expert intervention. The objective of KE is to ultimately translate the Kansei into product properties. It implements different techniques to link emotion of products with product properties. In the process, the chosen product domain is mapped from both semantic and physical perspectives. The Kansei is linked to corresponding physical properties, where a prediction model can then built and validated [11].

Lokman [12] has developed a framework to summarize the principles in implementing KE processes, which includes 8 different types of KE Implementation; Category Classification, KE System, KE Modelling, Hybrid KE, Virtual KE, Collaborative KE, Concurrent KE, and Rough Set KE. In all types, the procedure involves phases of Domain Decision, Kansei Dimension, Product Design Dimension and Synthesis.

Desirable algorithm required for this project is the one that can store and cluster a collection of KWs and their similarities. The algorithm also need to be flexible and dynamic, where it can update its knowledge-base depending on the datasets that are provided into. The research has identified data clustering problem in the process of collecting and grouping of KWs. A flexible, robust, decentralized and self-organized property of Swarm Intelligence (SI) is seen as

suitable mechanism to solve the complex problems of data clustering [13], which exist in this project. Natphoric algorithms have been applied and found to be very successful in many applications such as business, engineering, space exploration and many others [14]. In this research, the ability of Natphoric algorithm in data classification and clustering will be used to collect and process KWs. Clustering with swarm-based algorithm is emerging as an alternative to more conventional clustering techniques. These algorithms have recently been shown to produce good results in a wide variety of real-world applications. During the last five years, researches on ant-based clustering algorithms have reached a very promising state.

Thus, due to this many previous success stories in many applications, this research will formulate one of the Natphoric algorithm, which is ant-based clustering. It will be used to develop an intelligent repository of KWs to be used in the intended N-KES.

III. METHODOLOGY

The intended N-KES is targeted to improve the manual process of KE Type 1. There are several techniques of performing KE Type 1, mainly based on the kind of analysis performed. Among the many techniques, the chosen techniques for this research purpose is the process of a standard KE Type 1, which involve the use of Factor Analysis (FA) and Partial Least Square (PLS) Analysis. The process shown in Figure 1 depicts the manual synthesizing of KWs, which will be used in the next process to develop Kansei checklist. The process followed with identification of valid specimens, and empirical analysis to determine design elements from the specimen. The checklist and specimen are then used in Kansei evaluation, to gather data from evaluation subjects. The obtained data will then be analyzed using FA and PLS, to enable formulation of guideline to the design of target product concept. The computer-aided web-based KE, N-KES, is designed adapting the manual process of the standard KE Type 1, to meet the identified requirement for N-KES. The process is shown in Figure 2. Detail description of the computer-aided web-based KE can be found in [15,16].

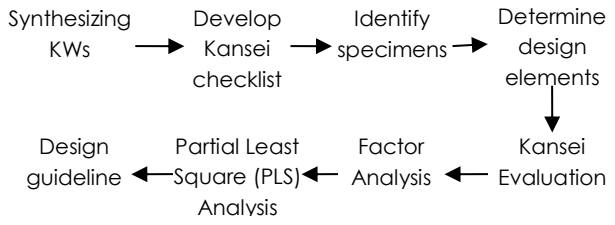

Figure 1: Manual KE Process

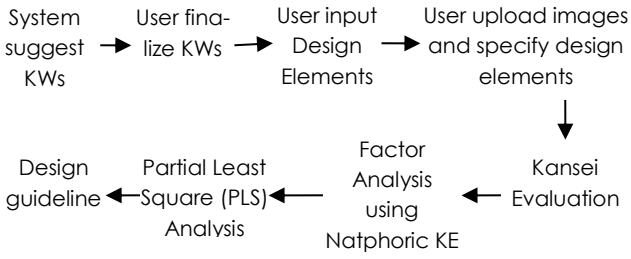

Figure 2: N-KES Process

The research adopted ADDIE (Analysis, Design, Development, Implementation and Evaluation) model in its N-KES development stage.

A. *Analysis Phase*

In Analysis phase, the research analyze past work in KE, specifically the work that involve the implementation of FA and PLS. The findings from this phase were used to provide input to the design phase of this research, in the form of design specification to develop a prototype for the N-KES.

