Immersive Kansei Engineering – A New Method and its Potentials

P. Häfner, M. Ommeln, J. Katicic and J. Ovtcharova

2012

Abstract

Product development becomes more and more complex. Products obtain more and more functions and at the same time they must be still attractive for the customers to ensure a successful product launch. To predict their acceptance and to gain knowledge on how to design attractive products new methods are developed in the field of the emotional design. Such a method is the Kansei Engineering, which collects the customers hidden subjective needs and their translation into concrete products. We present and validate a new form of the Kansei Engineering method for emotional assessment by the customers during the product development, based on an interactive product experience in Virtual Reality. The major novelty of our kind of method is the use of immersive representations which focuses on both, the product itself and its environmental context, too. Customers experience these virtual representations quite dynamically and with this freely describe their emotional influence on them. We come to the conclusion that more reliable emotional customer feedback can be acquired through the implementation of the proposed context paradigm shift. The fusion of product and environmental context enables the simultaneous role of the customer as a subject (actor) and an object (observer) in the virtual world, thus promoting reliable emotional reactions. Despite of some disadvantages, we propose Immersive Kansei Engineering as a reliable method for emotional product assessment by the customer.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Virtual reality—Applications

1. Introduction

Nowadays in the consumer products marketing customers have increasing individual demands on engineering products. In this field goods are never emotionally completely neutral. Because of the personal identification and the association of ideas related to these products, their pure perception as well as their handling affect involve humans themselves emotionally as potential customers. Hence emotion has been defined as one of the three success parameters of modern marketing [KM08]. The Virtual Reality concepts and the available technology today help designers and engineers to communicate their ideas in a very realistic manner using 1:1 scale representation, stereoscopic displays and interactive experience. Early customer presentation can save costs and accelerate the product development process and guarantee good product realization.

The challenge of future product development is thus to enable the reliable capturing of emotions in order to develop products at early stages, when these products exist only in virtual, even just conceptual form. In this way a genuine customer-centered product development will be realized continuously – this is important, because it means that the customer involvement gap between the definition of requirements and the test of the first physical prototype will be closed. The major method used for capturing customer emotional feedback to products is Kansei Engineering. In this paper, we propose a new kind of this method, applying the technology of Virtual Reality for interactive visualization of virtual products in real size and real-time. This new method, which we named Immersive Kansei Engineering, improves the imagination of customers regarding physically non-existing products and thus promotes their more relevant emotional assessment.

In the next sections we first describe the related works and our new method. The major results are depicted in detail such as the potentials, advantages and disadvantages of the proposed solution. These are based on two validation studies conducted in a three-side passive stereoscopic projection environment. The theoretical and practical implications and some further future perspectives are discussed at the end.

2. Related Works

2.1. Methods for Affective Engineering

Emotional or affective engineering is a new research field that introduces methods for detection and quantifying of the emotional customer needs and transform them into products. The focus lies on the emotional assessment during the product development phase. This is achieved by letting the customer experience early prototypes to comprise his needs and expectations in the product concept and design. The most important methods for affective engineering, addressing the emotional component of product evaluation are Citarasa Engineering [HPK07] and Kansei Engineering [Nag89]. Methods which can be applied for affective engineering, but are mainly used for rational product evaluation are Quality Function Deployment (QFD) [GS78], Kano model [KSTT84] and Conjoint analysis [MAI94].

2.2. Virtual Reality in Product Development Process

Virtual Reality technology finds widely usage in the product development process. Zepelin [Zep07] states that "upfront investment and high penetration of VR across the overall product development life-cycle leads to increased maturity, reduced development time (30%) and reduced costs (20%)". Adenauer et al. and Tideman et al. [TVH08, AIS13] show the enormous potential of VR to support creative design in the early conceptual phase. VR in the context of consumer product design can be used to understand the mental models of the user related to the operation of a system and his needs and emotional feelings related to the external product characteristics [RDNS11]. Ogi [Ogi11] has already recognized the advantages of Virtual Reality as support environment for emotional design, namely the sensation of the actual size and the perspective view thanks to head-tracking. Additionally the use of haptic devices for force and touch feedback is possible and makes the virtual product experience more realistic.

