Extending Kansei Engineering for Requirements Consideration in Web Interaction Design

Maxim Bakaev[1(✉)], Martin Gaedke[2], Vladimir Khvorostov[1], and Sebastian Heil[2]

[1] Novosibirsk State Technical University, Novosibirsk, Russia
{bakaev,xvorostov}@corp.nstu.ru
[2] Technische Universität Chemnitz, 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 website quality in terms of functionality, usability, and appeal. We provide an 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 82 participants, in which a Kansei-based survey with 21 university websites was performed, and outline preliminary results and prospects.

Keywords: Web interface design · Kansei Engineering · Non-functional requirements · Usability

1 Introduction

As the number of websites worldwide is approaching 10^9, systematic and efficient application of Web Engineering (WE) methodology continues to gain in importance – it is generally agreed that it could lead to more rapid, reliable, and economical web development. Web interaction design, which embraces HCI, information engineering, user interface design and testing, graphic design, etc., has long been affirmed as an integral part of WE, due to the crucial importance of positive user experience for website success. However, the application of formal and AI methods in this area remains quite limited, particularly in engineering usability and user satisfaction [1].

Kansei Engineering (KE) is a set of methods and techniques that originated in Japanese automotive industry in the 1980s and since then were successfully applied in

V. Khvorostov's Ph.D. Advisor is Assoc. Prof. Galina Kurcheeva.
S. Heil's Ph.D. Advisor is Prof. Martin Gaedke.

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numerous other fields. 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 prospective product attributes from the desired Kansei (emotional feeling) of the target customer.

Probably the most recent and quite extensive review of KE applications for web design can be found in [2]; however the authors conclude that they are still relatively scarce. We discovered that a recurring theme in related research works (see e.g. [3, p. 2, 4]) was the contraposition of the emotional aspect vs. the other dimensions of website quality: this can best be summarized in a quote "… the new paradigm of producing desirable websites as opposed to current focus on website functional usability and performance" [4, p. 147]. Indeed, when applying KE, they virtually never consider unambiguous parameters related to users' interaction with a website beyond the emotional experience, and although proposals to construct KE/WE support knowledge bases were made repeatedly (e.g. [3, 5]), seemingly none of them were adopted by practicing web engineers. In one of our previous works [6], we proposed to employ an extended KE method as a core part in web interaction design on the basis of evolutionary algorithms (EAs). KE neural network (NN) could automatically evaluate 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. This approach in particular would allow adaptability to the ever-changing software requirements, owing to robust self-learning capabilities of KE NN [5].

Thus, our research work is dedicated to ensuring greater applicability of KE in web design, through enhancing it to consider all aspects of website interaction quality (or *fitness*, in terms of EA), not merely the generic emotional impression of the users. In Sect. 2 we explore how concordance of a website to various types of interaction-related requirements can be measured within the method's framework, at least in conventional projects with typical user tasks. In Sect. 3 we describe the ongoing experimental study seeking to illustrate the applicability of the proposed approach.

2 Kansei Engineering, Neural Networks, and Requirements

The synthetic KE method in essence attempts to automate the transition from requirements to design resolutions – long time a Holy Grail of software engineering – and implies a significant amount of pre-accumulated technological and usage knowledge in the industry. It would seem that WE is mature enough, with hundreds of millions of active websites, most of which are reasonably well accessible, since even the increasingly used AJAX technologies do not present an ultimate barrier for automated retrieval (NNs need lots of diverse data for self-learning). Still, our review of the field suggests that endeavors in improving KE application in the web design domain are mostly aimed towards the closer and more systematic involvement of users/customers [7, 8] – we were unable to find attempts to incorporate non-emotional requirements or established, even if not explicitly specified, interaction quality parameters.

Requirements engineering is widely recognized as the most crucial dimension of WE, essential for building and maintaining a web product within a reasonable timeframe and budget. There seems to be a multitude of requirement classifications, so the related common vocabulary even had to be organized as ontological concepts [9], while a very holistic work at cataloguing types of non-functional requirements (NFR) was carried out in [10]. The NFR types relevant for web systems are denoted as *Integrity*, *Interoperability*, *Performance*, *Privacy*, *Scalability*, *Security*, and, finally, *Usability*. 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.

