Extending Kansei Design for Requirements Consideration in Web Engineering

Maxim Bakaev[1], Martin Gaedke[2], Vladimir Khvorostov[1], Sebastian Heil[2*]

[1] Novosibirsk State Technical University, Novosibirsk, Russia
{bakaev, xvorostov}@corp.nstu.ru
[2] Technische Universität Chemnitz, Germany
{martin.gaedke, sebastian.heil}@informatik.tu-chemnitz.de

Abstract. In our paper we consider how the eminent Kansei Engineering (KE) method can be applied in computer-aided development of websites. Although principally used for exploring emotional dimension of users' experience with products, KE can be extended to incorporate other types of software requirements. In conjunction with AI Neural Networks (Kansei Type II), it then becomes possible to automate, up to a certain degree, evaluation of websites quality in terms of functionality, usability, and appeal. We provide overview of existing works related to KE application in web design, and note its certain gap with systematic Web Engineering. Then we summarize approaches for auto-validation of different types of requirements, with particular focus on computer-aided usability evaluation. Finally, we describe the ongoing experimental study we undertook with 40 participants, in which Kansei-based survey with 21 university websites was performed, and outline preliminary results and prospects.

Keywords: web design; human-computer interaction; Kansei engineering; non-functional requirements; usability

1 Introduction

As the number of websites worldwide is approaching one billion, systematic and efficient application of Web Engineering (WE) methodology continues to gain in importance. Among the most crucial dimensions of WE we consider Requirement Engineering (RE) that is essential for building and maintaining a web product within reasonable timeframe and budget, and Web Interaction Design. The latter comprises such areas as human-computer interaction, information engineering, user interface design and testing, graphic design, etc. Obviously, higher degree of Artificial Intelligence (AI) methods application in these WE dimensions could lead to more rapid, reliable, and economical web development as well as, presumably, to better average interaction quality, at least in conventional projects with typical user tasks.

* Sebastian Heil's PhD Advisor is Prof. Martin Gaedke. The reported study was funded by RFBR according to the research project No. 16-37-60060 mol_a_dk.

In one of our previous works [1], we proposed a set of methods for evolutionary algorithms' (EA) application for interaction design. According to our ideas, an important component of the EA should be the neural network (NN) that automatically evaluates candidate solutions per specified fitness function, so that 1) potentially deficient web interfaces are not presented to real users, and 2) the time gaps between generations of solutions are decreased, speeding up the algorithm's convergence. In this, the respected Kansei Engineering (KE) method (see its extensive review in [2]) seems a promising and systematic basis, since it has the following advantages:

1. Applicability for maturing industries (as certain degree of pre-accumulated knowledge is required), such as web development.
2. Self-learning capabilities of KE NN, which allows it to accommodate to the ever-changing software requirements [3].
3. Formal mathematical representations and reasonable computational effectiveness in evaluating the fitness function, which is crucial in EA.
4. Good correspondence to Web Engineering, since websites are abundant and accessible (NNs need lots of diverse data for self-learning), and web interfaces currently have higher typicality in terms of user tasks, technologies, standards, and platforms employed, compared to desktop or mobile software.

However, before KE can be applied for evaluation of a fitness function reflecting integral quality of candidate web designs, the generic method that focuses on emotional dimension of customer's interaction with a product, must be supplemented with the means to measure concordance to software requirements as well as established, even if not explicitly specified, interaction quality parameters. So, our research work is dedicated to the extension of the Kansei Design method to integrate all aspects of web interaction, and in Section 2 we explore how the validation of various types of requirements' fulfillment can be automated within the method's framework. In Section 3 we describe the ongoing experimental study seeking to illustrate the applicability of the proposed approach.

2 Kansei Design, Requirements, and Web Engineering

Kansei Engineering is a set of methods and techniques that originated in Japanese automotive industry in the 1980s and since then were successfully applied in numerous other fields [2]. KE's *analytical* method seeks to establish formal relations between target customers' feelings and impressions of existing or prospective products (expressed per measurement scales – *Kansei Words*) and particular attributes of the products. The *synthetic* method of KE aims to obtain the list of the prospective product's attributes from the desired Kansei (emotional feeling) of the target customer. Thus, the latter in essence attempts to automate transition from requirements to design resolutions – long time a Holy Grail of software engineering – and implies significant amount of pre-accumulated technological and usage knowledge in the industry.

Probably the most recent and quite extensive review of KE applications in areas related to WE can be found in [4], and the authors conclude that in webpage design they

are still relatively scarce. Notably, in our own literature review we were unable to find attempts to incorporate more types of requirements into KE-based design – quite on the contrary, a recurring theme (see e.g. [5, p. 2], [6]) was a contraposition of the emotional aspect, that can be probably best summarized in a quote "…the new paradigm of producing desirable websites as opposed to current focus on website functional usability and performance" [6, p. 147]. Thus, existing works virtually never consider unambiguous parameters related to users' interaction with a website beyond the emotional experience, and also have little consistency in selecting design factors to be analyzed and varied in KE. In the absence of accepted website design factors structure in the industry, the selection methods range from near omission of their origin [7] to experts' surveys [4], to reasonably systematic approaches (e.g. eye tracking in [8]). Since many agree that "more efficient and complete description methods of the factors should be applied" [4, p. 13], proposals to construct KE / WE support databases for the web were made repeatedly (see [5], [3], or our own research [9] that employs ontology-based approach), but their implementation so far remains limited.