B. *Design Phase*

The project is designed based on the knowledge acquired from the analysis phase. During this phase, specifications of the project were identified. The system was identified to be developed separated into two modules. The first module is the KW Repository system that stores a collection of KWs and their relationship. The second module is the Computer-aided Web-based N-KES to be used by end users.

a. *The KW Repository*

The N-KES require a repository that store KWs and their relationship with each other. To do this, an Ant Colony Optimization clustering technique was used. Clustering of KWs were formed on a 2-dimensional plane by ants walking, picking up or dropping down projected KW vectors with different probability.

The reason why the Natphoric ACO clustering algorithm was used, instead of simple counts of how many times each KWs are related to one another, is due to the ability of Natphoric algorithm in extracting hidden information. Illustration of these relationships are shown in Figure 3. For instance, when KW ‘A’ is said to be highly related with KW ‘B’. KW ‘B’ on the other hand is said to be highly related with KW ‘C’. Using simple logic, it can be said that KW ‘A’ is also related to KW ‘C’. This hidden information cannot be seen using simple counting approach, especially when there is a huge amount of complex relationships. By using Natphoric ACO clustering approach, KW ‘A’, ‘B’ and ‘C’ will be clustered close to each other.

b. *N-KES Architecture*

After all the main components of the system are identified, the overall architecture is designed to show interactions between them. The input and output will also be identified. The system is developed on a web-based system using J2EE library. The architecture of the system is shown in Figure 4. This web-based system runs inside a web container, the Apache Tomcat server. For data storing, CSV files and MySQL database system is used. The system consists of 4 main components which are Ant Colony Clustering, FA, PLS Analysis and the User Interface. User will need to insert the selected KWs to be used to the user interface.

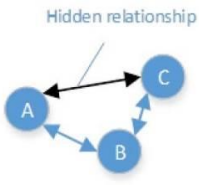

Figure 3: The hidden relationships

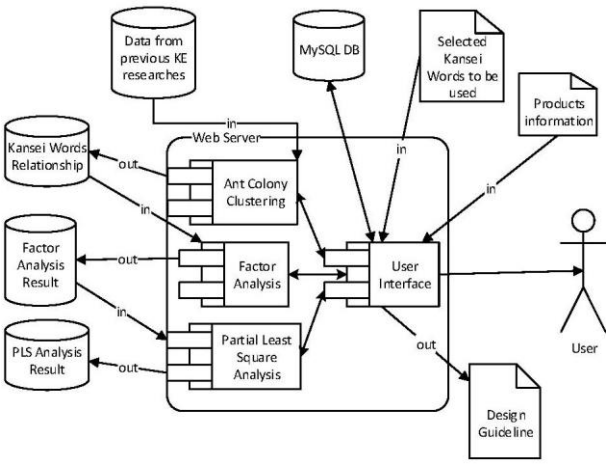

Figure 4: N-KES Architecture

The web system will assist user when inserting these information. All the data is then saved into CSV file. MySQL database system will be used to keep track of all these files. This is because every Kansei project in the system will have several data associated with it. A unique ID will be generated for each project and appended to all data files associated with the project and stored inside the MySQL database.

For the analysis process, users will not be allowed to skip the steps. Users need to follow the analysis steps which are Ant Colony Clustering, Factor Analysis and Partial Least Square. The output for the step will be the input for the next step. The output will also be stored inside CSV files and being keep tracked using MySQL database. After all of these steps are completed, the user will then be able to view the design guideline for the product.

C. *Development Phase*

In the Development Phase, the two modules of the system which are KWs repository and the web-based systems will be developed. The repository with ACO clustering engine will be trained with several datasets obtained from previous KE researches and the performance of clustering algorithm will be simultaneously measured. For the web system, each module will be developed including the statistical analysis modules which are integrated with the web system. The system that will be developed consists of several packages with a lot of classes that interact with each other. During the development process, if the performance of the built prototype is unsatisfied, it will be backtracked to the earlier stage, the design phase. The steps continue until the satisfied result is obtained. Upon satisfactory result is obtained, project integration is done and proceed to testing phase.