Our understanding of Virtual Reality is based on the human-centered definition of [SC03], who describes it as "... a medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation". Virtual Reality is realized through multiple input and output devices, which enable the bidirectional information flow between the user and the virtual world. Immersion will be referred to as degree of fidelity of sensory stimuli that are produced by VR systems. We characterize a virtual environment as immersive from a technological point of view if it provides stereoscopic presentations of objects in real size on three- or more-sided projection walls (CAVEs) as well as head-tracking of the user. This was confirmed by an earlier study with more than 100 participants that we performed [OK11].

2.3. Kansei Engineering

Kansei is a Japanese word that refers to the sensitivity of a human sensory organ which perceives stimuli from the external world [Yan10]. This means that Kansei Engineering is a reactive method of emotional product assessment - the product is presented preferably multi-modally to the users and they give verbally their emotional feedback. The vice-versa approach of emotional evaluation of product attributes driven not extrinsic by perception, but intrinsic by desire, is called Citarasa Engineering [HK12]. The measured subjective product quality through Kansei Engineering is called Kansei quality. There are several alternative processes in the literature which can be referred to as Kansei Engineering. According to [SS07], following major steps (Figure 1) of the consolidated basic process can be identified:

- Selection of assessed products and their form of representation (Choice of Domain)
- Selection of Kansei adjectives for description of Kansei quality (Span Semantic Space)
- Selection of relevant product attributes (Span the Space of Properties)
- Kansei assessment: determination of Kansei values (Synthesis)
- Assignment of Kansei values to product attributes (Test of Validity and Model Building)

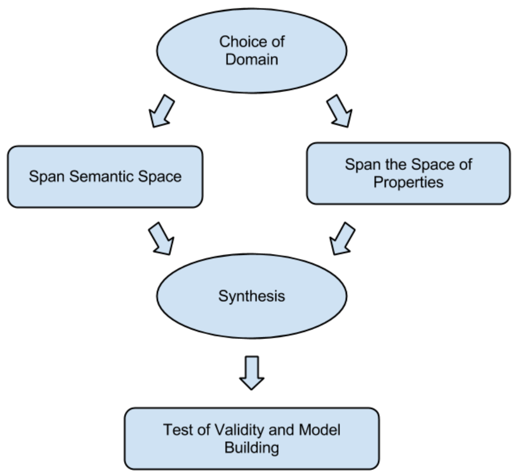

Figure 1: *A model on Kansei Engineering Methodology according to [SS07]*

Assessed products in the stages of their virtual existence are usually represented as two-dimensional pictures. There are already first approaches for application of spatial representations, three-dimensional pictograms [LHS02] or virtual models [Nag89]. The Kansei adjectives are usually pre-given as pairs of opposites, called semantic differentials, as for example "beautiful"-"ugly". The product developers have to select the relevant product attributes which are to be assessed, as for example form, color etc. During the survey customers usually grade each pair of adjectives on a Likert scale, preferably with an even number of points to avoid neutral answers. Having examined a representative group of customers, product developers can carry out statistical examinations of the collected material. In order to assign Kansei adjectives to certain product attributes, classification algorithms as multi-regression-analysis, fuzzy logics or neuronal networks can be applied [HH02]. One big advantage of the classical Kansei Engineering is its ability to build mathematical prediction models on how feelings are connected to product properties [Sch05]

