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A Qualitative Investigation of Product Smartness utilizing User Experience Data

사용자 경험 데이터를 활용한 스마트 제품 특성에 대한 질적 연구

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Abstract

A Qualitative Investigation of Product Smartness utilizing User Experience Data

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We are surrounded by products that have minds of their own. Smart products share the ability to collect, process, and produce information and can be described as "thinking" for themselves. The smart design has been applied to so many products so frequently, and in so many different contexts, that it is becoming more of a marketing claim than a well-defined technical description. Which consumer devices should be categorized as smart products? While the rapid growth in embedded computing power and the absolute number of microcontroller chips are well-documented facts, the definition of a smart product is still evolving. Definitions and characteristics differ considerably depending on the point of view of researchers.

The purpose of this study is to identify 'product smartness' and users' implicit needs more effectively and efficiently for developing new ideas/concepts for smart products. The overall procedure of developing idea/concept for new smart products/services is as follow.

In phase I, product smartness is identified. A conceptual model of product smartness was identified based on the literature review and the expert interview. As a result, five main dimensions of product smartness are selected (Autonomy, Adaptability, Multi-functionality, Connectivity, and Personalization). Also, to explore the relationship between product smartness and user experience, user experiences of smartphones were classified according to the reason of emotions (positive/negative) utilizing social media data (Twitter). According to the results, there were many positive experiences for all of dimensions, but there were negative experiences only for multi-functionality and connectivity.

In phase II, to identify users' needs, a Day Reconstruction Method (DRM) and a Self-Organizing Map (SOM) were conducted. To collect more natural and longitudinal user experience, the DRM was conducted with a case study on smart TVs. Also, to analyze the collected user experience data more effectively and efficiently, a clustering analysis was conducted using the SOM. As a result, similarity between episodes could be identified by analyzing a two-dimensional map, and 15 groups were classified from 330 episodes of user experience on smart TVs.

The results from the two phases are integrated in phase III, where new ideas/concepts for smart products/services are developed with relationship analysis. From the case study of developing new idea/concept for smart TV, a total of seven detail concepts were developed with five extracted user experiences of smart TV.

Also, to explore the relationship between idea quality, product smartness and satisfaction of new ideas/concepts, the evaluation experiments were conducted by practitioners and researchers. Idea quality metrics were collected from previous studies, and then they were re-organized into three dimensions: Workability, Relevance, and Attractiveness.

To validate the conceptual model, an evaluation experiment was conducted. According to the results of the experiment, the relationship between idea quality, product smartness, and satisfaction on new idea/concepts were identified and explored. In the idea quality, 'Relevance' is relatively more important than the others. It is found that 'Workability' has no significant influence on satisfaction. Also, in the product smartness, 'Autonomy' is the most important factor for

satisfaction of new idea/concept. However, 'Multi-functionality' shows no significant influence on satisfaction of new idea/concept.

This study will motivate researchers and practitioners to develop and improve smart products and its applications. Even though developed new idea/concept is difficult to be implemented or acceptable to users, users and developers will be satisfied if the idea/concept is relevant and attractive. Also, developers may want to implement their ideas for multi-functional products in a stepwise manner and to provide consumers with the opportunity to get used to certain levels of product smartness.

Keywords: Smart Product, Product Smartness, User experience (UX), User Implicit Needs, Idea/Concept Generation, Idea/Concept Evaluation
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Chapter I

INTRODUCTION

1.1 Background and Problem Definition

We are surrounded by products that have minds of their own. Computing power, in the form of microcontrollers, microprocessors, sensors, and data storage chips, has become so cheap that manufacturers are building microcomputers and embedded product intelligence into a daily life. Everyday appliances can now keep a track of how often we use them and remind us then it is time to order new batteries or replacement parts. For example, mobile phones can download our email, display digital photos, remind us of today's appointment/agenda, and let us scan the internet for breaking news over breakfast.

Even on the realm of consumer products, the feature of connected embedded intelligence and term "smart product" are used to describe a myriad of objects as disparate as automobiles, mobile phones, and electric utility meters (Cronin, 2010). When applied to home appliances such as refrigerators and dishwashers a decade ago, the smart descriptor typically meant that the appliance was connected to the internet.

Now it is more likely to indicate an interface with a smart utility meter that sends the appliance signals about the cost of electric power at different times of the day and monitors its energy consumption. Smart products are products that contain information technology (IT) in the form of, for example, microchips, software, and sensors and that are therefore able to collect, process, and produce information. As a result, smart products show a range of capabilities that can only be found in non-smart products to a limited extent. Rijsdijk and Hultink (2002) referred to theses abilities collectively as product smartness.

The smart design has been applied to so many products so frequently, and in so many different contexts, that it is becoming more of a marketing claim than a well-defined technical description. Which consumer devices should be categorized as smart products? While the rapid growth in embedded computing power and the absolute number of microcontroller chips are well-documented facts, the definition of a smart product is still evolving. Definitions and characteristics of a smart product differ considerably depending on the point of view of researchers.

In recent years, smart devices such as smartphones and smart cars have been proliferating, expecting the age of "Internet of Things (IoT)". IoT portrays a status that a variety of appliances be "smart" by sensing and processing, and be interconnected (Kortuem et al., 2010). However, in reality, researchers have discovered that consumers actually do not utilize their "smart" functions, and the reasons can be summarized as 'connectivity' and 'communication' (Holroyd, Watten, & Newbury, 2010; Korzun, Balandin, & Gurtov, 2013).

Smart devices are struggling in recognizing context of use, whereas other appliances do not provide information due to lack of sensors, security, or privacy regulation (Sutherland, Read, & Xynos, 2014). Besides such an operational-level reason, the consumers consider products "smart" when they actually take relative advantages (Rijsdijk, Hultink, & Diamantopoulos, 2007), rather than novelty or functionality of the product itself. It portrays that researchers should identify which services are in need and how to make the consumers use it before adopting technologies.

For instance, smart TV, a television with integrated interactive internet capabilities, takes the same stream. While the smart TV is predicted to be the heart of IoT-environment (Yusufov & Kornilov, 2013) and the ownership rate reaches 35% of U.S. households (Park's Associate, 2014), smart functions are rarely used. More than half of the owners only use smart TVs to watch broadcastings, being only interested in video quality or design factors (Analysis Mason, 2013; Tarr Greg, 2013).

Obrist, Bernhaupt, and Tscheligi (2008) said, to make the consumers use TV interactively, functions should fit into users' conventional routines, not forcing to replace users' existing behaviors. Thus, Smart TV manufacturers should have considered users' implicit needs for TV viewing experiences. As TV is a well-known lean-back media which is steadily consumed through a day, it would be necessary to observe surrounding environment as well as users' behavior in everyday life.

Considering the fact that smart TV users rarely use smart features, it seems that manufacturers did not consider the UX enough to make the users utilize the functions appropriately. Thus, there are several problems with the smart TV.

First, although they have a wide range of capabilities, smart TVs have been evaluated whether it possesses lack of contents needed (Shin et al., 2014). Whereas the users strongly consider TV as lean-back media, the smart TV manufacturers have developed services prevalently used in smartphones or laptops. The approach caused that 91% of the viewers are unaware of which applications were currently available in their smart TV (Brilot, 2012).

Moreover, besides watching live broadcasts, the majority of smart TV users in U.S. utilize TV by receiving contents from other devices such as smartphones, PCs, and set-top boxes, not from smart TV applications (Gritton, 2013). This phenomenon caused as core services of TV applications were copied after smartphone apps. The effort should have made to estimate the user value through identifying their TV-watching behavior.

Second, the interface design is counted as the reason for the disuse of functions (Chorianopoulos & Spinellis, 2006; Shin et al., 2014). Despite of new interface technologies such as voice recognition and gesture interfaces, today's smart TV interface is not appropriate for most of users to use easily and conveniently (Gritton, 2013). Elders prefer traditional remote controls rather than the controls with the voice command interface (Bures, 2012).

Also, the gesture interface has problems in recognition and gesture-to-function mapping (Norman, 2010). Although the natural interfaces can be useful, standardization of provided services should be considered precisely. Even though the manufacturers focus on adaptation of the novel interface, the consumers would have no interest, if it is not apt to the proper circumstance.

1.2 Purpose and Motivation of this Study

The purpose of this study is to identify product smartness and users' implicit needs for developing new ideas/concepts of smart products. Also, to identify the relationship between idea quality, product smartness, and satisfaction, new ideas/concepts were evaluated. The detailed goals and motivations of this study are as follows:

First, this study will summarize the findings of previous studies related to product smartness, and observe user experiences of smart products by utilizing external data sources in an effort to identify product smartness. Smart products or services share the ability to collect, process, and produce information and can be described as "thinking" for themselves. As a result, smart products can, for example, operate autonomously (e.g., robot cleaner), respond to their environment (e.g., the Sony AIBO), or communicate with other products (e.g., smart phone).

However, in reality, researchers have discovered that consumers actually do not utilize their "smart" functions and do not think some "smart" products as real "smart" products. Hence, this study will discuss user perceived product smartness based on previous findings in studies from product design, ergonomics and industrial design.

Also, observing User Experience (UX) is complex because the amplitude of experience varies with each interaction, and the overall evaluation of the products changes over time (von Wilamowitz-Moellendorff, Hassenzahl, & Platz, 2006; Karapanos et al., 2009). Previous observational techniques can be characterized by the degree of structured form as well as research environment. There are three limitations in the previous observation techniques. First, subjective bias is incorporated in interpreting the observed data (Shapiro, 1994). Also, it can be easily influenced by participants (Lazar, Feng, & Hochheiser, 2010). Finally, since most of previous methods are observed in confined environment, it is difficult to observe UX in naturalistic settings (Kuniavsky, 2003).

However, social media (e.g. Facebook, MySpace, Twitter, etc.) can be helpful for observing variant and natural UX with users' words. It is a potentially valuable source of data that can be used to delve into the thoughts of millions of people. This could make it possible to infer people's opinions, both at an individual level as well as in aggregate, regarding potentially any subject or event (Schonfeld, 2009). Therefore, social media was selected to gather user experiences of smartphones. This can be helpful for exploring user experiences related to product smartness from not only expert view but also user view in a natural context of use.

Second, this study will suggest a method that identifies user implicit needs of smart products. With a growing interest in the topic of UX, it became a cornerstone to observe and identify users' latent needs in the product development (Kraft, 2012; Kaulio, 1998). Diary technique is known to be in a mediate position of observation in naturalistic setting and controlled settings (Hyldegård, 2006). It has its benefits on observing users' experience for long term, and able researchers to obtain quantitative as well as qualitative data (Kahneman et al., 2004). Thus, a day reconstruction method (DRM), which has been widely used to observe users behaviors of a target product (Brown, Sellen, & O'hara, 2000; Lewis et al., 2005; Forlizzi, 2007), was conducted in this study.

Previous studies using DRM have not been considered the full context of use enough. They were primarily focused on the respondents' description to discover which function or application was used and with whom users were interacted. In addition, they limited their observations to the activity using the product, or the emotion incurred by the product. Thus, this study focused on not only observing which contents, functions or applications were used but also figuring out specific situations which were simultaneously conducted while users use the products.

Also, to analyze UX more efficiently and effectively, the Self-Organizing Map (SOM) was utilized in this study. Observing user behavior and analyzing collected data require abundant time and effort (Lazar, Feng, & Hochheiser, 2010). Clustering analysis can be helpful for analyzing enormous observed data more efficiently and effectively. Especially, the SOM can be used to carry out the classification tasks effectively. The SOM has the ability to learn and detect regularities and correlations in the inputs, and predict responses from input data (Westerlund, 2005). The main reason for using SOM rather than other clustering methods is that it would be possible to gain some idea from the structure of the data by observing the map due to the topology preserving nature of the SOM (Alahakoon, Halgamuge, & Srinivasan, 2000). The SOM-based visualizations offer an intuitive aid for extracting concepts and insights from the collected data. Also, SOM can be used in conjunction with other clustering methods to visualize clustering results (Vesanto & Alhoniemi, 2000), and the hierarchical SOMs could be possibly used to extend results. Therefore, the SOM will be helpful for analyzing abundant data sets.

Third, this study will propose a methodology that makes new smart product/service concepts considering product smartness and users' implicit needs. Previous methods of idea generation have been mainly focused on how to increase 'creativity thinking' (Runco, 1991; Dacey, Lennon, & Fiore, 1998; Takahashi, 2002; Cropley, 2006). There are also some methods focused on 'logical method' (Shah, Kulkarni, & Vargas-Hernandez, 2000). The logic methods involve the use of past solutions that have been catalogued or archived in some form of database or develop ideas from first principles by systematically analyzing basic relations, causal chains, and desirable/undesirable attributes. This study focused on how to utilize product smartness and users' implicit needs as idea generation materials. Therefore, new ideas for smart product/service will be developed according to the relationship analysis of collected user needs and identified product smartness.

Finally, this study will investigate the relationships between idea quality, product smartness, and satisfaction on new ideas/concepts for smart products. Despite the strategic importance of effective new product development as a source of competitive advantage, most new product development activities fail to achieve their anticipated level of market success. Thus, Eliashberg et al. (1997) report a major complaint that most of the products developed tended to be marginal contributors to the firm's portfolio, rarely involving very new or "breakthrough" ideas.

Also, many firms have been struggling with selecting and evaluating new ideas of smart products or services. Thus, many researchers have made their efforts on improving the quality of idea generation. Ideation quality is the degree to which an idea generation technique produces ideas that are helpful in attaining a goal. It pertains to the relative merits of an ideation process or intervention rather than to the value of a particular idea. One of the metrics for ideation quality is 'idea quality' which is related to feasibility and conformance to design specifications (Shah et al., 2003). In engineering design, this metric is required because an engineering idea needs to be feasible and practical (Charyton et al., 2011). Thus, identify the important sub dimensions of idea quality for overall satisfaction of new ideas/concepts could be helpful for developing or selecting new ideas.

