Chapter 10
Affective Human Factors Design with Ambient Intelligence for Product Ecosystems

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ABSTRACT

The fulfillment of affective customers needs may award the producer extra premium in gaining a competitive edge. This entails a number of technical challenges to be addressed, such as, the elicitation, evaluation, and fulfillment of affective needs, as well as the evaluation of capability of producers to launch the planned products. To tackle these issues, this research proposes an affective human factor design framework to facilitate decision-making in designing product ecosystems. In particular, ambient intelligence techniques are applied to elicit affective customer needs. An analytical model is proposed to support affective design analysis. Utility measure and conjoint analysis are employed to quantify users’ affective satisfaction, while the producers’ capability to fulfill the respective customer needs is evaluated using a capacity index. Association rule mining techniques are applied to model the mapping of affective needs to design elements. Configuration design of product ecosystems is optimized with a heuristic genetic algorithm. A case study of designing the living room ecosystem is reported with dual considerations of customers’ satisfaction and producer’s capacities. It is demonstrated that the affective human factors design framework can effectively manage the elicitation, analysis, and fulfillment of affective customer needs.

INTRODUCTION

Among the spectrum of customer needs, affective needs, which focus on customers’ emotional response and aspirations, are arousing more and more attention in comparison to the functional needs which focus on the product performance and usability factors (Jordan, 2000; Khalid, 2001). As an extension of traditional human factors and ergonomics, which have concerned with cause and effect relations between products and human performance, affective design emphasizes the emotional
relations between them (Talbot, 2005). Affect is a basis for the formation of human values and human judgment. For this reason, it might be argued that models of product design that do not consider affect are essentially weakened (Helander and Tham, 2003). This is especially true for consumer products, where a broad spectrum of similar products is available, with minor differences in functionality (Stanton, 1998). Therefore, it is essential for manufacturers to incorporate the affective human factors in their product offerings in order to gain competitive advantages. However, until recently, the affective aspects of product development have been substantially absent from formal design theories (Helander and Tham, 2003).

Affective customer needs basically imply an issue of addressing the customer perceptions with context-awareness. In this regard, the environment or ambience is an important determinant of customer perceptions. Hence, the performance of a product is human-centred and could only be tackled through the study of human-product-ambient interactions. At the same time, rapid response to diversified customer needs at affordable cost presents a constant challenge to manufacturers. Traditional mass production paradigm is inadequate to meet this challenge because the actual production volume usually cannot defray the huge investments in product development, equipment, tooling, maintenance and training. Mass customization lends itself to be a paradigm shift for manufacturing industries to provide products that best serve individual customer needs while maintaining near mass production efficiency (Tseng and Jiao, 1996). At the front-end, it caters to the requirements of individual customers or customer groups by developing product families that cover a spectrum of product performance requirements. At the back-end, production efficiency is ensured by developing product platforms that leverage upon commonality, standardization, and modularity across different products, along with process platforms that accommodate flexibility and reusability of the production systems (Meyer and Lehnerd, 1997).

This research proposes an analytical model for product design with consideration of fulfilling customer’s affective needs and the mass customization rationale. The aim is to develop a decision framework that incorporates various technologies to fulfil affective customer needs in product planning and development. In this chapter, Section 2 presents the background research related to affective design. The major challenges and key research issues are formulated in Section 3. In section 4, a decision framework is proposed to address the major research issues. The implementation of the framework to facilitate affective design of the living room is presented in Section 5. The merits and limitations of the research are discussed in Section 6, and conclusions are drawn in Section 7.

**RELATED WORK**

From a business perspective, product development aims at maximizing of the overlap of the producers’ capabilities with the window of customers’ needs in the marketplace. This can be achieved either through expanding producers’ capabilities by developing the company’s portfolio, including products, services, equipments, and skills that market demands, or through channelling customers to the total capacity of the company so that customers are better served. The former strategy is largely the research focus of product planning and platform-based product development, where strategic development of product and process platforms gives the producer an advantage of improved resource utilization (Meyer, 1997; Sanderson, 1991). The latter strategy advocates directing market needs to the capacity of a producer, where a clear understanding of customer needs and subsequent fulfilment of the customer needs with the appropriate design elements suggest themselves to be critical issues.
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