D. *Implementation Phase*

After the prototype has been successfully developed, the next phase is to test the prototype. This is to check whether the prototype is developed according to the requirement. This phase employ the process of validating and verifying the developed prototype to meet the research objectives, which is achieved it desired objective to automate the analysis process. Functional testing includes testing the functional actions and features of the prototype and non-functional testing that includes scalability and performance of the prototype will be evaluated. The detail of implementation and evaluation phase is described in the result and discussion section.

E. *Evaluation Phase*

After the result of the testing is identified, the last stage will be result analysis. In this last stage, the result of the web-based KE will be analyzed and evaluated. A comparative analysis will be done to determine the ability of this new web-based KE as compared to traditional KE. The detail of the implementation and evaluation phase is described in the result and discussion section.

IV. Result and Discussion

N-KES has a main interface for users to interact with the system. The system has a very useful KWs repository that can be accessed through the web system, in which it stores and displays distances in values between KWs as a result from Ant Map clustering. For example, the distance between Interesting and Unique is 1.4142, and the distance between Interesting and Sophisticated is 14.2126. We can conclude that Interesting is highly related or similar with Unique and not so related with Sophisticated. All this values were obtained using Ant Colony Clustering using data from a number of previous KE research. When there are new datasets inserted into the database, the system can retrain the Natphoric algorithm to adapt with the new data by user click to the system interface.

A. *Synthesizing KWs*

N-KES provides suggestion for users which KWs to choose based on result obtained from KWs repository. Users are also allowed to edit the list, by removing or adding any new related KWs. This has enable the reduction to the amount of work involved in investigating the full range of domain specific keywords in web design, which is huge and exhaustive in manual KE (Lokman, 2009).

B. *Specifying Products or Specimens*

Users will need to click “Products” link at the project main page, which they will then be redirected to the page where they can upload product specimens. This ease the process of storing the product images, and enable visual at low cost and worldwide access. In manual process, researcher needs to prepare specimens for every evaluation procedure. This will implicate not only waste of time and resources, but possible biasness in terms of control and consistency of specimen.

C. *Specifying Design Elements*

Design elements are the design attributes and value that can be identified according to specimens. For inserting these design elements information into the web system, user need to click “Design Elements” link from the project information page. Using the web system, the manual process is improved and amount of work needed to do the process is reduced. The possibility of errors also will be reduced by highlighting the intersection row and column, as shown in Figure 5.

Figure 5: Design Elements coding page

D. Kansei Evaluation

N-KES generates the evaluation tools automatically, and it is unique to a project. The tools can then be shared with the evaluation subjects. The arrangement of the KWs will be randomized for every specimen to eliminate bias. N-KES displays KW one by one. This ease the view and encourage users to focus on each question, instead of trying to complete the evaluation quickly since they see a lot of KWs on 1 view in manual form. A sample of the evaluation page is shown in Figure 6. The average evaluation score will then be calculated automatically, which reduces a whole lot of effort if done manually.

Figure 6: Evaluation by Natphoric KE System

E. Factor Analysis (FA)

N-KES uses R statistical library to perform statistical analysis. To perform FA, users need to click the "Execute" button on the system. Result obtained from N-KES is comparable with manual KE implementation. For instance, in Figure 7, the first factor can be observed to explain 41% of the data, which is almost equal to the manually one, which is 40.23%. In the system, the selected KWs by N-KES is the same with the manual one on the right, which are Gorgeous, Cool, Professional, and so on. The observable difference in factor values are due to the different tools used for FA. This result indicates that the N-KES has successfully replicate the experts' intervention to select the factors.

Factor 1 [41.0%]

Kansei Word	Value		
☐ Old Fashioned	-0.653562		
☐ Boring	-0.498736		
☑ Gorgeous	0.819303	Professional	0.805803
☑ Cool	0.819430	Cool	0.811333
☑ Professional	0.820650	Gorgeous	0.812754
☑ Impressive	0.827418	Impressive	0.822734
☑ Surreal	0.845569	Surreal	0.846445
☑ Sophisticated	0.855452	Sophisticated	0.848426
☑ Luxury	0.886117	Luxury	0.878831
☑ Masculine	0.914786	Masculine	0.899118
☑ Futuristic	0.917269	Futuristic	0.913165
☑ Mystic	0.946832	Mystic	0.941857

Figure 7: Sample Factor result

F. Partial Least Square (PLS) Analysis

N-KES uses R programming to develop the PLS analysis module. In N-KES, all the design elements that were determined in the earlier process is automatically converted into dummy variable. All the taxing process in the manual KE implementation to convert and append data is simplified in N-KES. The system will display the result after one click, as sample shown in Figure 8, for KW Adorable".