Even though there have been many previous studies on identifying product smartness and the relationship between sub dimensions of product smartness and overall rating of perceived product smartness, there have been lack of studies on identifying the relationship between product smartness and satisfaction on new ideas/concepts. Although smart products can provide various characteristics to users, it is possible that users do not prefer all of them and the importance of them could be different. According to figuring out those relationships, practitioners and researchers related to development of smart products could utilize the important attribute of smart product or idea quality strategically to develop products which users will satisfy. Thus, identifying important dimensions of product smartness for overall satisfaction of new ideas/concepts could motivate researchers and practitioners to develop and improve smart products and its applications.

The overall procedure of this study is illustrated in Figure 1.1. To develop new ideas/concepts for smart products, identifying product smartness and user needs are performed. Then, new ideas/concepts of smart products are developed based on product smartness and user needs with conducting a case study of smart TV. Finally, new ideas/concepts of smart product are evaluated to figure out the relationship between idea quality and satisfaction on new ideas/concepts and also identify the relationship between product smartness and satisfaction on new ideas/concepts.

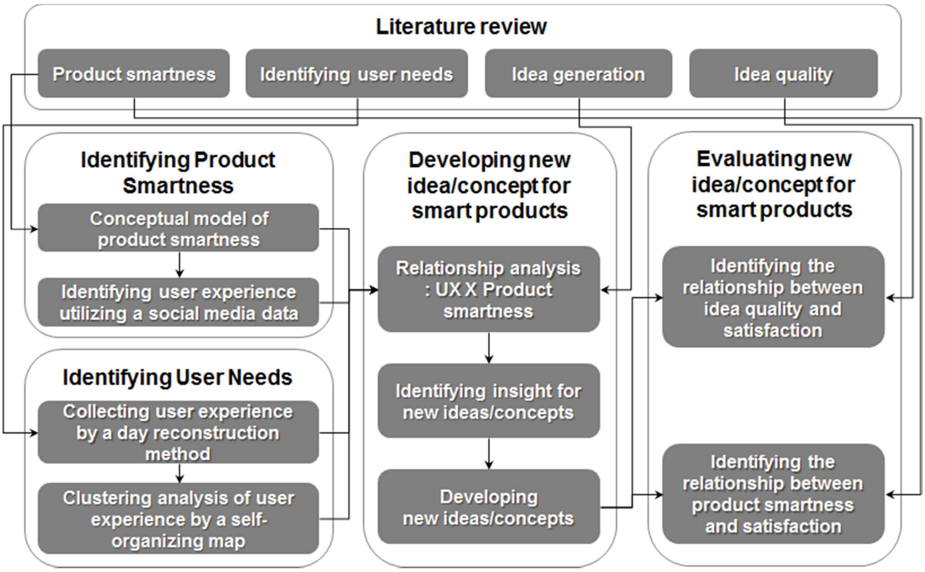


Figure 1.1. Overall procedure of this thesis

1.3 Organization of the Thesis

This thesis will cover the subjects shown in Figure 1.2.

Chapter 1 describes the background, motivation, and purpose of the study. Also, methods which were used in this study and the overall structure of the study are described. Chapter 2 introduces the findings of previous studies and theories related to the origin, definition, characteristics of smart products. In addition, previous studies related to methods of identifying user needs, idea/concept generation, and idea/concept evaluation. Chapter 3 explains the conceptual model of product smartness based on literature review and expert review. Also, the relationships between product smartness and user experiences are discussed based on collecting external data. Chapter 4 explains how to identify user's implicit needs using a diary-based technique and how to analyze the collected user experience data effectively and efficiently. In Chapter 5, a framework for developing smart product idea/concept is proposed with conducting a case study. The method of evaluating smart product idea/concept with a case study is illustrated in Chapter 6. Finally, Chapter 7 discusses the conclusions of the study as well as its contributions and limitations.

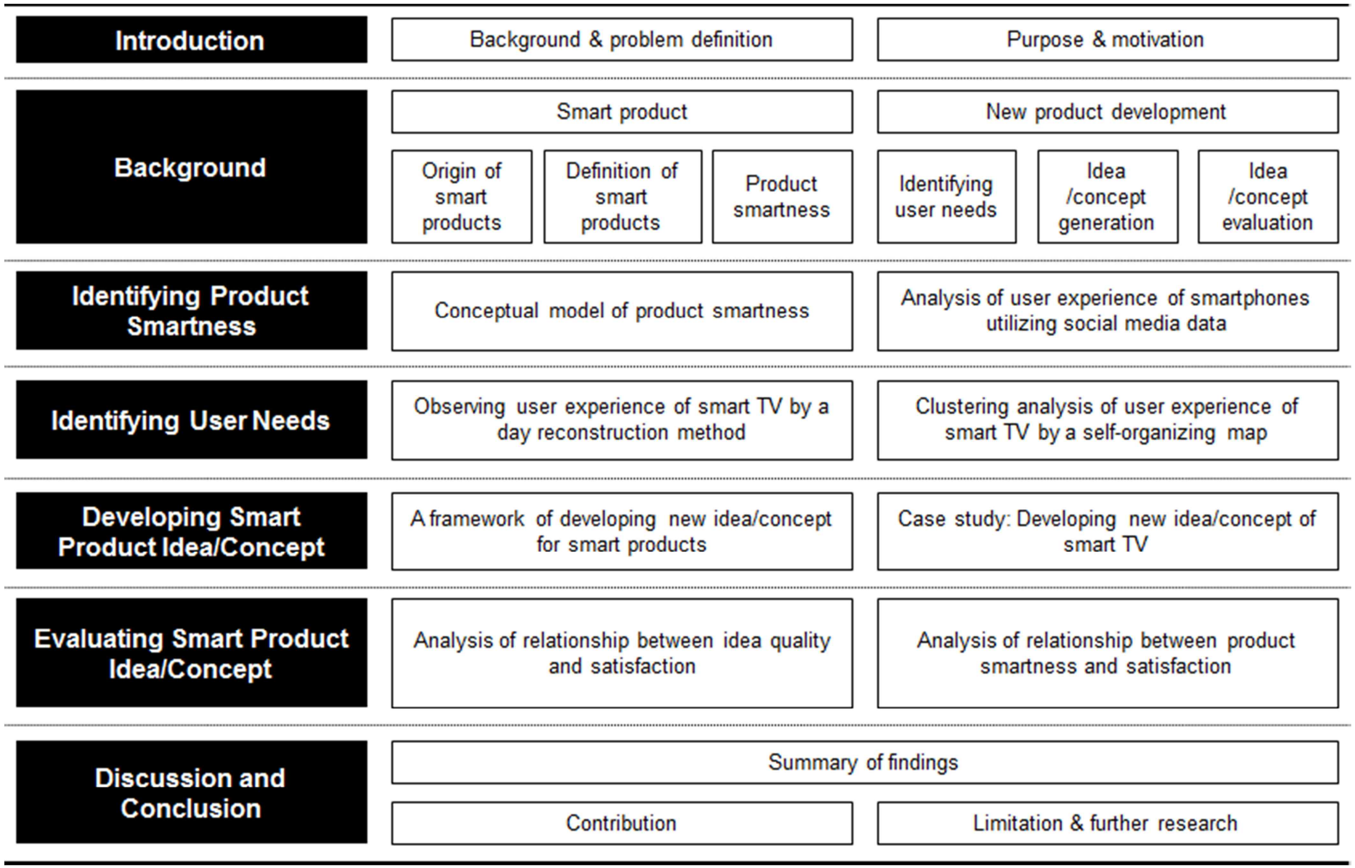


Figure 1.2. Organization of the thesis

Chapter II

BACKGROUND

2.1 Smart Product

In recent years, smart devices such as smartphones and smart cars are increasingly being prevalent. The term "smart" was first introduced by "smartphone" in the market in 1997, when Ericcson launched GS 88 Penelope. However, smart product actually existed at least far back to 1988, as the term of "intelligent object" was used in service context by Ives and Vitale (1988). 'Smart product', which is also referred as 'intelligent object (Meyer, Främling, & Holmström, 2009)' or 'smart object (Beigl et al., 2001)', originated from Weiser's vision of ubiquitous computing (Figure 2.1).

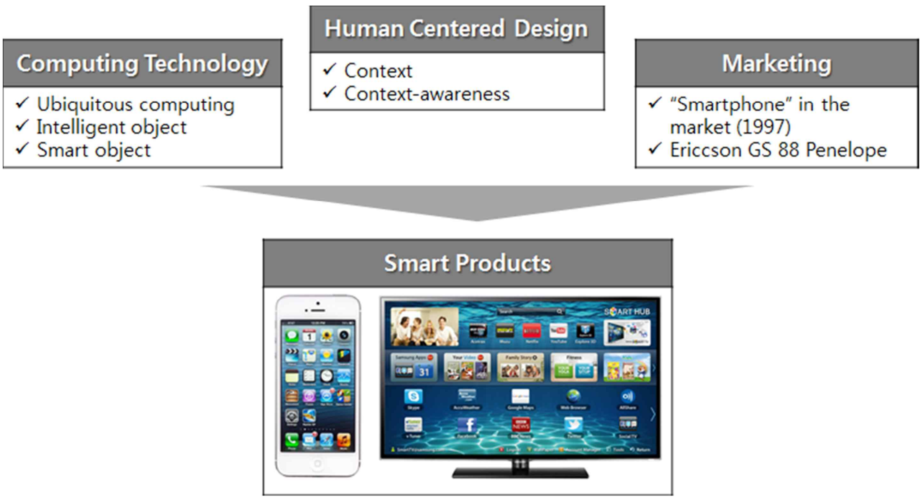


Figure 2.1. Origin of the term 'Smart product'

2.1.1 Ubiquitous computing and context-awareness

Mark Weiser (1991) stated the vision of ubiquitous computing in his article as below.

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

The above statement induced a paradigm shift in computing by opening a door to a new way of thinking about computing technology. Weiser (1991) pointed out that ubiquitous computing will change the way we currently perceive technology. There will be no more desktop computers but computing will be all around us to match our social behavior and will guide our everyday activities. Computers will slowly disappear from our main visual field and will operate at the periphery vision as a part of natural environment. This will enable us to focus on our primary activities, and to switch our attention to computing only when it is appropriate.

Weiser (1991) also pointed out that how can we make computer disappear from our perception. Making computers disappear is about the development of technology in everyday environment in a way that humans do not realize them as separate objects anymore. One obvious way to realize this is by making computers smaller than in such a scale that they could be easily embedded into everyday objects that form a natural human environment. The proliferation of micro-electronics in fact enables us to do that.

Moore's Law (Moore, 1965), drawn up in 1965 which states that the power of microprocessors doubles about every 18 months, has held true with astonishing accuracy and consistency. Similar convergence has been observed in storage capacity and communications bandwidth resulting in the computer to be much more powerful, smaller, and cheaper. A direct consequence of this technology trend is the integration of computing in the fabric of the environment and the emergence of instrumented everyday objects to form intelligent home, intelligent office, intelligent bus stop, etc. It is more cost-effective, useful and innovative to integrate computing into the already available artefacts of our surroundings, thus making our connection with digital world a lot closer. Beigl et al. (2001) also stated as below.

"Computers are becoming ubiquitous in our everyday lives but not as the computers that we know. The computer that we know is a primary artefact, explicitly perceived and used as computer. Instead, the computers that will proliferate further into our everyday lives will mostly be secondary artefacts embedded in primary artefacts that have their own established appearance, purpose, and use in everyday experience."

Norman (1998) considered that paradigm shift from design and human interface perspectives, and induced the notion of "information appliance" integrated into the environment. Although he emphasized on the home appliance designed and developed to support a specific task, his observations raised interesting design challenges for the emergence of instrumented everyday objects.

The human-centered design is a fundamental challenge of ubiquitous computing. As micro-computers are being embedded into the basic materials of the environment, it is necessary to ensure that this embedding is discrete, unobtrusive and matches the social behavior of human. Hence, significant research efforts focused on finding the proper balance among ease of interaction, perceptual complexity, computational overload and social acceptability to make sure that computing services are provided in an appropriate way. Context-awareness is used to denote this property of computing and plays the important role in designing the human-centered ubiquitous computing systems.

Context is any information that can be used to characterize the situation of an entity which is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves (Dey, 2000).

This could mean that context is always bound to an entity and any information could be context as long as it is relevant to that entity. Hence, any system can be context aware if it offers services utilizing the context relevant to the user system (Dey, 2000). This is a crucial attribute of human-centered systems and smart products that form the foundation for the proliferation of context-aware computing.

2.1.2 Definitions of smart product

Maass and Varshney (2008) defined smart products as "products with digital representations that enable adaptation to situations and consumers." However, Mühlhäuser (2008) defined as below.

"A Smart Product is an entity (tangible object, software, or service) designed and made for self-organized embedding into different (smart) environments in the course of its lifecycle, providing improved simplicity and openness through improved product-to user and product-to-product interaction by means of context-awareness, semantic self-description, proactive behavior, multimodal natural interfaces, AI (Artificial Intelligence) planning, and machine learning."

Based on above definition, Sabou et al. (2009) introduced the abilities of smart products in more detail as below.

"A smart product is an autonomous object which is designed for self-organized embedding into different environments in the course of its life-cycle and which allows for a natural product-to-human interaction. Smart products are able to proactively approach the user by using sensing, input, and output capabilities of the environment thus being self-, situational-, and context-aware. The related knowledge and functionality can be shared by and distributed among multiple smart products and emerges over time."

Moreover, Miche, Schreiber, and Hartmann (2009) mentioned that

"Smart products assist their users during the whole life-cycle, literally talking to and guiding them to deal with their complexity." With the role of a smart product as an assistant, Miche, Schreiber, and Hartmann (2009) also noted two major challenges as follow. First is to support natural interaction with the user, and the other is to make use of other smart products and resources available in the environment. Otherwise, in terms of information technology, Rijsdijk and Hultink (2009) identify smart products as "products that contain information technology and therefore able to collect, process and produce information."