A major critical point of classical Kansei Engineering is the application of questionnaires with pre-given adjectives [OMT10]. In this way, the expression possibilities of the customer are significantly constricted and follow a rigid time pattern which is non-intuitive. Due to this linguistic and fixed categorical method the classical method implies the assumption of a human representation i.e. of the consumer as a strongly linguistic and therefore rational one. Both characteristics support therefore static methodologies and measurements in principle. But, psychological feelings and their related values are in generally, first of all, nonverbal and unaware, and require continuous methodologies as far as technically possible. Awareness and classifying oneself into fixed categories means an interruption and time delay, in the worst case a falsification of emotions. In order to minimize these undesirable static intervals in the affective engineering, we think, that the practice of immersive Virtual Reality is a pretty good tool for us. Moreover, it enables us to soften the strong categories and to find one possible way out of the 'speech-dominated' dilemma. Another critical point of the classical method is the assessment of products based on two-dimensional representations. We propose emotional assessment in three dimensional space similar to Nagamashi and Ingrassia et al. [Nag89, ILNS08] where we focus not only on the product, but on its very environmental context. The here proposed visualization in immersive Virtual Reality environments allow the user to interact with the virtual product presented in real-size and real-time and to describe its emotional effect freely and intuitive with own words in a quite dynamic context, thus overcoming the stated disadvantages.

3. A New Method – Immersive Kansei Engineering

Here we propose a new form of the Kansei Engineering method in an immersive environment, which aims to eliminate the identified critical points of the classical form. Immersive Kansei Engineering consists of following five steps (Figure 2):

- Selection of products to be assessed in Virtual Reality and of the technological platform to be applied (Choice of Domain and VR Platform)
- Definition of the user group
- Selection of the environmental context of product experiencing
- Free description of the experience using Kansei adjectives (Free Span of Semantic Space)
- Classification of Kansei words and their assignment to product attributes (Synthesis and Model Building)

The major novelty of the introduced method is presented in the third step. In an immersive environment, the customer can be placed in different contexts during the experiencing of the virtual product. In this paper we will show that the more realistic the holistic context is regarding the usage of the experienced product, the more easily it is for the customer to assess the product emotionally. This holistic context consists of the represented product and all additional environmental variables - its surroundings, the position of the customers, their interaction possibilities etc. The surroundings have to be as similar to real surroundings as possible; the users have to explore the product in the position in which they are used to handle it in real life; they have to interact with it in an easy learnable way. Because of the dynamic nature of exploration in immersive environments, the users must have the freedom to describe how the product affects them with own words. In order to induce emotions, the user should be previously asked to imagine to have bought the product and use it really. The Kansei adjectives can be recorded on a tape or manually by the supervisor. The subsequent classification of the Kansei words can happen semi-automatically or manually, using human-defined categories and classical classification methods.

4. Description of the Validation Studies

In order to validate the Immersive Kansei Engineering method, we performed two studies called EMO VR and FH VR. They both used the same scenario, procedure and apparatus and differ in the target group and position of the user.

4.1. Scenario

The scenario was a car cockpit configuration system in Virtual Reality developed for the early stage of conceptual design. The participants could choose between several variants of different design interior elements (steering wheel, gear lever, pedal sets, textures etc.) and build so their individually best configuration.

4.2. Participants

The first study was a part of the complex study EMO VR (Emotion Capturing in Virtual Reality) [Kat12], aiming a highly heterogeneous group to show the universal applicability of the developed method. The 21 participants were of both sexes (11 male and 10 female) and with different ages (8 participants between 21 and 30 years, 6 between 31 and 40 years, 7 above 40 years). Because of the parallel capturing of physiological signals, they had to wear a mobile device and attached electrodes. In the second study FH VR, a more homogeneous group was intended in order to study the behavior of a specific customer segment. Therefore, all of the 23 participants were between 20 and 31 years. Only 4 of them were female. They were all engineering students.