Given the apparent gap between WE and KE – endeavors in improving KE application, particularly in web design domain, are mostly aimed towards closer and more systematic involvement of users/customers ([10], [11], [12]) – we instead would need to turn to RE. There seems to be a multitude of requirement classifications, so the related common vocabulary even had to be organized as ontological concepts [13], and a very holistic work at cataloguing types of non-functional requirements (NFR) was done in [14]. The NFR types relevant for web systems are denoted as *Integrity*, *Interoperability*, *Performance*, *Privacy*, *Scalability*, *Security*, and, finally, *Usability* that we'll consider in more detail. In Table 1 we reason about the requirement types' applicability for interaction on the web and outline approaches for automating the evaluation of a website's compliance with them (validation), for the KE framework.

Usability is a complex measure reflecting quality of user's interaction with an artifact (software, website), and is relative to users traits and needs, context of use, etc. The principal approaches towards automation of usability evaluation (UE) include:

- Interaction-based UE: analyzes real or "staged" (User Testing) interactions. The degree of "optimality" of a user behavior on website can be estimated based on visualization (e.g. in Yandex.Webvisor tool) and/or logs data mining. However, so far automation remains incomplete (experts involvement required) and reliable quantitative values are hard to obtain, given the diversity of use contexts [15].
- Metric-based UE: attempts to define and quantify user interface metrics (from concordance to design guidelines to amounts of text on a webpage, in WaPPU tool [15]) that reflect its usability. Some KE works already use metrics like this (e.g. ratio of graphics to text in [3]), but only as high-level design factors affecting emotional experiences. Fundamental issue of considering effect of different user tasks and contexts of use on the metrics significance, however, seems to be unresolved.
- Model-based UE: if User Model and UI Model are available, AI methods (e.g. simulation) can be used to obtain usability evaluations without real interactions. This may be a promising approach, especially in conjunction with evolutionary algorithms that offset certain disadvantages of the model-based interface design [1].

Table 1. Approaches for automated testing of compliance with requirements

Requirement type and relevance	Auto-validation approaches
Functional requirements in interaction are mainly represented as *Use Cases*.	Test scripts, web interface test automation software: Selenium, HtmlUnit, etc.
Integrity and *Privacy* are in essence *Security* requirements. Main focus is on data entry, while channels and server security are not relevant.	Web application security scanners, web-form validators: SQLMap, W3AF, Metasploit Framework, etc.
Interoperability with applications and components is not relevant.	For assessing quality of interaction with users see *Usability*.
Performance for web interaction by and large means response/latency time per planned website capacity.	Load testing/benchmarking, e.g. with tools like Apache JMeter that can use scripts to simulate user behavior.
Scalability may refer to dealing with increasing complexity in user tasks (increasing number of users rather relates to *Performance*).	No known approaches for automation. Generally, creative interface re-designs are required when user tasks are complemented or modified.
Usability is the major requirement type and may be sub-categorized into *do-goals* (in-use, achieving tasks) and *be-goals* (being satisfied, etc.).	*Usability in-use* evaluation can be interaction-based, metric-based, or model-based. *Satisfaction* is extensively measured with conventional KE.

3 The Experimental Study

To confirm the proposed idea that KE can be effectively enhanced to consider non-emotional requirements, we designed an experimental study, to be performed in two main stages. The setup of the first part is more or less typical for Kansei surveys, with target customers evaluating a number of websites varying in both visual design factors and unambiguous parameters stemming from NFRs. Then we are going to construct the extended KE NN, train it with data collected from the subjects, and use it to generate two "optimal" website designs, #1 considering purely emotional aspect, and #2 taking into account the extra parameters. In the second part of the experiment, in another survey with target customers we'll test the hypothesis that web design #2 rates significantly better that #1 and the control group of websites.

To date, we performed the first session of the first survey, collecting Kansei data from 40 subjects (36 of whom were male), age ranging from 19 to 33 years, mean 24.5 (SD=3.19), all of whom were students at a German university (14 of Bachelor and 26 of Master program), the greater part of them (38 subjects) majoring in Computer Science / Informatics. They were given a scenario to be performed with 21 real websites of several German and Russian universities, then rate them on 10 developed Kansei scales based on the ones used in similar research works ([4], [5], [6], [7], and [8]). The experimental scales and their evaluations (5-point Likert scale, with -2 meaning most prevalence of the first term, +2 most prevalence of the second term) are

presented in Table 2. The second session of the first survey will be performed with respected number of students from a Russian university, so that cultural differences in Kansei could be investigated and accounted for in the further research.