Also, smart products are products whose functionality is increased by an embedded microprocessor. It is a superset of the field that has become known as Mechatronics. Embedded microprocessors can already be found in everything from dishwashers to automobiles – and more smart products appear every day. Hence, smart products contain IT in the form of, for example, microchips, software and sensors, and that are therefore able to collect, process, and produce information (Rijsdijk, Hultink, & Diamantopoulos et al., 2007). Smart products are real-world objects, devices or software services bundled with knowledge about themselves and their capabilities. Thus, smart products share some key properties as follow (Lyardet & Aitenbichler, 2008). First, smart products have the ability to have multiple uses. Second, smart products should be deployed independently. Finally, smart products can network with others to augment their individual and collective capabilities.

In summary, smart products are network-connected items with embedded microprocessors and software programmed to manage various aspects of the product's functionality considering context-awareness (Figure 2.2).

Figure 2.2. Definition of 'smart product'

2.1.3 Characteristics of smart product

From the previous studies about smart products, researchers also provided the characteristics of smart products called as 'product smartness'. Previous studies on smart products can mainly be found within the fields of ergonomics and industrial design.

The ergonomics literature addressing product smartness (Feldman, 1995; Freudenthal & Mook, 2003; Han et al., 2001) emphasizes the importance of appropriate interface designs. Within the area of industrial design, the focus of the literature is mainly on the new opportunities that product smartness offers to designers and how they should deal with these opportunities (Buurman, 1997; Holmquist et al., 2004; Robertson, 1992).

The dimensions of product smartness and the descriptions of them are displayed in Table 2.1.

Table 2.1. The characteristics of smart products (Product smartness)

Reference	Product smartness	Description
Rijsdijk & Hultink (2002; 2009)	Autonomy	The extent to which a product is able to operate in an independent and goal-directed way without interference of the user
	Adaptability	A product's ability to improve the match between its functioning and its environment
	Reactivity	The ability of a product to react to changes in its environment
	Multi-functionality	The phenomenon that a single product fulfills multiple functions
	Ability to cooperate	Ability to cooperate with other devices to achieve a common goal
	Humanlike interaction	The degree to which the product communicates and interacts with the user in a natural, human way
	Personality	Ability to show the properties of a credible character
Swallow, Blythe, & Wright (2005)	Identity	Private identity: how we express ourselves through them / Public identity: how others perceive us
	Sociability	Ability to maintain and create social groups
	Security	Ability to protect private information
	Organization	Ability to organize personal life (e.g., simple calendar, schedule plan, to-do list, e-mail, etc.)
	Relevance	Ability to appeal to a wide range of users
Thompson (2005)	Communications	Smart objects should allow us to send and receive messages. Also, they must be able to accept queries and commands from each other, using wired or wireless connectivity.

Table 2.1. (Continued)

Reference	Product smartness	Description
Thompson (2005)	Identity and kind	Because different kinds of objects perform different functions, they will need different custom interfaces. Interfaces should be reflective, that is, self-describing other objects should be able to ask them what they can do.
	Memory and status tracking	Smart objects must have persistent memory to ensure that they can maintain their settings and histories. But we should also be able to erase these memories when discard objects.
	Sensing and actuating	Smart objects will be able to monitor their environments and, if needed, change them.
	Reasoning and learning	Smart objects might or might not include various learning plug-ins. The first generation might not be very smart, but will improve.
	Controllability	If we just count larger physical objects we own and control, they might number in the hundreds. But if we count sensors, motes, and objects we pass near, we could interact with thousands or millions.
	Maintainability	We won't want to continually boot or upgrade individual smart objects, but we might need to turn them on or off or reset their controls at certain points.
	Scalability	Numerous smart objects must be able to dynamically join and leave various enclaves, leaving the store behind to join your household, recording a change of ownership, and getting to know a new collection of other smart objects.

Table 2.1. (Continued)

Reference	Product smartness	Description
Thompson (2005)	Interoperability	If several manufacturers develop competing variations on how to configure and connect smart objects, we could well experience smart object wars regarding interoperability standards.
	Security	We don't want just anyone to be able to turn our ovens on, but we might want our employees, teammates, or guests to be able to control the temperature in rooms they occupy. We can also expect analogs to viruses and spyware. We'll need to be able to distinguish between friendly, neutral, and enemy objects.
	Privacy	People will need ways to control how much information
	Reliability	Will smart objects work and fail in ways we understand, helping us to pinpoint these failures?
	Survivability	If we add a new smart object, or if one stops working correctly, will that cascade and harm others? If our lives depend on smart objects, will we be vulnerable to new forms of attack such as a virus that causes
Maass & Varshney (2008)	Personalization	Customization of products according to buyer's and consumer's needs
	Business-awareness	Consideration of business and legal constraints.
	Situatedness	Recognition of situational and community contexts
	Adaptiveness	Change product behavior according to buyer's and consumer's responses to tasks

Table 2.1. (Continued)

Reference	Product smartness	Description
Maass & Varshney (2008)	Network ability	Ability to communicate and bundle with other products.
	Pro-activity	Anticipation of user's plans and intentions.
Mühlhäuser (2008)	Context-awareness	Ability to sense context
	Proactivity	Ability to make use of this context and other information in order to proactively approach users and peers
	Self-organization	Ability to form and join networks with other products
	Support the entire life-cycle	Ability to distinguish the different user categories reflected in the lifecycle plus each individual user herself
	Multimodal natural interfaces	Offering multimodal interaction with the potential users, in order to increase the simplicity characteristics of the products
Sabou et al. (2009)	Autonomy	Smart products need to be able to operate on their own without relying on a central infrastructure.
	Situation and context-aware	Ability to adapt interaction with other products and users accordingly, as well as to infer new knowledge.
	Self-organized embedding in smart product environments	A smart product is able to embed itself into an existing smart product environment and to automatically build a smart product environment.
	Proactively approach in the user	The situation information is used to decide when the smart product should proactively approach the user. Also, proactivity should characterize the interaction with other products.

Table 2.1. (Continued)

Reference	Product smartness	Description
Sabou et al. (2009)	Support the user throughout whole life-cycle	The particular life-cycle stage of a product has a major influence on its behavior. For example, a worker in the production phase needs access to other functionalities than an end-user during the usage phase.
	Multimodal interaction	Smart products should provide a natural interaction, however most smart products have only limited in- and output resources. For that reason, the smart products are able to make use of the different input and output capabilities in their smart product environment supporting the usage of various modalities.
	Support procedural knowledge	Smart products need to support procedural knowledge, including how the user needs to be involved in the different steps and how implicit interaction can be integrated in the procedure (e.g., recognizing when the user has completed a step in the procedure).
	Emerging knowledge	Smart products learn new knowledge from observing the user, incorporating user feedback and exploring other external knowledge sources like Wikis. They are thus able to gather a more accurate user model and to learn new procedures.
	Distributed storage of knowledge	The distributed storage enables that the new smart product can be initialized with the knowledge of the old smart product and thus does not need to learn everything from scratch.

Table 2.1. (Continued)

Reference	Product smartness	Description
Miche, Schreiber, & Hartmann (2009)	Context	How to react in a given context (Context awareness: Acquiring context and reacting to context)
	Interaction	Ability to allow smart products to initiate the interaction with a user in a proactive way. This enables the product to proactively offer help by itself and to assist the user in interacting with it
	Ubiquitous Data Store	Ability to facilitate the distribution of information among smart products plus the access to data stored in backend systems. In addition, this component provides a synchronization mechanism to ensure different levels of consistency (e.g., atomic and eventual) for data replicated and stored in the mobile cache cloud of a smart product.

As a result, smart products show a range of capabilities that can only be found in non-smart products to a limited extent. Rijsdijk and Hultink (2002) referred to these abilities collectively as product smartness. Product smartness consists of the dimensions of autonomy, adaptability, reactivity, multi-functionality, ability to cooperate, humanlike interaction, and personality. Smart products possess one or more of these dimensions to a lesser or higher degree. Therefore, the overall smartness of a product can be conceptualized as the extent to which it possesses these dimensions. Non-smart products may show these dimensions to a limited extent (e.g., washing machines can be described as autonomous). However, when such functionality is not based on IT these products are not described as ‘‘smart.’’

Swallow, Blythe, and Wright (2005) examines several techniques to analyze and evaluate user’s experience of interactive technology with case studies of smartphone. The grounded theory analysis of the data generated experiential categories: identity, sociability, organization, and security within the superordinate category of relevance. The experiential categories could be considered as the characteristics of smart products, especially for smartphones.

Thompson (2005) predicted potential problems and found ways to reduce or eliminate them through suggesting capabilities of smart objects (communications, identity and kind, memory and status tracking, sensing and actuating, reasoning and learning). Not all smart objects will have all capabilities, but it would be useful to be able to upgrade them over time to include additional capabilities. Thompson (2005) also suggested additional capabilities of smart objects which are only partial list of end-to-end capabilities that smart-object collections might have (controllability, maintainability, scalability, interoperability, security, privacy, reliability, survivability).

Maass and Varshney (2008) addressed the characteristics of smart products. Smart products can be characterized by a framework with six general dimensions (situatedness, personalization, adaptiveness, proactivity, business-awareness, and network capability). In addition to those characteristics, Mühlhäuser (2008) and Sabou et al. (2009) emphasized the fact that smart products should support their entire life-cycle.

In addition, special care should be devoted to offering multimodal interaction with the potential users, in order to increase the simplicity characteristics of the products. The rest of the characteristics refer to aspects of the knowledge component that enables the smartness of the products. This knowledge has an important procedural component, it should evolve during the life-cycle of the product as a side effect of its interaction with users and products and, finally, it might need to be stored in a distributed fashion in order to overcome the resource limitations imposed by some products.

Miche, Schreiber, and Hartmann (2009) suggested a novel architecture for building smart products that are able to interact with humans in a natural and proactive way, and assist and guide them in performing their tasks. Further, they showed how communication capabilities of smart products are used to account for the limited resources of individual products by leveraging resources provided by the environment or other smart products for storage and natural interaction. The authors suggested three main dimensions of the characteristics of smart product (context, interaction, and ubiquitous data store).

There are also some previous studies that defined the characteristics of smart products through investigating users' perceived values in using smartphones or smart products (Table 2.2). User perceived value refers to what the users believe they get from buying and using a product, and not to what companies believe their users value (Woodruff, 1997). According to Zeithaml (1988), for value to be created, what the users receive from using a product or service have to exceed what the users give.

Grönroos (2008) discussed that users are not primarily interested in what they buy and consume, but in what they can do with what they have in their possession. Similarly, Holbrook (1999) claims that value is an experience since it is not in the purchase, but rather than in the consumption of the good or service. In this regard, user perceived value can be measured by user experience of products.

Andersson and Frost (2013) conducted a qualitative approach such as in-depth interviews and self-observations to gain a deeper understanding of the consumer perceived value in using smartphone applications by studying how and why people use them. As a result, six use values have been identified in smartphone apps (convenience, control, motivation & inspiration, monetary savings, entertainment, and knowledge).

Jung (2013) investigated the various values users achieve with smartphones, which is a form of user-empowering information technology. The author explored the meaning of a smartphone from the users' standpoint. A total of 13 user values were associated with smartphone use.

Table 2.2. User perceived values in using smart products

Reference	User perceived value	Description
Andersson & Frost (2013)	Convenience	Convenience for the user means saving time, that it is simple to use, and can be used wherever the user is.
	Control	Ability to help the user stay in control, by keeping track of the daily life. It gives the user a feeling of control by aiding in planning processes and reducing the need of remembering things by heat.
	Motivation & inspiration	Motivation & inspiration is perceived when the usage of smart products motivates and inspires the user to perform better in actions connected to something outside the actual usage of smart products.
	Monetary savings	Monetary savings is connected to bringing value by helping the user save money through reduced costs.
	Entertainment	Entertainment is connected to having fun, providing the use value when the user is bored or wanting to pass time. Consequently, it is not only connected to having fun, but also to being less bored.
	Knowledge	Knowledge is gained when the usage of smart products stimulate curiosity and widen the user's base of knowledge.

Table 2.2. (Continued)

Reference	User perceived value	Description
Jung (2013)	Personalized device environment	Have a device based on personal preference, configure applications wanted
	Restorative	Feel refreshed, reduce stress
	Socialization	Extend social networks, have better social relations, meet different types of people
	Use more multimedia content	Enjoy more music, watch more video clips
	Thrill of new apps	Feel thrill from using new applications
	Productive daily life	Waste less time, manage schedule better, make better decisions, help concentration
	Habitual use	Use habitually
	Hanging out	Goof off, kill time
	Sense of comfort	Emotional stability, feel connected, become comfortable
	Sense of confidence	Have confidence, feel superior to others
	Amusement	Feel pleasant, have happiness
	Acquire information	Acquire real-time information, acquire knowledge as needed, acquire more information than ever before
	Improve communication	Smooth communication with friends, communicate with several people at once, keep continuous communication

Table 2.2. (Continued)

Reference	User perceived value	Description
Park & Han (2013)	Comfort	Producing or affording physical support or ease / Time spent something a person do to rest
	Relationship	A friendly relation or intimacy / Reminding a person of particular events / Affectionate, or loving
	Pleasure	The state or feeling of being pleased / A stimulating or active life / The quality or state of being happy
	Convenience	Anything that simplifies work, adds to one's ease
	Beauty	The state or quality of being beautiful
	Social status	Belief in oneself/Sense of belonging

Unlike previous studies, Park and Han (2013) extracted user value elements of a smartphone from the list of life value elements through a case study using longitudinal observation approach. As a result, six smartphone user value elements were extracted (comfort, relationship, pleasure, convenience, beauty, and social status).

Even though the extracted elements of product smartness are different according to each previous research, product smartness could be re-categorized by the similarity of meanings. Also, some user perceived values of smartphone could be merged into product smartness. More detail about re-categorization of dimensions of product smartness is explained in Chapter 3.1.

2.2 New Product Development for Smart Product

New product development (NPD) is the transformation of a market opportunity into a product available for sale (Krishnan & Ulrich, 2001). Understanding customer needs, the competitive environment, and the nature of the market are the most important factors for the success of a new product (Kahn, 2012). The typical process of NPD is described in Figure 2.3.