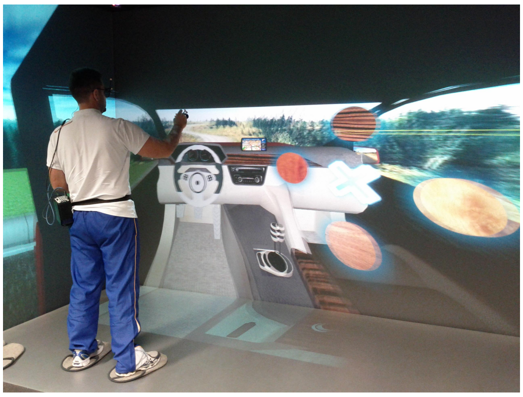

Figure 3: *The environment, use case and context of the Kansei Engineering experiment during the EMO VR study*

4.3. Experimental Design

In order to estimate the influence of minimal context changes on the emotional reaction of the customer, we changed only one variable of the context between the two studies - the position of the user (walking/sitting). Through this choice we wanted to compare the ability of customers to give relevant emotional feedback on products in the position of a pure design observer (who explores freely the product). Here the customers were allowed to walk freely in the CAVE (Figure 3). In order to enable a more context-faithful product experience in the second study, we asked the participants to study the product in sitting position, which was actually adjusted to be the actual driver position (Figure 4).

4.4. Procedure

After the participants have selected their best configuration from the available variant space, they were asked to imagine that they have bought this product and use it for 30 seconds, as well as to let the product impact on them emotionally during this period. Afterward, they had to describe the emotional effect of this product on them using free adjectives. Subsequently they had to describe the emotional effect of this product on them using adjectives. At the end of the experiments, the participants commented if they would change their configuration.

4.5. Apparatus

Both studies were performed in the same highly immersive virtual environment - the Virtual Reality Lab of the XXX. It consists of a three-wall passive stereoscopic projection (CAVE) with dimensions 4,5 m x 2,6 m x 1,9 m and high resolution. The applied interaction technique is based on ART tracking system for head and hand tracking and algorithms for gesture recognition. Simple gesture was chosen instead of other input devices, to reduce the emotional influence of the interaction. The car was presented in real size and re-

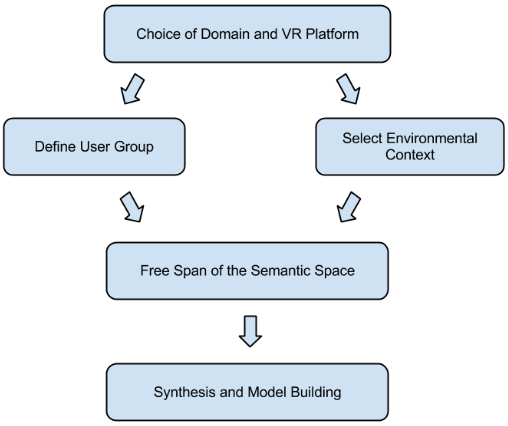

Figure 2: *A Model on Immersive Kansei Engineering Methodology*

Figure 4: *The environment, use case and context of the Kansei Engineering experiment during the FH VR study*

alistic surroundings (landscape) were modeled. The application for visualization, configuration logic and interaction used is XXX – a virtual reality 3D Engine. XXX is a framework developed at our institute since 2009, based on open source libraries like OpenSG [Rei04] and OpenGL. Important features of XXX are the flexible integration of tracking systems and flexible software configuration of different hardware systems for distributed visualization on computer cluster. The auto cockpit 3D models are design using CAD software and the landscape using the modeling tool Blender.

5. Major Results

The major operative results of the EMO VR and the FH VR study concerning the here proposed method "Immersive Kansei Engineering" are presented in this section. They are sorted according to the corresponding steps of the method (see Section 3). However they are not presented in the same order as these steps, but rather in descending significance of the results. The general implications of these results are described in the following section.