Table 2. The Kansei scales and their evaluations in the experiment (session 1)

Scale	Mean	SD
masculine – feminine	-0.15	0.37
conventional – creative	-0.03	0.68
homely – global	0.25	0.30
reasonable – premium	0.02	0.42
academic – practical	-0.12	0.35
handcrafted – professional	0.13	0.47
natural – technical	0.19	0.27
stable – dynamic	-0.03	0.61
exclusive – attainable	0.30	0.21
bright – temperate	-0.21	0.28

4 Conclusions

In our research work we seek to justify and develop approaches for extension of Kansei Engineering beyond the conventional emotional aspect, so that the method could be used to consider other types of requirements and effectively applied in WE. The motivation for this stems from our existing work, in which we proposed to use extended KE neural network for assessment of fitness for solutions obtained in the course of evolutionary web interaction design [1], and a wider research context of transforming requirements into design resolutions [9]. Further, a prototype Web Design Support Intelligent System developed by our team (see description in [16]) is able to consider requirements when generating a web interface wireframe, but this capability is so far quite rudimentary and calls for further enhancement.

In the current paper, we overview applications of KE for web design and note a certain contraposition between emotional aspect of user interaction and other types of software requirements. From research in requirements engineering, we extracted most common types of NFRs and outlined the approaches towards automated evaluation of website compatibility with the requirements. We gave particular focus to automated usability evaluation, noting pros and cons of interaction-based, metric-based, and model-based UE, as well as mentioning some existing testing automation tools.

To confirm that KE can be effectively enhanced to consider non-emotional requirements, we designed the experimental study and performed its first stage with 40 subjects evaluating 21 operating university websites per 10 specially developed Kansei scales. Our plan for future work involves construction of the extended KE NN, training it with the experimental data, and showing that web design created with extended KE is superior in comparison to the one generated with the conventional method that only considers the emotional aspect of web interaction.

Acknowledgement. The reported study was funded by RFBR according to the research project No. 16-37-60060 mol_a_dk.

References

1. Bakaev, M., Gaedke, M.: Application of Evolutionary Algorithms in Interaction Design: from Requirements and Ontology to Optimized Web Interface. In IEEE ElConRusNW, pp. 125-130, LETI, St Petersburg (2016).
2. Schütte, S.T.W., Eklund, J., Axelsson, J.R.C., Nagamachi, M.: Concepts, methods and tools in Kansei Engineering. Theoretical Issues in Ergonomics Sc. 5 (3), 214-231 (2004).
3. Lin, Y.C., Yeh, C.H., Wei, C.C.: How will the use of graphics affect visual aesthetics? A user-centered approach for web page design. Int. J. of Human-Computer Studies 71 (3), 217-227 (2013).
4. Guo, F. et al.: Optimization design of a webpage based on Kansei Engineering. Human Factors and Ergonomics in Manufacturing & Service Industries 26 (1), 110-126 (2016).
5. Lokman, A.M., Noor, N.M., Nagamachi M.: Kansei Database System for Emotional Interface Design of E-Commerce Website. In 4th Int. Cyberspace Conf. on Ergonomics (2008).
6. Noor, N.M., Anitwati, M.L., Nagamachi, M.: Applying Kansei Engineering to Determine Emotional Signature of Online Clothing Websites. In 10th ICEIS (5) vol. HCI (2008).
7. Song, Z., Howard, T.J., Achiche, S., Özkil, A.G.: Kansei Engineering and Web Site Design. In ASME 2012 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, pp. 591-601 (2012).
8. Qu, Q.X.: Kansei knowledge extraction based on evolutionary genetic algorithm: an application to e-commerce web appearance design. Theoretical Issues in Ergonomics Sc. 16 (3), 299-313 (2015).
9. Bakaev, M., Avdeenko, T.: Ontology-Based Approach for Engineering Web Interface Design Resolutions. 5th Int. workshop on CS and Engineering, Moscow, pp. 196–201 (2015).
10. Carreira, R., Patrício, L., Jorge, R.N., Magee, C.L.: Development of an extended Kansei engineering method to incorporate experience requirements in product–service system design. Journal of Engineering Design, 24 (10), 738-764 (2013).
11. Falk, S., Tursch, P., Woll, R.: The Improvement of Kansei Engineering by Using the Repertory Grid Technique. Management and Production Eng. Review 6.3, 77-82 (2015).
12. Jiang, H., Kwong, C.K., Liu, Y., Ip, W.H.: A methodology of integrating affective design with defining engineering specifications for product design. Int. J. of Production Research, 53 (8), 2472-2488 (2015).
13. Avdeenko, T., Pustovalova, N.: The ontology-based approach to support the completeness and consistency of the requirements specification. Int. Siberian Conf. on Control and Communications (SIBCON), IEEE, Omsk (2015).
14. Mairiza, D., Zowghi, D.: Constructing a catalogue of conflicts among non-functional requirements. In Evaluation of novel approaches to Software Engineering. Springer Berlin Heidelberg, 31-44 (2010).
15. Speicher, M., Both, A., Gaedke, M.: SOS: Does Your Search Engine Results Page (SERP) Need Help?. In Proc. of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM, 1005-1014 (2015).
16. Bakaev, M., Avdeenko, T. Indexing and comparison of multi-dimensional entities in a recommender system based on ontological approach. Comp. y Sistemas 17 (1), 5-13 (2013).