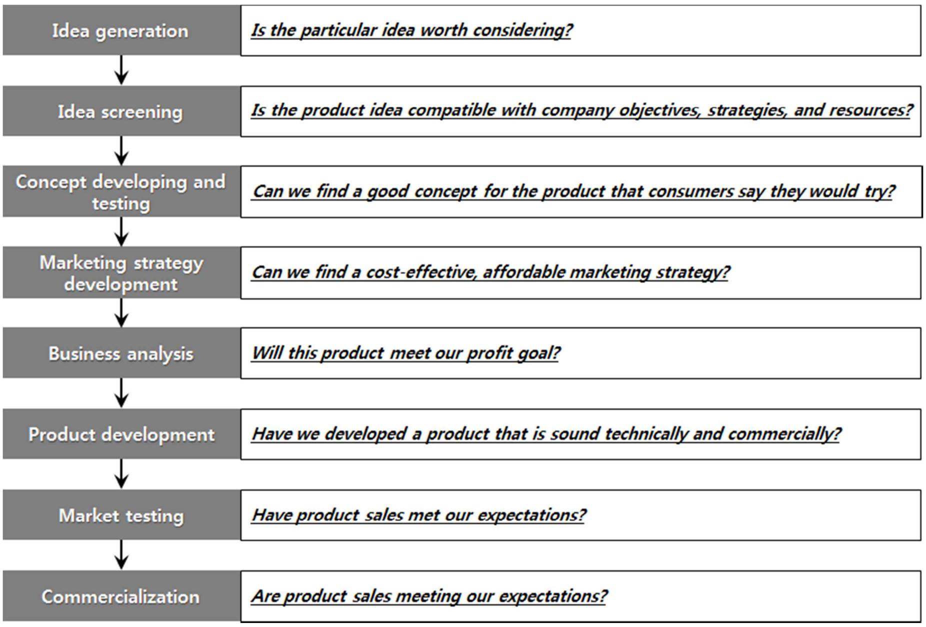


Figure 2.3. New product development (NPD) process

All phases of NPD process are important for developing successful new products. Idea generation is the creative process of generating, developing, and communicating new ideas, where an idea is understood as a basic element of thought that can be either visual, concrete, or abstract (Gänshirt, 2007). Ideation comprises all stages of a thought cycle, from innovation, to development, to actualization (Michael, 2006). As such, it is an essential part of the design process, both in education and practice (Fowles, 1979). In the step of idea generation, identifying user needs plays a crucial role. Also, building a concept or idea and selecting new ideas by evaluating them are essential process.

2.2.1 Identifying user needs and user experience (UX)

With a growing interest in the topic of User Experience (UX), it became a cornerstone to observe and identify users' latent needs in the product development (Kaulio; 1998; Kraft, 2012). Considering a good user experience is vital to continuous commercial success and it is believed to improve customer loyalty. For example, Jordan (1998) suggests that if people have pleasurable experiences with a product, they are more willing to buy the next product from the same company. Although, the notions and necessity of UX have been widely accepted, it has not yet been enough applied to the development of products (Hassenzhal, 2008). Thus, it is important to observe a user's behavior to collect and analyze UX for developing new products or services.

Observing UX is complex that the amplitude of experience varies each interaction, and the overall evaluation of the products changes over time (von Wilamowitz-Moellendorff, Hassenzahl, & Platz, 2006; Karapanos et al., 2009). To understand UX, observational techniques have been used, which can be characterized by the degree of structured form as well as research environment (Table 2.3).

Ethnographic study is used to understand the context of users when using technologies in real life. However, it has its weakness that subjective bias can be incorporated in interpreting the observed data (Shapiro, 1994). Also it is unable to observe users' perceived emotion.

Field survey able researchers investigate a large number of participants asking to fill out the questionnaires. However, it is hard to collect in-depth reasons for their answer (Gable, 1994). Also, it is apt to lead biased data (Lazar, Feng, & Hochheiser, 2010).

Task analysis is conducted to observe the exact time for each behavior by recording video (Kuniavsky, 2003). As the methodology is observed in confined environment, it is appropriate to adopt when observers defined exact problem beforehand (Kuniavsky, 2003).

Table 2.3. Methods of identifying user needs

Method	Description	Strength & Weakness	Reference
Ethnographic study	Observe groups of people in the field or in a natural setting	- Pay attention to the context, artifacts, and environments - Interpretation varies depends on researcher - Unable to observe users' perceived value/emotion	Shaprio (1994)
Questionnaires (Field survey)	Investigate participants asking to fill out the questionnaires	- Easy to investigate a large number of participants - Hard to analyze in-depth reasons for their answer - Easy to lead biased data	Gable (1994); Lazar, Feng, & Hochheiser (2010)
Task analysis	Measures the exact time for each behavior by recoding a video	- Understand users' context of technology usage - Influenced by researcher's intention - Cannot observe longitudinal experience	Kuniavsky (2003)
Focus Group Interview	Usually conducted in the early development procedure by structured group interview	- Perception of users can be identified (priorities, desires) - Can be easily influenced by participants - Should define the exact problem beforehand	Shaprio (1994)
Day Reconstruction Method	Requires participants to fill out the questionnaire once a day	-Collecting longitudinal and temporal information -Identifying the daily experiences -Time lags between event occurrence and record	Kahneman et al. (2004)
Experience Sampling Method	Asks participants to stop at certain times and make notes of their experience in real time	-Collects people's feelings in real time in natural context -Influenced by researcher's existence	Csikszentmihalyi & Larson (1987)

Focus Group Interview (FGI) is usually conducted in the early development procedure by structured group interview. Perception of users, such as priorities and desires, can be identified through FGI, but the result can be drastically differentiated depend on participants.

Since experiential aspect changes over time, diary techniques are increasingly used. Diary technique is known to be in a mediate position of observation in naturalistic setting and controlled settings (Hyldegård, 2006). It has its benefits on observing users' experience for long term, and able researchers to obtain quantitative as well as qualitative data (Kahneman et al. 2004). Although the data recording time has a gap between when the event occurred, several studies configured little affect exists (Kahneman & Krueger, 2006; Kujala & Miron-Shatz, 2013).

There are two types of diary research techniques: structured and unstructured. While unstructured diaries are used to track everyday experience, structured diaries are used to identify specific aspect of products. Among diary techniques, Experience Sampling Method (ESM) and Day Reconstruction Method (DRM) are widely used. Whereas ESM collects people's feelings in real time in natural context (Csikszentmihalyi & Larson, 1987), DRM requires person to fill out the questionnaire once a day (Kahneman et al., 2004). DRM has its strength that it collects context and internal feelings of people through structured and unstructured information.

However, there are three limitations in the observation techniques. First, subjective bias is incorporated in interpreting the observed data (Shapiro, 1994). Also, it is hard to analyze in-depth reasons for their answer (Gable, 1994). Finally, observing user behavior and analyzing collected data require abundant time and effort (Lazar, Feng, & Hochheiser, 2010). Thus, it is needed to analyze observed data more efficiently and effectively.

Clustering analysis can be helpful for analyzing enormous observed data more efficiently and effectively. The Self-Organizing Map (SOM) can be used to carry out the classification tasks effectively, especially for the analysis and visualization of a variety of economic, financial, scientific, and manufacturing data sets (Wang, 2001; Petrushin, 2005).

The SOM is a fully connected single-layer linear network, where the output generally is organized in a two-dimensional arrangement of nodes. It is then possible to visually identify the clusters from the map. The SOM has the ability to learn and detect regularities and correlations in the inputs, and predict responses from input data (Westerlund, 2005).

The main reason for using SOM rather than other clustering methods is that it would be possible to gain some idea from the structure of the data by observing the map due to the topology preserving nature of the SOM (Alahakoon, Halgamuge, & Srinivasan, 2000). Also, clustering is performed nonlinearly on the given input data sets. The topologically preserving property allows the SOM applied to document clustering, which results in grouping similar documents together in a cluster and organizing similar clusters close together unlike most other clustering methods (Gharib et al., 2012).

2.2.2 Idea/concept generation

Creativity thinking, which is the source of idea generation, is classified into ‘divergent thinking’ and ‘convergent thinking’ (Dacey, Lennon, & Fiore, 1998; Takahashi, 2002). Divergent thinking is a thought process or method used to generate creative ideas by exploring many possible solutions (Runco, 1991). Convergent thinking is the type of thinking that focuses on coming up with the single, well-established answer to a problem (Cropley, 2006). Previous methods of idea generation can be categorized into those two creativity thinking (Table 2.4).

Table 2.4. Classification of creativity thinking

Creativity thinking		Idea generation method	Reference
Divergent thinking	Free association	Brainstorming	Osborn (1953)
		Card brainstorming	Takahashi (2002)
		Brain writing	Rohrbach (1969)
		Mind mapping	Buzan (1982)
	Forced connection	Check list	Osborn (1953)
		SCAMPER	Eberle (1996)
	Analogical thinking	Gordon	Gordon (1961)
		NM	Nakayama (1970)
		Synetics	Gordon (1961)
Convergent thinking	Inductive similarity	KJ	Kawakita (1975)
		Cross	Gregory (1967)
	Logical flow	Fishbone	Ishikawa (1982)

Brainstorming is often used in a generic sense to describe groups who generated ideas. The term was popularized by Osborn (1953). Osborn (1953) claimed that brainstorming is the most effective means of ideation. The success of brainstorming as an ideation technique depends strongly on suspended judgment. According to Osborn (1953), in order to be maximally productive, brainstorming groups should follow four rules as follow. First, criticism is ruled out. Adverse judgement of ideas must be withheld until later. Second, “Free-wheeling” is welcomed. The wider idea is the better; it is easier to tame down than to think up. Third, quantity is wanted. Developing more ideas can increase the likelihood of winners. Finally, combination and improvement are sought. In addition to contributing ideas of their own, participants should suggest how ideas of others can be turned into better ideas; or how two or more ideas can be joined into still another idea. These rules are designed to generate a large number of ideas by sparking creativity through suspend judgment.

Card brain storming, which is one of brainstorming method using cards, was developed by Takahashi (2002). Typical brainstorming method could be biased by opinion leader, high social status. Also, it is difficult to collect ideas from all of members and record the whole ideas for a short term. Thus, in the card brainstorming method, those limitations are supplemented through writing their own idea on the card. This method proved plenty time for thinking and equal opportunity to present their own ideas.

Brain writing, which is also called as 6-3-5 method, is a group structured brainstorming technique to aid innovation process by stimulating creativity (Rohrbach, 1969). In brief, it consists of six participants supervised by a moderator who are required to write down three ideas on a specific worksheet with in five minutes. The specific procedure is as follow. First, present, discuss and define the problem within the group of six participants. Second, give each team member an idea-form with thee boxes. Third, fill the top boxes with three ideas in five minutes. Fourth, pass the forms to the right and the next person writes down three more ideas. Fifth, the process is repeated until the ideas boxes are filled in. Sixth, participants can adjust the time per round and increase it as necessary with the last round taking a maximum of ten minutes. Finally, if desired repeat the circulation process and mark interesting ideas as a rough pre-evaluation. There is a risk of clash of similar ideas since there is no immediate group discussion which constitutes a loss of possible innovation (Pahl, & Beitz, 1988).

Mind mapping is developed by Buzan (1982). A mind-map is a tree-like diagram used to represent related ideas and themes using interconnected nodes. The use of mind-maps as an effective method for brainstorming evolved from generating ideas by associations using semantic networks (Buzan, 1990). Their study concluded that the act of collectively structuring shared idea space using a hierarchical structure that is implicit in a mind-map has the potential of improving brainstorming performance over a free-form structure that is assumed in a whiteboard.

Osborn’s checklist is usually used in the method of checklist. A checklist was formulated as a means of transforming an existing idea into a new one. The checklist is designed to have a flexible, trial and error type of approach. The elements of checklist are as follow: Put to other uses, Adapt, Modify, Magnify, Minify, Substitute, Reverse, and Combine them.

A derivation of Osborn's checklist is SCAMPER (Eberle, 1996). The SCMAPER stands for are Substitute (components, materials, and people), Combine (mix, combine with other assemblies or services, integrate), Adapt (alter, change function, use part of another element), Modify (increase or reduce in scale, change shape, modify attributes), Put to another use, Eliminate (remove elements, simplify, reduce to core functionality), and Reverse (turn inside out or upside down).

Gordon method, which is developed by Gordon (1961), is solving problems through analogical thinking. Only a moderator knows the real specific main theme, and more basic idea is demanded for participants through symbolic analogy. Gordon (1961) claimed that "to generate innovative idea, we should not be bound in the current product type". Since, participants don't know the theme in the Gordon method, they can think about that more freely. Hence, it is effective to eliminate the basic cause of the problem.

NM (Nakayama Masakazu) method is also related to analogical thinking (Nakayama, 1970). In this method, participants represent natural characteristics of theme with some keywords. The procedure is as follow. First, it is needed to find keywords of theme, and find proper examples of analogy from the keywords. Then, participants identify characteristics of analogies' examples. Finally, forcedly connecting characteristics to theme for idea generation is conducted.

Synectics is a problem solving methodology that stimulates thought processes of which the subject may be unaware (Gordon, 1961). It is a way to approach creativity and problem-solving in a rational way. This method has three main assumptions as follow. First, the creative process can be described and taught. Second, invention processes in arts and sciences are analogous and are driven by the same "psychic" processes. Finally, individual and group creativity are analogous. With these assumptions in mind, Gordon (1961) claimed that people can be better at being creative if they understand how creativity works.

KJ method is introduced by Kawakita (1975), and it has become one of the 'Seven management (New) tools' of modern Japanese quality management and uses values of Buddhism intended as structured meditation. The KJ method comprises four basic procedures as follow. The first step is Label Making (each label is generally obtained, using brainstorming). The second step is Label Grouping (it consists of label collection, grouping and naming). The groups can be nested and each subgroup is also named. The third step is Chart Making (this involves finding the relation among groups and/or labels). The final step is Verbal or Written Explanation (the explanation is obtained by traversing through the entire chart beginning from any label along any relation edge).