For easy analysis, the system sorts the sub-elements list in the second column in decreasing order of coefficient score. Sub-Elements that have the highest score are the one that highly influence a particular Kansei. For example, as in Figure8, the influential elements will be underlined and the highest influential sub-element is in bold-green color. The result suggests that to design Adorable website, designer must set priorities to design elements according to the influence, i.e. Background Color, Dominant Item, Empty Space, and so forth. Sub-elements in red must be avoided by designers for new product. This result has been compared to the result of manual KE implementation, and the research found that the result is the same.

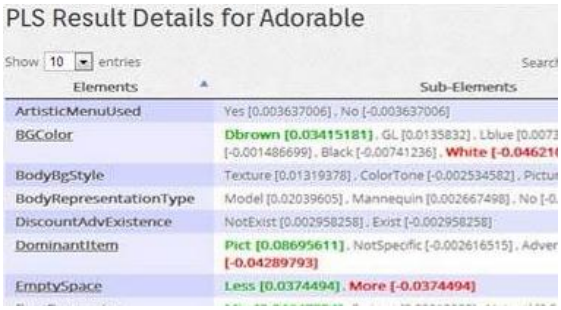

Figure 8: Sample PLS result

G. Design Guideline

All the above analyses have enabled the research to develop a proposed design guideline for the product domain, which in this research case, website design. Results of the structure of emotion identified from FA were used to conceptualize emotion, and result from PLS Scores were used to compose the design requirement that correspond to the emotion. The design requirements included in the guideline were from the elements that have highest influence in eliciting a target emotion. The process is similar to the manual KE implementation, accept the system displays the proposed guideline in one click, which highly improved the time and energy consumed in manual structuring of the guideline.

V. Conclusion

This research has explored the potential to develop automated KE system using Natphoric algorithm, to simulate expert intervention in its conceptualization of Kansei responses. The system called N-KES, could be used to facilitate KE implementation mostly by novice KE researcher advocates. The research has identified that FA process in KE requires expert input to find significant factor of emotion from the gathered data, which is crucial to help determine the concept of emotion in the product design. The developed N-KES shows that it is able to learn how the process is done and produced similar results with the expert. The algorithm was trained using training datasets obtained from previous KE research works.

The system is flexible to be used for any type of products, whether be it a physical object such as shoe or clothing, or digital products such as website or software interface design. The proposed system will automate all the key processes and reduce complexity of KE implementation. N-KES has successfully optimized all the processes required in KE. The processes that were complicated, time consuming and exhaustive are enhanced, and simplified. Table 1 summarizes the KE implementation phases and comparison of manual KE and N-KES.

The developed N-KES is proven to be working as an

alternative to the manual KE. The only part where most users' interaction is required is during the data specification phase. The rest will only require users click to the system and the system will do the rest of the work. The part where expert intervention is required, which mostly is during the FA, is also successfully automated by using the Natphoritc algorithm.

N-KES is a web-based system, which extend the potential use by producers and designers advocates all over the world. Additionally, the evaluation process can also be done using worldwide subjects.