5.1. Selection of the environmental context of product experiencing

As already stated in Section 4, in both studies we applied the same models of realistic surroundings for the car. The single context variable we changed was the position of the customer - in the EMO VR they could move freely in the CAVE and in the FH VR study they took a sitting position which assures them the perspective of the driver. The more realistic context of the FH VR study significantly contributed to higher immersion and better imagination of the customers. About the half of the participants in FH VR used the sitting position to really check "how it feels to drive the car" - they took a driving posture although no physical simulation was implemented. The other participants were rather static observers. In the EMO VR study almost all of the participants did not use the possibility to observe the product from different perspectives and behaved statically - only one of them moved freely in the CAVE. It was also only one participant who mentioned that the standing position was not the usual position to observe a car cockpit; the others accepted the less realistic context implicitly and did not complain. Some of the participants in FH VR used the adjective "large" (German: "groß") to describe the positive emotional effect of the car, which suggests that they became aware of its actual dimensions. On the contrary, no participant in the EMO VR study spoke about spatial characteristics of the car. The higher immersion in sitting position encouraged the customers to take decisions more confidently. 35% of them stated that they would definitely change their configuration after the more careful observation, the rest of the participants would take the selected configuration and none of them was unsure about their choice. In contrast to that, 24% of the participants of the EMO VR study admitted that they did not know if they made the best choice for them and only one (5%) stated that she would change the configuration after the more careful observation.

5.2. Classification of Kansei words and their assignment to product attributes

The admission of free description of emotional effects solves the problem of the falsifying and constricted cognitive mediation through pre-given adjective pairs. Customers do not have to assess how well pre-given adjectives, which are actually very often irrelevant for the individual, describe their emotional reaction on the product. They find their own adjectives which express suitably this emotional reaction, which is definitely a more objective and non-manipulative approach. However, due to this new approach, a new problem appears - the classification of the used adjectives for interpersonal comparison of the emotions. This problem is much easier formally solvable than the problem of constricted cognitive mediation. Because only mother-tongue humans can assess the relations of different applied words, the classification has to be done manually (after the experiment, through binary comparison of the words) or semi-automatically (using pre-defined classes). For example, in our studies the class "comfortable" (German: "komfortabel") consisted of three similar German words: "komfortabel", "gemütlich" and "bequem". A very important hint for the supervisors is that they have to ask the customer immediately about the meaning of a word in the context of the verbal description if they are not sure about it. The assignment of adjectives to product attributes happens in real-time through the participant itself. Every second participant related at least one adjective to a certain product attribute. However, a comparable fraction of the participants gave a comment that certain variable element does not "match" (German: "zusammenpassen") to the actual configuration. This means that products are very often preferably assessed holistically and the assignment of Kansei adjectives to certain product attributes is only limited reasonable.

5.3. Free description of the experience using Kansei adjectives

We could show clearly that people assess emotionally both aesthetic and functional product attributes, as pictured on Figures 5 and 6, presenting the five most often used adjective categories during the both studies. Categories which appear in the top five mentions of both studies are marked with different colors for comparison. One of the most mentioned Kansei adjective classes was "comfortable", considering the ergonomic functionality of the car cockpit. Other examples of functionality-related Kansei adjectives were "practical" (German: "praktisch") or "unreadable" (German: "unleserlich"; concerning the speed indicator). Often used aesthetic words were for example "beautiful" (German: "schön"), "el-

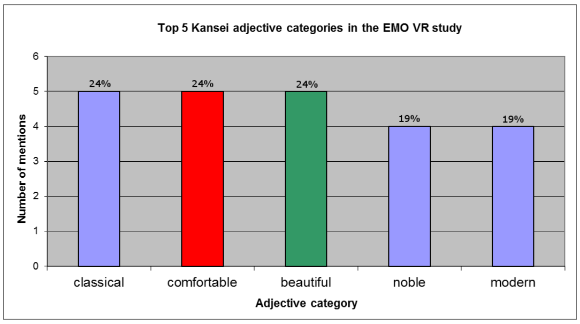

Figure 5: *Top five adjective categories in the EMO VR study*

egant" (German: "elegant") and "harmonic" (German: "harmonisch").