Cross method (7 x 7 method) is developed by Gregory (1967). In this method, participants write their own idea on a memo which is called "idea slip (idea bite)". Then, collected idea slips are arranged in the 7 x 7 matrix. Gregory (1967) claimed that it is useful for organizing ideas effectively. The specific method is as follow. First is making idea slip (writing own idea on a card). Next is identifying categories (classifying collected ideas into seven categories according to similarity). Then, participants arrange idea categories (rating the importance of seven categories to determine the priority, and then arranging them left to right according to the priority). Finally, participants arrange idea slips (rating the importance of idea slips, and then arranging them up to down according to the priority).

Fishbone method, which is created by Ishikawa (1982), shows causal diagrams for identifying the causes of a specific event. This method is commonly used in product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. The categories of fishbone diagrams include people (anyone involved with the process), methods (how the process is performed and the specific requirements for doing it, such as policies, procedures, rules, and laws), machines (any equipment, computers, tools, etc. required to accomplish the job), materials (raw materials, parts, pens, paper, etc. used to produce the final product), measurements (data generated from the process that are used to evaluate its quality), and environment (the conditions, such as location, time, temperature, and culture in which the process operates).

Those idea generation methods are mainly focused on the creativity thinking. There are also other methods which are mainly focused on analytical thinking (Figure 2.4). Creative thinking is related to intuitive, and analytical thinking is related to logical. Intuitive methods work by stimulating the unconscious thought processes of the human mind. The outcome is rather unpredictable, yet they may facilitate finding a novel solution. Logical methods involve systematic decomposition and analysis of the problem. These methods make use of science and engineering principles and/or catalogs of solutions or procedures.

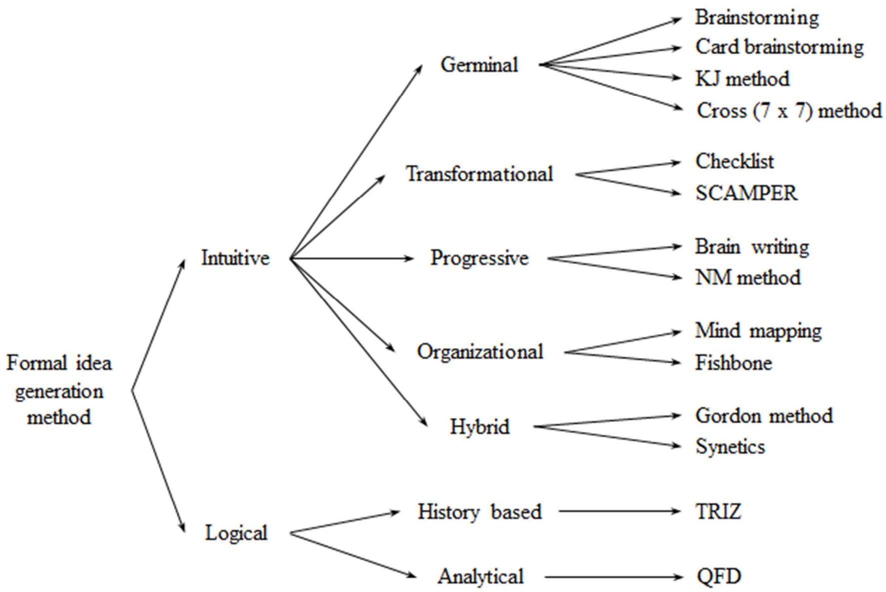


Figure 2.4. Classification of idea generation methods

Intuitive methods have been sub-classified into five categories: Germinal, Transformational, Progressive, Organizational, and Hybrid (Shah, Kulkarni, & Vargas-Hernandez, 2000). Germinal methods are those used when a designer is starting with a clean sheet of paper, when there are no existing solutions. Transformational Methods are used to generate ideas by modifying existing ideas. In Progressive Methods ideas are generated by repeating the same set of steps a number of times, thus generating ideas in discrete progressive steps. Organizational Methods are those that help designers group together in some meaningful way, the ideas that have been generated. Hybrid Methods combine many different techniques to address varying needs at different phases of idea generation.

Logical methods may be classified into two categories: History Based and Analytical methods (Shah, Kulkarni, & Vargas-Hernandez, 2000). History Based Methods involve the use of past solutions that have been catalogued or archived in some form of database. Analytical methods develop ideas from first principles by systematically analyzing basic relations, causal chains, and desirable/undesirable attributes.

Quality function deployment (QFD) is one of commonly used methods in analytical thinking. QFD is a customer-oriented approach to product innovation (Akao, 1994). It guides product managers and design teams through the conceptualization, creation, and realization process of new products. QFD is designed to help planners focus on characteristics of a new or existing product or service from the viewpoints of market segments, company, or technology-development needs. QFD supports design teams to develop products on a structured way that relates market demand via engineering specifications to parts specifications and to production process variables and thus to production operations planning (Govers, 1996).

In general, the product development process from customer-needs to manufacturing process operations, can be outlined by a step by step approach marking the points at which the requirements for intermediate results are established and go-or-no go decisions can be made (Govers, 1996). Four phases are usually considered (Figure 2.5).

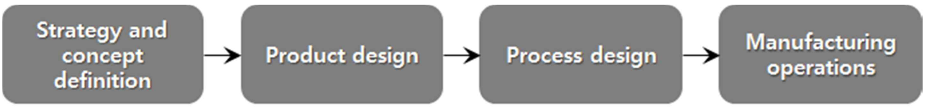


Figure 2.5. Four phases of the product development process

In the strategy phase, product policy and determination of the customer will be established and the customer needs are translated into a product concept. The design requirements (What's: Customer needs) serve as input to establish the component characteristics (How's: Product functions or Company's policy) of the product design. Because of the complex relationships between the inputs and outputs, these relationships are mapped into matrices. The basic structure is depicted in the relationship matrix (Figure 2.6).

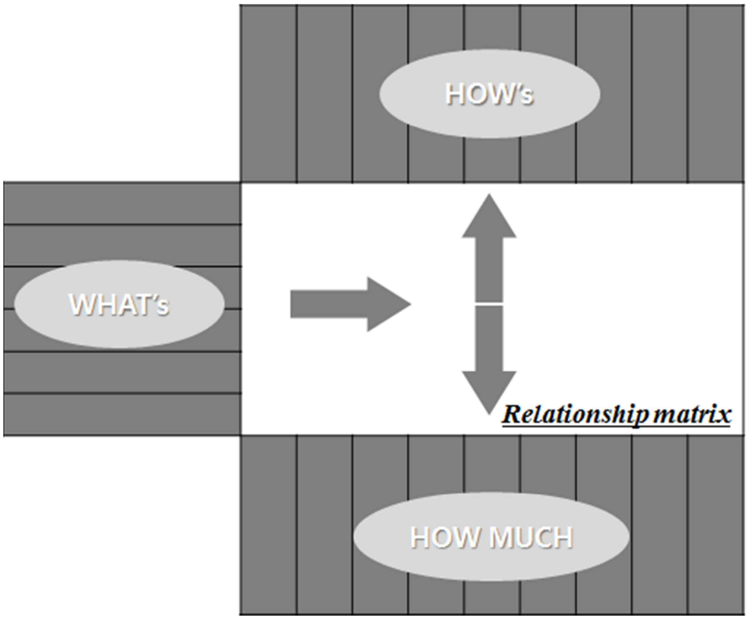


Figure 2.6. Basic structure of QFD

This method is flexible to allow adding any other information which may be useful to the decision making. Through exploring the What's – How's relationships, each attribute of How's will be appraised to set target goals or values, the How Much should be measurable as much as possible. Using QFD charts the outlined development process can be depicted in four phases (Figure 2.7) although in actual use as many levels of charts as necessary may be used.

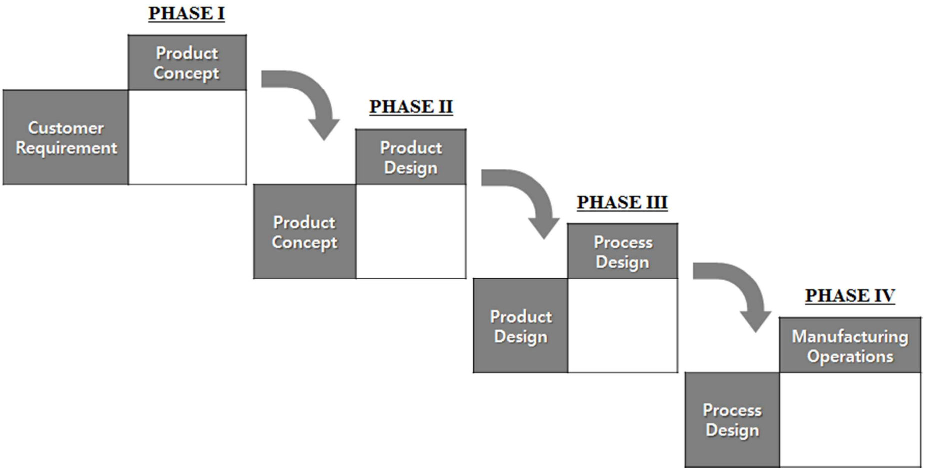


Figure 2.7. Illustration of cascading QFD charts

The several objectives of QFD are as follow (Franceschini, 2002). First, defines the product features which satisfy the client's needs. Second, structures all the information relevant to developing a new product or service. Third, defines the product as a relation of needs and features and compares this definition to the competitions' products. Fourth, reduces the risk of costly corrections in the advanced stages of product development since it takes into consideration all defining factors from the first stages. Finally, guarantees coherence between product and process planning.

To implement QFD successfully, a company has to be system oriented. QFD provides activities that bring together all required disciplines to work and plan the development efforts in a highly disciplined, communicative and effective manner (Govers, 1996). QFD as such is not high technology rather it is a technology developed by users based on common sense and effective information transfer. The foundation of the method lies in the belief that a product must be developed starting from the consumers' needs and tastes, therefore an interdisciplinary collaboration of all departments involved is necessary from the very beginning of the development phase (Hauser & Clausing, 1988).

Due to its wide spread use, ability to translate customer needs into solution features, and accuracy in analysis of correlations between needs and features, QFD could be an appropriate method in the approach of Chapter 5. Since approach of idea generation in this study considers the marketing strategy and business analysis less than customer needs, correlation analysis of QFD was utilized to generate new products/service idea. More detail is explained in Chapter 5.

2.2.3 Idea/concept evaluation

For years, researchers and practitioners have studied methods of increasing the idea output of individuals and groups, respectively. Particular emphasis has been placed on improving the tools and methods used to support idea production because the ability to generate ideas is critical to enhance innovation and managerial problem-solving abilities.

According to Briggs et al. (1997), two challenges confront researchers wishing to evaluate the output of an idea generation process. First, a reliable way to rate each individual idea must be devised, which is especially difficult as in idea generation studies the number of ideas commonly ranges from several hundred (Dennis et al., 1996) to more than a thousand (Hender et al., 2002). Second, the ratings of individual ideas must be aggregated into an overall score in order to assess the performance of the individual or group that produced the ideas.

Also, idea generation (ideation) is identified as a key step in system development, organization planning, decision making, and problem-solving (Ackoff, 1970; Bringtman, 1980; Bross, 1953; Whitten & Bentley, 1998). It is therefore understandable that interventions for improving the method of idea generation have been the subject of much research (Barki & Pinsonneault, 2001; Diehl & Stroebe, 1987; Fjermestad & Hiltz, 1998). Thus, many researchers have made their efforts on improving ideation quality. Ideation quality is the degree to which an idea generation technique produces ideas that are helpful in attaining a goal. It pertains to the relative merits of an ideation process or intervention rather than to the value of a particular idea.

The main metrics of ideation quality is illustrated in Figure 2.8. Shah et al.'s (2003) four ideation metrics (quantity, quality, novelty, and variety) is usually used to evaluate the quality or effectiveness of idea generation method (Dahl & Moreau, 2002; Jensen et al., 2009; Yang, 2009; Nagai, Taura, & Mukai, 2009; Charyton et al., 2011; Linsey et al., 2011; Kudrowitz & Wallace, 2012).

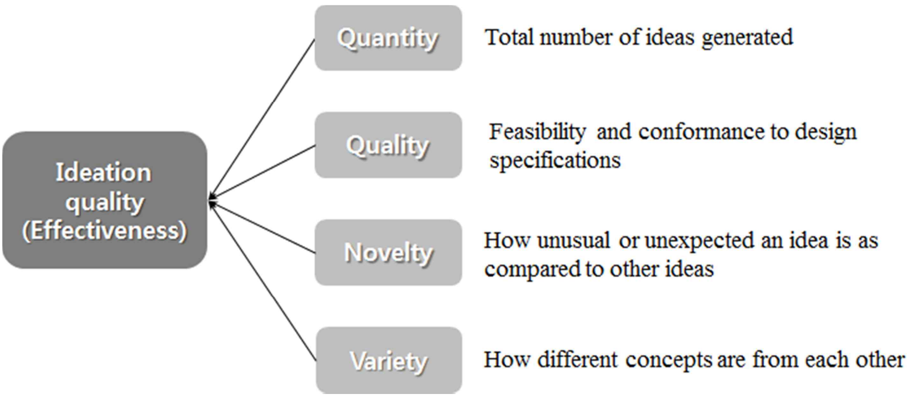


Figure 2.8. The metrics of ideation quality

Quantity is the total number of ideas generated (Lamm & Trommsdorff, 1973; Shah et al., 2003). MacCrimmon and Wagner (1994) stated that the quantity of generated ideas is a commonly agreed upon metric. The rationale for the measure quantity is that generating a large number of ideas enhances the chance of better ideas (Basadur & Thompson, 1986; Kumar, Holman, & Rudegeair, 1991; Osborn, 1953). However, this is applicable under certain conditions (e.g., generating a large number of ideas with timely evaluation) (Jagtap et. al, 2014).