Table 1
Result summary

Phase	Manual	Computer-aided Natphoric KE
Synthesizing KWs	Collected and analysed manually.	Suggestions based on previous KE works.
Specification of design elements	Specified using binary matrix. Complicated data entrance into computer system and error prone.	Using "Yes" and "No" notation that automatically generates the corresponding binary matrix in excel file. Current row and column will also be highlighted to assist users.
Develop Kansei checklist	SD scales will be constructed for each of the selected KWs on an evaluation form. There will be one copy of form for each specimen.	The evaluation is using a web-based form and being generated automatically. The order of KWs will also be randomized for each specimen to eliminate bias.
Kansei Evaluation	Each participants will be given the evaluation forms for them to do the evaluation. They will be given a number of forms according to specimens. The process of inserting data into computer system for the purpose of analysis is also complicated and error-prone. Inserting, validating and calculating the huge data population is time consuming and challenging (Lokman, 2009).	Participants will do the evaluation by visiting the link which are automatically generated by the system. Only one KW will be shown to them at one time. The process is being done automatically by the system. Users of the system do not have to do additional work.
PLS Analysis	Data for PLS need to be prepared by researcher. Those data will then be run manually using statistical tools to get the result. The process is then repeated for huge amount of data. It is very time consuming and error-prone.	Users just have to click a link and the system will automatically prepared all the data and run the statistical analysis for them.
Factor Analysis	The number of factors to be extracted is determined by the expert. KWs selected to represent each factors is based on the score and expert's knowledge.	Optimum number of factors to extract is determined using Kaiser-Guttman rule. KWs to represent each factors is selected using Natphoric algorithm.
Design guideline	Design guideline is constructed manually using results from statistical analysis. PLS range also need to be calculated manually to determine influential attributes.	The design guideline is constructed automatically by the system with just one click. PLS range calculation is also being done automatically.

ACKNOWLEDGEMENT

This work is supported by Research Management Centre of Universiti Teknologi MARA, Malaysia under the Research Entity Initiative Grant Scheme [Project Code: 600-RMI/DANA 5/3/REI (6/2013)], and the Exploratory Research Grant Scheme [Project Code: 600-RMI/ERGS 5/3 (32/2012)].

REFERENCES

[1] Nagamachi, M., Lokman, A.M. 2015. Kansei Innovation: Practical Design Applications for Product and Service Development, *Taylor & Francis Group*, Florida.
[2] Nagamachi, M., Ishihara, I., Ishihara, K., Matsubara, Y., Nishino, T., Lokman, A., Childs, T., Eklund, E., and Hirata, R. 2011. Kansei/Affective engineering. Industrial Innovation Series, Adedeji B. Badiru (Eds.), *Taylor & Francis Group*, Florida.
[3] Ishihara, S., Ayas, E., and Eklund, J. 2010. Kansei Engineering Applied To Triggers In Powered Tools. CRC.
[4] Seva, R., Duh, H., Henry, B., and Helander, M. 2007. The Marketing Implications Of Affective Product Design. *Applied Ergon*, pages 723–731.
[5] Lokman, A. 2009. Emotional User Experience in Web Design: The Kansei Engineering Approach. PhD thesis, Universiti Teknologi MARA.
[6] Nagamachi, M. 2004. Framework and Economical Power of Kansei Engineering.
[7] Lin, L. and Xue, C. 2009. Review Of Research And Development Of Computer-Aided Kansei Engineering. Frontiers of Mechanical Engineering in China.
[8] Jiao, J. Zhang, Y., and Helander, M. 2006. A Kansei minig system for affective design. *Journal of Expert Systems with Applications.*
[9] Lokman, A.M., Ishak, K.K., Razak, F.H.A., and Aziz, A.A. 2012. The feasibility of PrEmo in cross-cultural Kansei measurement, *IEEE International Symposium on Humanities, Science and Engineering Research (SHUSER)*, 1033-1038.
[10] Nagamura, N. 1991. Measurement of Kansei. Handbook of Advanced Technology of Kansei Measurement.
[11] Murai, T. 2001. Large Rough Sets And Modal Logics. *Journal of Japan Society for Fuzzy Theory and Systems*, 13:23–32.
[12] Lokman, A. 2010. Design & emotion: The Kansei Engineering methodology, *Malaysian Journal of Computing (MJOC)*, 1(1):1-11. Shah Alam: UPENA.
[13] Cui, X. 2009. Swarm intelligence in text document clustering. Oak Ridge Na¬tional Laboratory.
[14] Chiong, R. 2009. Nature-Inspired Informatics for Intelligent Applications and Knowledge Discovery: Implications in Business, Science and Engineering.
[15] Lokman, A.M., Haron, M.B.C., Abidin, S.Z.Z., Khalid, N.E.A., and Ishihara, S. 2013. Prelude to Natphoric Kansei Engineering Framework, *Journal of Software Engineering and Applications*, 6:.638-644.
[16] Lokman, A.M., Haron, M.B.C., Abidin, S.Z.Z., Khalid, N.E.A. 2014. Natphoric computer-aided Kansei Engineering system. *3rd International Conference on User Science and Engineering (i-USEr).*