5.4. Definition of the user group

The comparison of the five most used adjective categories in the both studies (Figure 5 and 6) shows that they are significantly dependent on the examined user group. For example, young people in the FH VR study described their individually best configuration far more often as "sporting" (12 mentions) (German: "sportlich") than the heterogeneous participants at the EMO VR study (only once). This also means that the customer segmentation process can be supported by Immersive Kansei Engineering.

5.5. Advantages and disadvantages of the method

During both studies we could detect some disadvantages of the method, which should be taken into account. The descriptions are often ambiguous, because people (especially non-native speakers) understand the same words in a different way and a clarification is necessary to avoid misunderstanding. Therefore it is always important to ask the participants how they would explain a word if there is a potential risk for misinterpretation. Some people have problems to find the proper words to describe their own emotions - for this reason the interviewer should let the customers take the time they need in order to find proper verbalizations. Despite of these disadvantages, the active, free description of products with adjectives within Immersive Kansei Engineering is more valuable than passive assessment using semantic differentials. This became evident during the EMO VR study as participants were additionally asked to assess the emotional effect of products on a semantic differential five-point Likert scale from "appealing" (German: "ansprechend") to "non-appealing" (German: "nicht ansprechend") - the most of them admitted that they gave strongly cognitively mediated answers and could not reproduce them later.

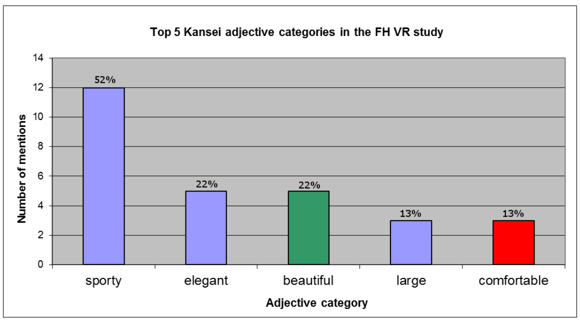

Figure 6: *Top five adjective categories in the FH VR study*

6. Theoretical and Practical Implications and Further Future Perspectives

The astonishing result of the second study, that a relatively high percentage (35%) of the participants would change their opinion regarding the best configuration choice due to the virtual experiencing of the product, needs to be discussed in details. It has to be analyzed which component in our modified form of Kansei Engineering influences the participants so strongly. We are convinced that it is not the realistic representation of product design and functionality solely. Comparing the here described two studies with a study we performed earlier, using a kitchen configuration scenario [OK11], we recognized the difference of our actual scenario in the enhancement of the product utilization through a new context paradigm. We do not focus only on the context "product and its functions" anymore, but also on the context of this context - for example, on the environment (landscape) in which we place the car. Although this difference may sound trivial, we find it necessary to emphasize its significance. Human beings' perception of visual signals depends significantly on changes of the view during their movements. Aesthetic and functional product attributes provoke thus customers' empathy and preference building more effectively when the context is more dynamic. This context shift from interactive product representation to dynamic environment closes the gap between linguistic cognition and perception. Customers do not have to accommodate to this environment - the environment itself guarantees the context-faithfulness. In this way customers do not have to falsify their behavior in Virtual Reality in order to accommodate to the technological solutions. This is crucial for our application, because each trial to accommodate to artificial contexts strongly influences customers' emotions and hence the reliability of the captured feedback. Emotions are unconscious, selecting and individual regarding their perceived objects [SBLS10]. This is why William Bricken stated in the early 1990s that "realism is not necessary" and that "psychology is the physics of Virtual Reality" [Bri90]. Thus we can conclude that the customer can give the most valuable feedback on products in an environment which promotes the fusion of the product as primary context (design and functionality) with the environment as secondary context (surroundings, other people etc.). This higher degree of immersion makes use of customers' intuitiveness in order to improve products - the environment influences retroactively the product utilization. For example, the emotional evaluation of a phone differs between the backgrounds of a writing desk and of a hike - if it was technologically possible to develop mobile phones and smartphones earlier, they would have also surely found application in the second context as nowadays. A particular suit can be suitable for some occasions and non-suitable for others, depending on the context. Context and product are coincident, form and contents are corresponding. In our scenario of a car cockpit configuration system the users are provoked by the dynamic environment to observe themselves while acting - they have to imagine driving the car and to focus on their assessment of the car at the same time, both actions are inseparable. The most effective acquisition of emotional feedback in a Virtual Reality environment occurs thus when the user has the possibility to be "subject and object", "actor and observer" at the same time. We suggest this as a new paradigm that redefines interaction and immersion in Virtual Reality. In order to show the plausibility of this new Subject-Object-Paradigm, we will compare it shortly with a parallel development in the area of humanoid robotics. The here traditionally applied paradigm "Sense-Act-Predict" is being gradually transformed into a "Predict-Act-Sense" paradigm - perception and movement processes do not follow a simple causal scheme, but rather fulfill the saying "One does not play the piano with fingers, but in its brain" [Asf12]. The important property of real-time presentation in VR challenges similarly our paradigm shift. Real-time presentation itself enables perception and emotion "recognition" in the "predict" phase, not in the following "act" phase of emotional reaction. Prediction and empathy are mutually interdependent and are expressed first through their relation to the dynamic context. The results of our considerations lead us to:

- an epistemological level and therewith to a simultaneity-paradigm concerning the user, which means that one should be able to act as 'an actor and an observer' at the same time,
- a practical level and therewith to a simultaneity-paradigm concerning all contexts together, which means that the product-context (design and functionality) and the environmental-context should be handled at the same time.

Both results can be summarized and generalized into one clear and new interaction-paradigm, which we named the "Subject-Object-Paradigm". This means that the user should change the perspectives (of subject and object, as well as of the diverse contexts) and then put them together in order to assess virtually presented products.

7. Conclusion

We showed that a new form of the Kansei Engineering method, using interactive, real-size and context-faithful representations in Virtual Reality, can provide reliable customer emotional feedback on developing future products. It largely eliminates the two major disadvantages of the classical Kansei Engineering method - the improper product representation, which does not sufficiently promote customers' imagination, and the strong constriction of customers' expression possibilities due to pre-given adjectives. The disadvantage of our method is that it is not so suitable for statistical analysis because of the free scope of verbal descriptions. The general implications of our results lead us to the definition of a new Subject-Object-Paradigm for successful user interaction in Virtual Reality. This paradigm unites on one hand the product and environmental contexts into a more intuitive representation, on the other hand it enables the user to be actor and observer in the virtual world simultaneously. In our specific application of emotional product assessment this paradigm promotes the reliable capturing of relevant emotions. A new interesting scientific topic based on this paper would be the definition of a suitable mathematic model underlying the described new Immersive Kansei Engineering method.

References

[AIS13] ADENAUER J., ISRAEL J., STARK R.: Virtual reality technologies for creative design. In *CIRP Design 2012*, Chakrabarti A., (Ed.). Springer London, 2013, pp. 125–135.

[Asf12] ASFOUR T.: Humanoide roboter. *In Kolloquium Wir Cyborgs. Die Geschichte des künstlichen Menschen* (2012).

[Bri90] BRICKEN W.: Virtual reality: Directions of growth. *In SIGGRAPH Panel Proceedings 3* (1990).

[GS78] GREEN P., SRINIVASAN V.: Conjoint analysis in consumer research: Issues and outlook. *Journal of Consumer Research 5* (1978), 102–123.

[HH02] HSIAO S.-W., HUANG H.: A neural network based approach for product form design. *Design Studies 23*, 1 (2002), 67 – 84.

[HK12] HELANDER M., KHALID H.: *Affective Engineering and Design*. John Wiley & Sons, 2012.