Quality is related to feasibility and conformance to design specifications (Shah et al., 2003). In engineering design, this metric is required because an engineering idea needs to be feasible and practical (Charyton et al., 2011). Previous studies about quality are summarized in Table 2.5.

Table 2.5. Dimensions of evaluating idea quality

Reference	Dimension
Taylor et al. (1958)	Feasibility, Probability, Effectiveness, Significance, Generality
Lamm & Trommsdorff (1973)	Feasibility, Effectiveness
Durand & VanHuus (1992)	Originality, Appropriateness, Detail, Depth, Clarity
MacCrimmon & Wagner (1994)	Novelty, Workability, Relevance, Thoroughness
Cady & Valentine (1999)	Novelty, Excitement, Adoptability, Non-violation of known constraints, Applicability, Ability to solve the problem, Business potential, How well described
Mumford (2001)	Novelty, Unusualness, Logical, Workability, Potential plausibility
Potter & Balthazard (2004)	Creativity, Feasibility, Relevance
Dean et al. (2006)	Novelty, Workability, Relevance, Specificity
Linsey (2007)	Technical feasibility, Implementability

There are previous studies about quality of idea focused on feasibility (e.g., Taylor et al., 1958; Lamm & Trommsdorff, 1973); Duran & VanHuus, 1992; Linsey, 2007). Lamm and Trommsdorff (1973) proposed that quality of an idea is effectiveness (the ability of an idea to fulfill the given requirements) plus feasibility (i.e. extent to which an idea can be implemented under the constraints of reality).Durand and VanHuss (1992) suggested that originality, appropriateness, detail, depth, and clarity are important factor for quality of idea. According to Linsey (2007), quality is synonymous to technical feasibility or implementability.

There are also previous studies that considered novelty and creativity of idea additionally (e.g., MacCrimmon & Wagner, 1994; Cady &Valentine, 1999; Mumford, 2001; Potter & Balthazard, 2004; Dean et al., 2006). For instance, Dean et al. (2006) suggested workability (acceptability plus implementability), relevance (applicability plus effectiveness), and specificity (completeness) as sub-dimensions of quality.

Novelty is an important ideation metric (Dahl & Moreau, 2002). According to Shah et al. (2003), novelty is a measure of how unusual or unexpected an idea is as compared with other ideas including those from other individuals. This suggests that uncommon ideas are likely to be seen as novel.

In terms of a design space, novelty is a measure of whether the exploration of ideas occurred in areas of the design space which are well traveled or little traveled (Nelson et al., 2009). In a design space, novel ideas occupy points that are not initially perceived (Shah et al., 2003). Shah et al. (2003) classified novelty into three different types, namely personal novelty (the outcomes of an individual are new according to that individual), societal novelty (a product or idea is new to all people in a particular society), and historical novelty (a product or idea is the first of its kind in the history of all societies and civilizations).

Jansson and Smith (1991) explain variety as the flexibility of generating a range of ideas. Variety means that how different concepts are from each other (Shah et al., 2003). A low flexibility indicates a narrow range of generated ideas, while a high flexibility shows a broadly searched idea space (Jagtap et al., 2014). To estimate variety, Sarkar and Chakrabarti (2008) compare the number of similar ideas to those with less similarity. Generating a large number of ideas that are very similar to each other does not guarantee an effective idea generation.

Those measures are usually used for evaluating ideas or concepts in the early stage of NPD process. There are also previous studies about evaluating more developed ideas or concepts such as products and concept. Previous studies mainly focused on the creativity of products. Main dimensions of previous studies are summarized in Table 2.6.

Table 2.6. Dimensions of evaluating creative products/concepts

Reference	Dimension
Amabile (1982)	Creativity cluster, technical cluster, Aesthetic judgment
Besener & O’Quin (1986; 1999)	Novelty, Resolution, Elaboration and synthesis
Christiaans (2002)	Creativity, Goodness of example, Technical quality, Interest, Attractiveness
Horn & Salvendy (2006; 2009)	Novelty, Importance, Affect

Those studies mainly evaluated products or scenario by creativity, feasibility/workability, affect. Novelty is the most important factor for measuring creativity (Amabile, 1982; Besener & O’Quin, 1986; Christianns, 2002; Hor & Salvendy, 2006). Many measures (e.g., resolution, elaboration, goodness of example, importance, etc.) are selected and used for evaluating feasibility or workability. Although those measures are limited to evaluating creative products/concepts, some of them could be utilized to evaluating the overall satisfaction on ideas or concepts. More detail explanations about selecting and re-organizing the dimensions of idea quality are in Chapter 6.

Chapter III

IDENTIFYING PRODUCT SMARTNESS

3.1 Overview

Many studies on identifying product smartness have been studied, but lots of those studies were mainly focused on expert view or using user survey. As it is discussed in Chapter 2.1.3, the extracted elements of product smartness are different from each other. Also, some user perceived values of smartphone could be merged into product smartness. Thus, in this chapter, the main dimensions of product smartness are re-categorized by the similarity of meanings. Also, in order to identify perceived product smartness based on user experience, techniques that mining external data (e.g., twitter) were used. Finally, according to the analysis of the collected data, the relationships between product smartness and user experiences of smart products are analyzed and discussed.

3.2 Conceptual Model of Product Smartness

3.2.1 Method

The purpose of this chapter is to explain what the product smartness is. The procedure of identifying product smartness is as follow. First, previous studies related to explain product smartness were collected, and discussed. Next, in-depth interviews of experts were performed. The interviewees, who are specialized in product design, are presented in Table 3.1.

Table 3.1. Participants of expert interview

#	Gender	Career
1	Male	Ph.D. in Ergonomics, Professor for 20 years
2	Male	Ph.D. in Ergonomics, Director, Electronics company for 17 years
3	Female	Ph.D. in Ergonomics, Designer, Electronics company for 11 years
4	Male	Ph.D. in Ergonomics, Strategic consulting agency for 20 years
5	Male	Ph.D. in Ergonomics, Developer, Electronics company for 8 years

The interviews were conducted for about an hour especially about appropriate usage of collected product smartness. Interview method is to record and organize interviewees' explanations about whether product smartness (abstracted from previous studies) actually influence to smart products. Finally, according to the results of literature review and expert interview, the dimensions of product smartness were re-organized.

3.2.2 Result of re-organization and discussion

The collected dimensions and attributes related to product smartness from various previous studies are shown in Chapter 2.1.3. In order to find the structure of product smartness, appropriate usage and the similarity of meaning among the collected attributes of product smartness were evaluated by five human factors experts. Since some of attributes are defined to broadly and some are identified in too much detail, the meanings of some characteristics were merged, specified or refined in the process of re-organization.

As a result, collected dimensions of product smartness could be re-categorized into five main dimensions as follow: Autonomy, Adaptability, Multi-functionality, Connectivity, and Personalization. The description of each dimension of product smartness is presented in Table 3.2.

Table 3.2. Description of each dimension of product smartness

Product smartness	**Description**
Autonomy	Smart products can operate in an independent and goal-directed way without control of users and central infrastructures.
Adaptability	Smart products can adjust their functioning to changes in their environment.
Multi-functionality	Smart products can provide various functions to enhancing users' convenience and comfort.
Connectivity	Smart products can be connected to other products and can communicate with other products and users.
Personalization	Smart products can show the properties of a credible character through customizing functions according to users' needs.

Previous studies related to dimensions of product smartness were re-categorized according to five main dimensions (Table 3.3).

Table 3.3. Re-categorization of main dimensions of the product smartness

Reference	Autonomy	Adaptability	Multi-functionality	Connectivity	Personalization
Rijsdijk & Hultink (2002; 2009)	Autonomy	Adaptability, Reactivity	Multi-functionality	Ability to cooperate, Humanlike interaction	Personality
Swallow, Blythe, & Wright (2005)			Organization	Sociability, Relevance	Identity
Thompson (2005)	Reasoning and learning	Controllability, Maintainability	Memory and status tracking	Sensing and actuating, Communications, Scalability, Interoperability	Identity and kind
Maass & Varshney (2008)	Proactivity	Situatedness, Adaptiveness		Networkability	Personalization
Mühlhäuser (2008)	Proactivity	Context-awareness	Self-organization	Multimodal natural interfaces	

Table 3.2. (Continued)

Reference	Autonomy	Adaptability	Multi-functionality	Connectivity	Personalization
Sabou et al. (2009)	Autonomy, Proactivity	Situation and context-aware, Emerging knowledge		Multimodal interaction	
Miche, Schreiber, & Hartmann (2009)	Interaction	Context		Ubiquitous data store	
Andersson & Frost (2013)			Entertainment, Knowledge, Monetary savings	Control	
Jung (2013)	Productive daily life, Comfort		Acquire information, Amusement, Convenience	Socialization, Improve communication	Personalized device environment, Sense of confidence
Park & Han (2013)	Comfort		Convenience	Relationship	Social status

In the process of re-organizing dimensions of product smartness, some of attributes are eliminated and merged into the other one. For instance, 'reactivity' is about the ability of a product to react to changes in its environment, and 'context-awareness' is about the ability to sense context and how to react in a given context. The purpose of those characteristics is similar. Those characteristics eventually adapt interaction with other products and users accordingly, as well as to infer new knowledge. Therefore, they could be merged and assigned to 'adaptability.' There was also confusion of meaning in 'proactivity' and 'reactivity.' Both of them indicate the ability to adjust their behavior, but 'proactivity' pay attention to users with anticipating users' intention and 'reactivity' focus on the environment with reacting to changes of its environment.

The first dimension of 'autonomy' refers to extent to which a product is able to operate without interference of the user (Rijsdijk & Hultink, 2009). It could be categorized into three sub dimensions: Proactivity, Machine learning, and Productivity. Proactivity means that the ability to anticipating users' plans and intentions. It is one of the key characteristics of smart products to provide autonomous functions or services.

Proactive behavior of smart products can save users' time, cost, and effort. Machine learning is related to save conventional action which can be reduced by auto-settings. Smart products might or might not include various learning plug-ins. A simple form of learning might be to save settings; a little smarter than that might be to play back a recent log. The first generation might not be very smart, but reasoning-capability plug-ins will improve (Thompson, 2005). Productivity is about helping users to waste less time, manage schedule better, make better decisions, and help concentration. These are an important goal associated with smart products.

Adaptability refers to a product ability to adjust its functioning to changes in its environment. This ability has traditionally been considered as an aspect of the intelligence of artifacts (Turing, 1950). It could be categorized into three sub dimensions: Context-awareness, Reactivity, and Maintainability.

Context-awareness is about how to acquire and reacting to context. It is important to figure out the context for reacting to changes of environment. Smart products are able to sense physical information (e.g., via a temperature sensor), virtual information (e.g., about the current state in the cooking process maintained by another smart product) and to infer higher level events from this raw data (e.g., the user has fished cooking). Situation and context information allow smart products to adapt their interaction with other products and users accordingly, as well as to infer new knowledge.

Reactivity is the ability of a product to react to changes in its environment (Bradshaw, 1997). It is also reflecting concern about how to adjust their functions to changes of the external environment. Maintainability is a little bit different from others.

It is related to how to maintain the conditions of products (e.g., on or off, version of software in products, etc.) according to users' needs. Users won't want to continually boot or upgrade individual smart products, but users might need to turn them on or off or reset their controls at certain points. Maintainability of smart products can help users in this regard.

Multi-functionality is one of the key characteristics for smart products. It refers to the phenomenon that a single product fulfills multiple functions (Poole & Simon, 1997). The application of information technology in physical products enables a larger set of attributes to be designed into one product (Dhebar, 1996). Modern cell phones, for example, can also be used to play games or send photos and text messages. It could be categorized into three sub dimensions: Organization, Entertainment, and Informative.

Organization is about the ability to organize personal life or daily life (e.g., simple calendar, schedule plan, to-do list, e-mail, etc.). Entertainment is connected to having fun, providing the use value when the user is bored or wanting to pass time. Consequently, it is not only connected to having fun, but also to being less bored. Informative is about providing information to satisfy users' curiosity and widen the user's base of knowledge. Also, it can satisfy users' needs to acquire real-time information, knowledge as needed, and more information than ever before. Those are typical features of smartphones. However, since it is not necessary for all smart products, the benefits of adding functions to a product are limited (Rijsdijk & Hultink, 2009). Thus, it should be carefully considered to adapt those characteristics to other smart products.

Connectivity is the ability to cooperate with other products and communicate with users. Smart products can be connected to other products and can communicate and cooperate with other products and users for their common goal. Connectivity could be categorized into three sub dimensions: Networkability, Sociability, and Scalability.

Networkability is the ability to communicate and bundle with other products. The current and emerging advances in ubiquitous computing, pervasive computing, and mobile technologies will enable smart products to communicate with other products and customers. The access to multiple wireless and mobile networks will extend the reliable range of communications to other products, environments and potential customers. This will also allow the selection of the best possible network for the type of communications needed (Dekleva et al., 2007) such as a wireless LAN to communicate with someone on the same floor, while use of personal area networks such as Bluetooth to someone at a close location.

Sociability is related to maintain and create social groups through interacting with users. Some of smart products can extend social networks to improve communications such as providing smooth communication with several people at once, keeping continuous communication, able to communicate with other people who possess same products. Improve communication can increase users' social relations (Jung, 2013). For example, mobile applications for extending social networks can make smartphone users feel a constant connection to their peers.

Scalability is about the ability to handle a growing amount of connections with users and other products. Also, it refers related to the ability to be enlarged to accommodate that growth. Numerous smart objects must be able to dynamically join and leave various enclaves, leaving the store behind to join user's household, recording a change of ownership, and getting to know a new collection of other smart objects (Thompson, 2005).

Personalization is about the ability to show the properties of a credible character. Personalized function is supposedly beneficial for the user's comprehension of the products (Bradshaw, 1997). It could be categorized into three sub dimensions: Identity, Customization, and Natural interaction.

Identity is related to ability to show user's identity through customizing smart products. Information and computing technologies have an impact on users' private identity in terms of how we express ourselves through them; they also impact on our public identity in terms of how others perceive us (Swallow, Blythe, & Wright, 2005). It is important to have own identity for smart products. Because different kinds of products perform different functions, they will need different custom interfaces (Thompson, 2005). Thus, interfaces should be reflective, and other products should be able to ask them what they can do.