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. The main focus is on data entry, while channels and server security are not relevant	Web application security scanners, webform 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

Understandably, *Usability* considerations, even if not explicitly specified in requirements, are the most important for web interaction design, but there are ongoing discussions about which measurement automation approach could accommodate the three peculiarities of usability, since it is by definition user-specific, task-specific, and context-specific. Probably the most widely applied one is *interaction-based* that infers usability evaluations (UE) from input in the course of real user interactions (like the promising WaPPU tool [1]), or from log data, which have to be previously accumulated. Another approach is *metric-based,* that attempts to identify a set of metrics that reflect a website's usability, from certain high-level design factors (e.g. the amount of text on a webpage), concordance to design guidelines [11], even users' opinions. A fundamental issue of determining the effect of different user tasks and contexts of use on the metrics' relative significance, however, seems to be unresolved.

The proposed KE NN evaluation method [6] belongs to *model-based* approaches, and conventionally the NN's input neurons are design factors, which we propose to supplement with requirements concordance metrics, and the output is user impressions or fitness evaluation for EA. Naturally, methods not involving real interactions can only provide approximate estimations of real usability, but this should be sufficient for application in EAs, for which fitness function approximations theory is reasonably well established. Also, since web interfaces are highly typical in terms of user tasks, technologies, standards, and platforms employed, compared to desktop or mobile software, the estimations should improve with NN training. So, in the next section we describe an ongoing experimental study undertaken to justify the proposed approach and illustrate how a factor of website cultural kinship affects user impressions.

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 aspects, 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 than #1 and the control group of websites.

To date, we performed the first session of the first survey, collecting Kansei data from the two groups of subjects. First, there were 40 students (36 of whom were male) of a German university (14 of Bachelor and 26 of Master program), age ranging from 19 to 33 years, mean 24.5 (SD = 3.19). Second, there were 42 students (30 males) of a Russian university (23 of Bachelor and 19 of Master program), age ranging from 20 to 28 years, mean 21.7 (SD = 0.89).

All subjects were given a scenario to be performed with 21 real websites of several German and Russian universities (all websites were presented in their English versions), then rate them on 10 developed Kansei scales based on the ones used in similar research works [2–4, 12, 13]. 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 websites' success in the suggested task (we call it *Overall* evaluation) was measured with the question *"Based on the website, would you recommend to your friend to go there for the Master's program?"*, answers were on the scale from 1 (*"definitely no"*) to 5 (*"definitely yes"*).

The correlation between the evaluations provided by German and Russian subjects was highly significant ($R^2 = .994$, $p < .001$). However, the results of the regression analysis for *Overall* evaluation have shown that significant factors (the single ones at $p \leq .01$) were different for the two groups of participants: *handcrafted – professional (HP)* for the German subjects ($R^2 = .718$) and *reasonable – premium (RP)* for the Russian

Table 2. The Kansei scales evaluations by German (DE) and Russian (RU) subjects

Scale	DE: mean (SD)	RU: mean (SD)
masculine – feminine	−0.15 (0.37)	−0.36 (0.38)
conventional – creative	−0.03 (0.68)	−0.16 (0.70)
homely – global	0.25 (0.30)	0.40 (0.39)
reasonable – premium	**0.02** (0.42)	**−0.18** (0.71)
academic – practical	**−0.12** (0.35)	**0.10** (0.30)
handcrafted – professional	0.13 (0.47)	0.43 (0.66)
natural – technical	0.19 (0.27)	0.64 (0.42)
stable – dynamic	−0.03 (0.61)	−0.08 (0.73)
exclusive – attainable	0.30 (0.21)	0.53 (0.34)
bright – temperate	**−0.21** (0.28)	**0.04** (0.71)
Overall	3.15 (0.39)	3.43 (0.58)

Table 3. Mean *Overall* evaluations per subject and website groups.

Subjects websites	German	Russian
German	3.22	3.20
Russian	3.07	3.69

ones ($R^2 = .805$). In Table 3 we illustrate how an objective factor of website's cultural kinship affects the resulting *Overall* evaluation for the two groups of subjects.

4 Conclusions

In our research work we seek to 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 can be effectively applied in WE. The motivation for this stems from our existing work, in which we proposed to use extended KE NN to assess the fitness for solutions obtained in the course of evolutionary web interaction design [6]. The prototypical Web Design Support Intelligent System developed by our team (see description in [11]) takes requirements into account when generating a web interface wireframe, but in a quite rudimentary way that calls for further enhancement.

In this paper, we provided an overview of KE applications for web design and noted a certain contraposition between emotional aspect of user interaction and other types of software requirements. From research in requirements engineering, we extracted the most common types of NFRs and outlined the approaches towards an 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 an experimental study and performed its first stage with 82 subjects evaluating 21 operating university websites per 10 specially developed Kansei scales. Our plan for future work involves the construction of the extended KE NN, training it

with the experimental data, and justifying that web interface 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.

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