[HPK07] HELANDER M., PENG H., KHALID H. M.: Citarasa engineering model for affective design of vehicles. In *Industrial Engineering and Engineering Management, 2007 IEEE International Conference on* (2007), pp. 1282–1286.

[ILNS08] INGRASSIA T., LOMBARDO E., NIGRELLI V., SABATINOM G.: Kansei engineering and virtual reality in conceptual design. *11th QMOD Conference. Quality Management and Organizational Development Attaining Sustainability From Organizational Excellence to SustainAble Excellence* (2008).

[Kat12] KATICIC J.: *Methodik für Erfassung und Bewertung von emotionalem Kundenfeedback für variantenreiche virtuelle Produkte in immersiver Umgebung*. PhD thesis, Karlsruhe Institute of Technology (KIT), 2012.

[KM08] KREUTZER R., MERKLE W.: Die Notwendigkeit zur Neuausrichtung des Marketing. In *Die neue Macht des Marketing*. Gabler, 2008, pp. 13–17.

[KSTT84] KANO N., SERAKU N., TAKAHASHI F., TSUJI S.: Attractive Quality and Must-be Quality. *Journal of the Japanese Society for Quality Control (in Japanese)* (1984), 39–48.

[LHS02] LEE S., HARADA A., STAPPERS P.: *Design Based on Kansei*. Contemporary Trends Institute. Taylor & Francis, 2002.

[MAI94] MIZUNO S., AKAO Y., ISHIHARA K.: *QFD: The Customer-Driven Approach to Quality Planning and Deployment*. Asian Productivity Organization, 1994.

[Nag89] NAGAMACHI M.: Kansei engineering. *Tokyo: Kaibundo Publishing Co. Ltd.* (1989).

[Ogi11] OGI T.: Emotional design in the virtual environment. In *Emotional Engineering*, Fukuda S., (Ed.). Springer London, 2011, pp. 103–117.

[OK11] OVTCHAROVA J., KATICIC J.: *Design of Immersive Environment for Capturing of Emotionas to Virtual Products*. Published by Technical University of Sofia, 2011.

[OMT10] OHKURA M. HAMANO M. W. H., T. A.: *Kansei Quality in Product Design*. Springer, 2010.

[RDNS11] REBELO F., DUARTE E., NORIEGA P., SOARES M. M.: 24 virtual reality in consumer product design: Methods and applications. *Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques 1* (2011), 381.

[Rei04] REINERS D.: Herausforderungen an moderne Szenengraphsysteme am Beispiel OpenSG. *Informatik-Spektrum 27* (2004), 531–541.

[SBLS10] SCHEIER C., BAYAS-LINKE D., SCHNEIDER J.: *Codes.: Die geheime Sprache der Produkte*. Haufe Sachbuch Wirtschaft. Haufe Lexware, 2010.

[SC03] SHERMAN W., CRAIG A.: *Understanding Virtual Reality: Interface, Application, and Design*. No. Bd. 2 in Morgan Kaufmann Series in Computer Graphics and Geometric Modeling. Morgan Kaufmann, 2003.

[Sch05] SCHÜTTE S.: *Engineering emotional values in product design: kansei engineering in development*. PhD thesis, Linköping, 2005.

[SS07] SCHÜTTE R., SCHÜTTE S.: Affective impact on warning-signs - a study utilizing kansei engineering methodology. *Proceedings of the First European Conference of Kansei Engineering* (2007).

[TVH08] TIDEMAN M., VOORT M., HOUTEN F.: A new product design method based on virtual reality, gaming and scenarios. *International Journal on Interactive Design and Manufacturing (IJIDeM) 2*, 4 (2008), 195–205.

[Yan10] YANAGISAWA H.: *Kansei Quality in Product Design*. Springer, 2010.

[Zep07] ZEPLIN O.: The application of virtual reality in the design of aircraft cabins. *Center of Excellence Cabin and Cargo Customization Airbus Deutschland GmbH* (2007).