Customization is about the ability to personalize smart products according to users' needs. Personalization has been a trend in Web services, and in particular, user-driven personalization (e.g. iGoogle) allows users to tailor the contents of information technology (IT) services to match their preference (Tam & Ho, 2006). Because most of smart products are linked to an individual user, their services have been assumed to achieve greater personalization than Web-based services (Jarvenpaa & Tomak, 2003). In particular, smartphone users can have highly adapted mobile services, which they are capable of configuring their own apps in their devices (Tossell et al., 2012).

Natural interaction is a little bit different from other sub dimensions of personalization. It refers to that smart products can interact with their users in more natural, humanlike and emotional way using varied types of user interfaces. Smart products should provide a natural interaction, however most smart products have only limited in- and output resources (Sabou et al., 2009). Smart products can discover multimodal user interface services in the network and can make use of them as need be. Bauer and Mead (1995) suggested that one way of increasing product usability is the application of voice production and recognition. Thus, natural multimodal interaction could help to show own identity.

Based on the results of literature review and expert interview, the conceptual model of product smartness is illustrated in Figure (3.1).

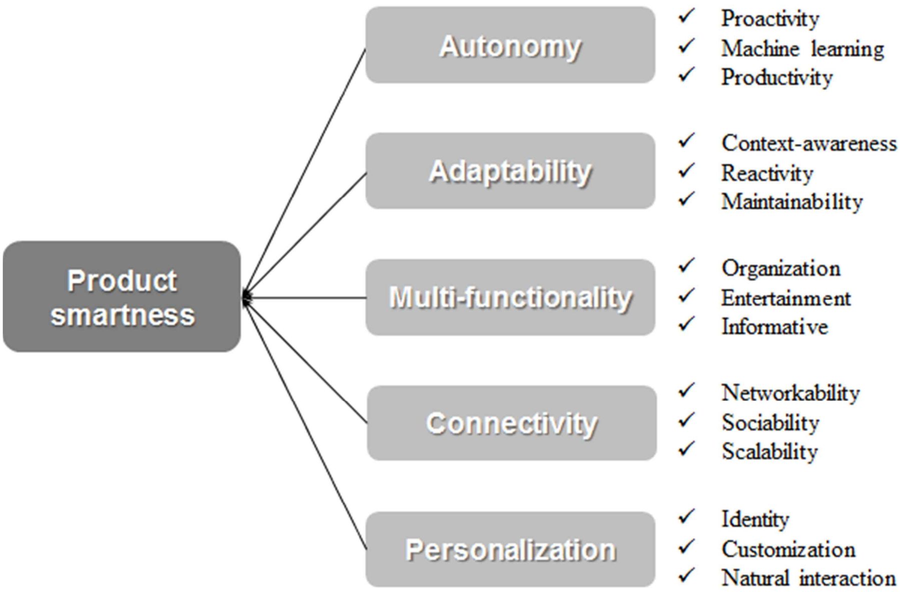


Figure 3.1. The conceptual model of product smartness

3.3 Analysis of User Experience of Smartphones utilizing Social Media Data

Even though there have been many studies related to identify product smartness, they mostly focused on the experts' view. Hence, in this chapter, user perceived product smartness will be discussed based on gathering user experience of smart products.

3.3.1 Method

Many studies on observing/gathering user experiences have been conducted. There several methods, which have been usually used in various research areas, are Focus Group Interview (FGI), Ethnographic study, Task analysis, Field survey/Questionnaire evaluation, and Diary techniques. However, there are some limitations related to the methods of analyzing collected data, which are discussed in Chapter 2.2.1, such as difficulty to collect observation data and analyze them due to needs of abundant time and effort. Thus, to gather user experience or user perceived value on smart product, techniques that mining external data (e.g., twitter and blog) were used. From the mined external data, user experiences related to product smartness were categorized according to the product smartness and identify the relationship between the product smartness and positive/negative experiences.

3.3.1.1 Selection of external data source

The Web contains a wealth of opinions about products, politicians, and more, which are expressed in newsgroup posts, review sites, and elsewhere (Popescu & Etzioni, 2005). As a result, the problem of "opinion mining" has seen increasing attention over the past (Turney, 2002; Hu & Liu, 2004). Users' reviews of products on Web sites such as amazon.com and elsewhere often associate meta-data with each review, indicating how prefer it is using a 5-point scale and also rank products by how they fare in the reviews at the site.

Social media (e.g. Facebook, MySpace, Twitter, etc.) can be defined as services that provide users the possibility to establish a connection with their friends through the application and share information with them (Noordhuis, Heijkoop, & Lazovik, 2010).

Among social media, Twitter is a “what’s happening right now” tool that allows users to post their thoughts or status (called tweets) and follow status updates of other users in almost real-time (Schonfeld, 2009). It is a potentially valuable source of data that can be used to delve into the thoughts of millions of people. This could make it possible to infer people’s opinions, both at an individual level as well as in aggregate, regarding potentially any subject or event (Schonfeld, 2009). Therefore, social media, especially Twitter, was selected to gather user experiences of smart products.

3.3.1.2 Search keyword and collected data

Even though smart products such as smart cars, smart electronics, and smart devices have been proliferating, they have not been usually used as smart products except smartphones. Smartphones are regarded as an essential component of modern life. About 6 billion people, corresponding to over four-fifths of the global population, had subscribed to a mobile phone service by the end of 2011 (IDC, 2011). Since a smartphone is one of the most successful smart products, it could be represent the characteristics of smart products better than other products. Therefore, for case study, ‘smart phone’ and ‘mobile phone’ are selected as search keywords.

3.3.1.3 Procedure of classification of user experience

The overall procedure of analyzing the relationship between perceived product smartness and collected user experiences of smart products from external data source (Twitter) is as follow (Figure 3.2).

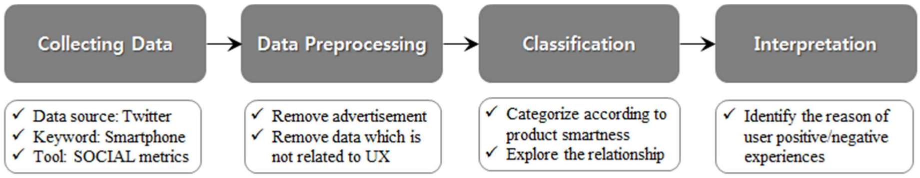


Figure 3.2. The procedure of the method

First, data of user experience of smart products was collected through mining Twitter data using software tool (SOCIAL metrics). SOCIAL metrics (http://socialmetrics.co.kr), which is developed by DaumSoft, can help for analyzing big data. It enables to collect Twitter data and show the frequency of keywords related to user's search keyword (Appendix A.1).

Second, data preprocessing was conducted. Twitter is gaining a lot of relevance with mainstream media like CNN showcasing tweets on air and posting its breaking news to the service (Noordhuis, Heijkoop, & Lazovik, 2010). Thus, lots of repetitive advertisement and news are shown in the search results. In the search results, the tweets which are not related to user experiences of smart products are eliminated.

Third, collected user experiences were categorized according to the conceptual model of product smartness. Then, identifying the relationship between each dimension of product smartness and users' positive/negative experiences was performed by manually.

Finally, the reason of users' positive or negative emotions on experiences of smart products was identified.

3.3.2 Result of classification and discussion

A total of 19,288 tweets including 'smartphone' were collected from 2014.06.01 ~ 2014.08.31. Among them, a total of 699 tweets are actually related to user experiences of smartphones. The collected tweets were categorized according to the dimension of product smartness and the reason of user's emotion. The results are shown in Table 3.4.

Table 3.4. The frequency of user experiences on smartphones

Product smartness	Positive experience (n)	Negative experience (n)
Autonomy	57	-
Adaptability	4	-
Multi-functionality	193	53
Connectivity	67	102
Personalization	2	-
Habitual use, Security	-	221
Total	323	376

The number of user experiences related to multi-functionality and connectivity is relatively higher than others among product smartness, and the number of user experiences related to personalization is the lowest. Also, a total of 221 user experiences are not categorized into the five dimensions of product smartness. The frequency of positive experience is almost same as negative experience.

To explore user experiences of smartphones related to each dimension of product smartness more in detail, collected data were categorized according to the reason of positive or negative emotion. The results are presented in Table 3.5. Though user experiences of autonomy are various in details, there is one main reason why users feel positive emotion from experiences related to autonomous product.

Main reason for positive experience on autonomous product is that smartphones can increase productivity of daily life. Productive daily life is a critical means for users to develop sense of confidence (Jung, 2013). By reaping benefits from schedule applications on smartphones (management of schedule & information function), users can achieve effective management of daily life or work.

In turn, with the positive experiences derived from productive daily life, users perceive characteristics of autonomous from the smart products. Such experiences arouse positive psychological states, which promote users' satisfaction on the products. This finding reflects the argument that individuals' confidence depends on their own assessment of their physiological states (Wood & Bandura, 1989).

Therefore, when users feel they manage their daily life well, they may have satisfied their products.

Table 3.5. Reason for positive or negative experience of product smartness

Product smartness	Emotional experience	Reason of emotion	Frequency (n)
Autonomy	Positive	Increasing productivity of daily life	57
Adaptability	Positive	Providing maintainability	4
Multi-functionality	Positive	Providing organization	79
		Providing the use value when the user is bored or wanting to pass time	48
		Providing information which user want to know	66
	Negative	Low quality of function	53
Connectivity	Positive	Providing networkability	18
		Improving sociability	49
	Negative	Decreasing sociability	30
		Lack of scalability	45
		Too high connectivity	27
Personalization	Positive	Well-customization	2
Habitual use	Negative	Waste time, addiction	188
Security	Negative	Privacy issue	33

However, even though negative experience of autonomous was not shown in the results, actually autonomous product does not always increase satisfaction of product. Rijsdijk and Hultink (2003) showed a significant positive impact of autonomy on complexity. High complexity in using products will decrease satisfaction of products. This indicates that new product developers should aim to reduce this negative effect. Providing an autonomous product with indicators that inform the user about what the product is doing may reduce risk perceptions (Rijsdijk & Hultink, 2009).

The reason for positive experience on adaptability is that smartphones are self-upgraded to improve the match between its functioning and environment. There are only four experiences from the collected data, but users perceive it useful when they don't need to continually boot or upgrade individual smart products.

According to the results, there are three main reasons for positive experiences and one main reason for negative experiences on multi-functionality. Providing various functions to give an assist for organize personal life (e.g., schedule plan, e-mail, etc.) is one of the reasons. Also, users acquired information which they want to know in real time from smartphones.

Users usually used their smartphones in the purpose of entertainment. Entertainment is connected to having fun, providing the use value when the user is bored or wanting to pass time. Consequently, it is not only connected to having fun, but also to being less bored. Those experiences increased users' satisfaction of products.

However, although smart products provide various multi-functions to users, it could also decrease users' satisfaction. According to Table 3.4, low quality of functions derived negative experiences.

Multi-functionality increases the complexity and risk that consumers perceive (Rijsdijk & Hultink, 2009). These results suggest that the benefits of adding functions to a product are limited. This finding supports the idea to develop products with a moderate increase in multi-functionality. Further study may provide insight into what level of multi-functionality is acceptable for users.

The results about connectivity are quite interesting. Only in the case of connectivity, the number of negative experiences is higher than positive experiences. Positive experiences are that smartphones improve communication with other products/functions and users.

For example, users extended social networks, met different types of people, connect to other products, and controlled functions or services of other products through smartphones. Those experiences derived positive emotions.

The main reasons for negative experiences are related to decrease of sociability, lack of scalability, and too high connectivity. Even though smartphones can improve communication with other users, it can also reduce opportunities of increasing social relationship in off-line. The results showed that people concern about reduced opportunities.

Also, smartphones are always around us and we cannot withstand without our smartphones. Excessive informing messages from smartphones can bother us. Thus, those experiences could derive negative emotions. This finding could be supported by that high connectivity can increase complexity (Rijsdijk & Hultink, 2009).

In addition, users have certain ideas of what a product category should and should not do (Rijsdijk & Hultink, 2009). For some product categories, it may be difficult for users to accept that their functionality is extended to communicate with other products.

According to the results, user experiences related to habitual use and security derived only negative experiences, respectively. Habitual use is about using smartphones habitually without any certain goal. Because habitual use may lead users to smartphone addiction, which can have a negative impact on their life, it could not be connected to positive emotion (Jung, 2013).

Users have concerns about the security of their smartphones. Since smartphones have various users' private data, they want to protect private information. Users also expect analogs to viruses and spyware, which means that users will need to be able to distinguish between friendly, neutral, and enemy objects or capability plug-ins Thompson, 2005).

3.4 Discussion

In this chapter, conceptual model of product smartness was identified based on the literature review and expert interview. As a result, five main dimensions of product smartness were selected (Autonomy, Adaptability, Multi-functionality, Connectivity, and Personalization).

To explore the relationship between product smartness and user positive or negative experiences, social media data (Twitter) were collected by a data mining technique. Especially, smartphone is the case study of this chapter. The results showed that experiences of connectivity derived lots of negative emotions. Also, besides five dimensions of product smartness, there were lots of experiences about user's habitual use and security issues.

Even though, in the case study, only smartphones were investigated, smartphones can serve as a good sample since they are one of the successful smart products with rich experience (Pence, 2011). If more smart products become being widely used, investigating them will be helpful for generalization of the conceptual model of product smartness, proposed in this study.

Also, in this study, dimensions of product smartness were defined by literature and expert review. To validate the conceptual model of product smartness, it is needed to investigate perceived product smartness by conducting user evaluation. In the perspective of affective engineering, user perceived smartness could be identified by affective adjectives which users usually use.

Chapter IV

IDENTIFYING USER NEEDS

4.1 Overview

In the current highly competitive marketplace, firms are under increasing pressure to develop new products and services that are both timely and responsive to customer needs. Especially, after a success of smart phone, many products have been developed as smart products. However, many users can not feel product smartness well from the smart products even if those products were sold well. Because many smart products were not developed well with identifying user's implicit needs. Identifying user needs is critical in new product development process. Thus, in this chapter, the methodology that collects user needs and analyzes collected data is proposed with conducting a case study.

4.2 Eliciting Users' Implicit Needs using a Diary-based Behavior Analysis

As it discussed in Chapter 2.2.1, the diary method is known to be in an intermediate position of observation between naturalistic settings and controlled settings (Hyldegård, 2006). It has its benefits in observing the users' experience for the long term and makes researchers able to obtain quantitative as well as qualitative data (Kahneman et al., 2004). Also, a key advantage of the diary method is the short time lag between event occurrence and recording data, hence, less subject to memory lapses and retrospective messaging, as may be the case with interviews.

However, observing user behavior and analyzing collected data require abundant time and effort (Lazar, 2010). Thus, it is needed to analyze observed data more efficiently and effectively. As it discussed in Chapter 2.2.1, clustering analysis can be helpful for analyzing enormous observed data more efficiently and effectively. Especially, the Self-Organizing Map (SOM) can be used to carry out the classification tasks effectively for the analysis and visualization of abundant data.

Therefore, in this chapter, in order to identify users' implicit needs, Day Reconstruction Method (DRM) was conducted to observer user experiences. Then, SOM is conducted to group the self-reported experiences into representative called codebooks to form a two-dimensional grid on a visual map. Also, concept hierarchy clustering is conducted on each group to identify characteristics of each group.

4.2.1 Method

The DRM originally aims to collect data describing respondents' experiences of a day, following the process: Respondents recall the previous day by writing short diary and answer the series of questions on the context such as 'when the episode began', 'what event occurred', and 'how the respondent felt'. In the last section, demographic information is asked as well.

4.2.1.1 Proposed framework

The overall flow suggested as the typical DRM was used, modifying the following three factors (Secondary activity, Structured TV-viewing context, and Description of the users' reason). The first factor is secondary activities. This study focused on the specific activities which were simultaneously conducted while the respondents were watching television. Second, the smart TV features, primary activities, and secondary activities were categorized in order to collect users' behavior. Also, considering the characteristics of watching television's behavior, respondents were asked to fill out the questionnaires twice a day. The last one is the specific reasons why the emotions of user's TV-viewing experiences occurred.

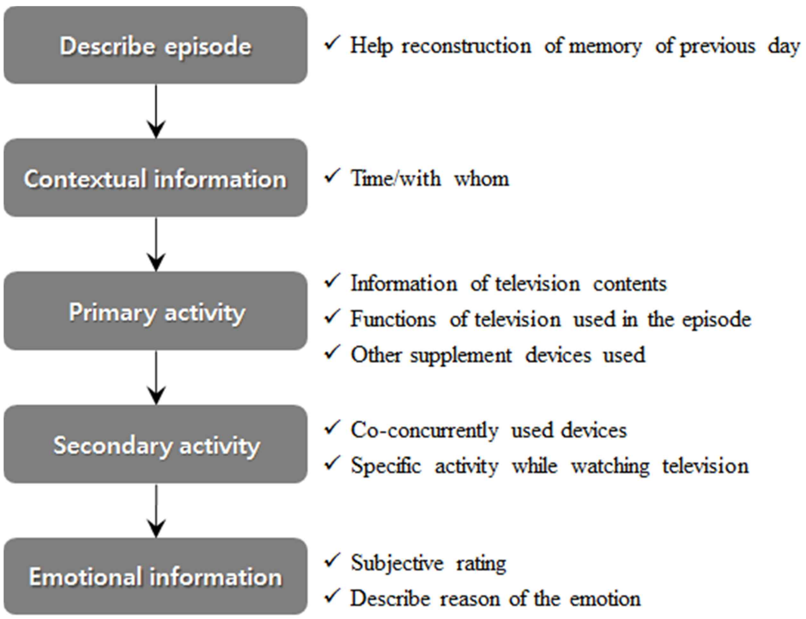


Figure 4.1. Procedure of the proposed DRM

The process of the modified DRM considering those three factors is as following (Figure 4.1). The series of questions ask participants to describe key features of each episode, including when the episode began and ended, whom they were interacting with, what they were doing (primary activities and secondary activities), and how they felt during that episode, assessed on multiple emotion dimensions.

4.2.1.2 Target product and participants

TV is one of the most commonly used everyday products during a day. It is proper to conduct the DRM for observing TV-viewing experiences, because there might be many episodes about the TV-viewing experiences during a day. Even though the smart TVs have been a big seller, the users do not perceive them as a smart product yet. Therefore, it is necessary to figure out how the smart TV-viewing experiences are different from previous TV-viewing experiences.

Since various features with high technologies are reflected in the smart TV, it is necessary to recruit participants who are familiar with those kinds of the features. Thus, participants in twenties and thirties, who might be familiar with the latest electronic products, were recruited. Also, there might be some differences in the smart TV-viewing experiences between home makers and single workers. Thus, the DRM for observing the smart TV-viewing experience was conducted among 20 participants (10 home makers, 10 single workers) for a week. The participants were 30.50 years old in average with a standard deviation of 5.65 years. The mean age of home makers was 29.80 years (SD = 6.75), and the mean age of single workers was 31.20 years (SD = 4.57). Over a week, a total of 330 complete datasets were retrieved.

4.2.1.3 Questionnaire formulation and administration

For the questionnaire, literature survey and expert review were conducted. The questionnaire consisted of 'Context' (Contextual information), 'Primary activity' (Features of the smart TV), 'Secondary activity' (Specific activities while watching the smart TV), and 'Emotional information' (Emotional information while watching the smart TV) (Table 4.1).

In the section of ‘contextual information’, participants could describe basic information of their episode when the episode began and ended, whom they were interacting with. Following our proposed framework, the aim of this study was to observe the smart TV-viewing experiences. So, the features of smart TV should be considered for the questionnaire of primary activities. The features of the smart TVs which were sold well in the market were investigated and categorized.

Table 4.1. List of questionnaire on proposed DRM for the smart TV

Category		Description
Contextual information	Time of event	When the episode began/ended
	Interaction partners	With whom the interaction occurred
Primary activities	Consumed contents	Broadcasting, Video on Demand (VOD)
	Consumed contents by external devices	Contents using direct/wireless connection
	Setting	Speaker, Display, Network, General setting
	Feature function	App, Social Networking Service (SNS; e.g., Facebook, Twitter), Internet, etc.
	Used interface	Remote controller, Gesture, Voice recognition, etc.
Secondary activities	Daily activities	Contents related/unrelated activities
	Used device	Phone, PC, Tablet, Laptop
Emotion	Ratings on emotion	Positive (Happy/Enjoy, Interested, Empathetic, Comfortable)
	Description of reason	Describe the reason of emotion

For the section of ‘secondary activity’, the questionnaire was developed to investigate what users could do while watching TV in daily life based on the expert review and the literature survey.

Finally, participants can rate their emotions (Happy/Enjoy, Interested, Empathetic, Comfortable, Tense/Stressed, Sad/Lonely, Imitated, and Tired) based on 7-Likert scale and describe the reason why the emotions of user’s TV-viewing experiences occurred in the section of ‘emotional information’. This response data was only returned to the researcher for analysis.

It is important that participants can easily and quickly access to fill out the questionnaire. Thus, online survey system was used to build the questionnaire. Also, for methodological reasons, it is important that participants should complete the questionnaire before they forget about each episode. To consider TV-viewing pattern, Rosenstein and Grant (1997) have identified habitual use in the morning and evening of the day. So, a push alarm was sent through short message service (SMS) to them twice a day not to forget to answer the questionnaire. When the participants received the SMS, they filled out their TV-viewing experiences which had been occurred until then through the online survey system.

In our experience, the participants could complete the full set of the materials in 20 to 30 minutes. Indications of the end of an episode might be ending one activity, starting another, or a change in the people with whom the participants are interacting.

4.2.1.4 Data clustering using the Self-Organizing Map

The SOM (Kohonen, 1995), an unsupervised neural network model that has properties of both vector quantization and vector projection, was used as a clustering algorithm for classifying self-reports of users' emotional experiences on the smart TV-viewing in this chapter. The input space is partitioned or vector-quantized into non-overlapping regions through the competitive learning process (Rumelhart & Zipser, 1986) among codebook vectors (or nodes, prototypes) in the neural network (Azcarraga et al., 2005).

The SOM is trained iteratively. In each training step, a sample vector, x from the input data set is chosen randomly and the distance between x and all the weight vectors of the SOM, is calculated by using a Euclidean distance measure. The neuron with the weight vector which is closest to the input vector x is called the Best Matching Unit (BMU). The distance between x and weight vectors, is computed by using the equation (1) below:

$$\|x - m_c\| = m\dot{n}\{\|x_i - m_i\|\} \quad (1)$$

where $\|.\|$ is the distance measure, typically Euclidean distance. After the BMU is found, the weight vectors of the SOM are updated so that the BMU is moved closer to the input vector in the input space (Miyamoto, 2007). The topological neighbors of the BMU are treated similarly. The update rule (2) for the weight vector of i is

$$x_i(t+1) = m_i(t) + \alpha(t)h_{ci}(t)[x(t) - m_i(t)] \qquad (2)$$

where $x(t)$ is a vector which is randomly drawn from the input data set, and function $\alpha(t)$ is the learning rate and t denotes time (Deboeck & Kohonen, 1998). The function $h_{ci}(t)$ is the neighborhood kernel around the winner unit c. The dataset of manufacturing details are fed into the input layer of SOM. Learning parameter is selected between 0.0 and 0.9, and the SOM is trained. The training steps will be in the range of 100,000 epochs in order to obtain a trained map. These training datasets are coded with reference to their prominent features (Wang, 2001).

In this chapter, the SOM was conducted to cluster collected emotional experiences (reason of users' emotion on their behavior) by the DRM. The procedure of clustering the smart TV-viewing using SOM is illustrated in Figure 4.2.

First, emotional experiences data were collected from the DRM. As a result, 20 participants reported 330 episodes for two weeks. The collected transcripts were transformed into the term-document matrix. Since collected users' emotional experiences of the smart TV-viewing written in Korean contain unrefined users' words and many specific terms related to TV contents (e.g., TV content' title, actor/actress, etc.), pre-processing requires technical and manual efforts. Also, it takes around 80% of the time as in other data mining applications (Wu et al., 2003).

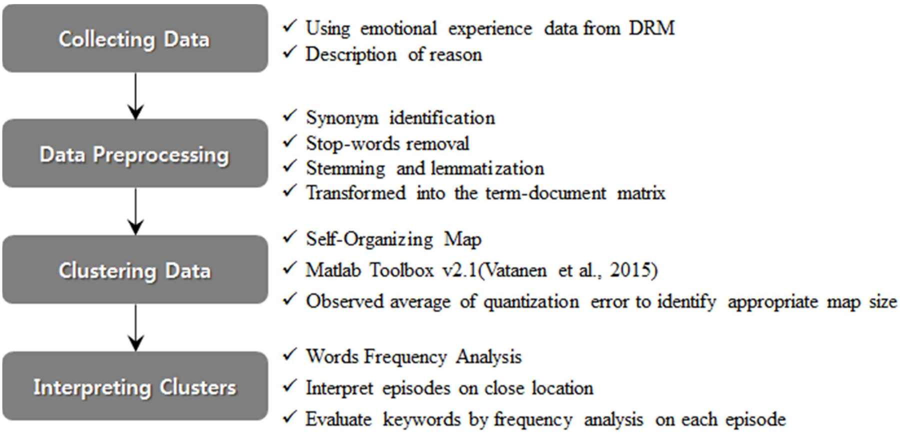
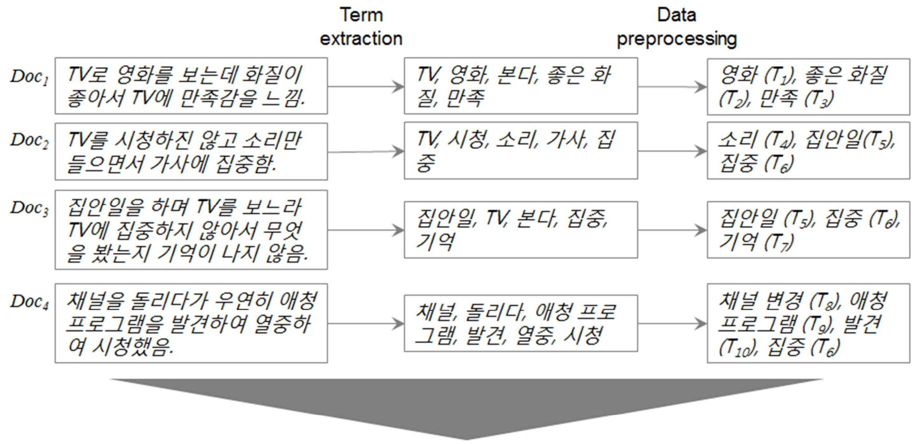


Figure 4.2. Procedure of clustering analysis

Second, to analyze collected data, data preprocessing is required. Synonyms were unified into a representative term, and stop-words were removed. Each sentence was parsed and transformed into a format of term-document matrix, which is becomes a term-episode matrix in this study. Synonyms and stop-words were preprocessed and parsed by using automation tool (Lee et al., 2014), which applies Lucene Korean Analyzer. Sentences on TV program contents were removed except for genre. As a result, total 268 terms were collected.

The example of data preprocessing is illustrated in Figure 4.3. From Figure 4.3, since the terms ‘TV’ and ‘watching’ were included in most of documents (episodes), those were removed. Also, the terms such as ‘household’, ‘housekeeping’, and ‘housework’ were integrated into the term ‘housework’. With 268 terms, the term-document matrix was developed.



Term-document (episode) matrix

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Doc_1	1	1	1	0	0	0	0	0	0	0
Doc_2	0	0	0	1	1	1	0	0	0	0
Doc_3	0	0	0	0	1	1	1	0	0	0
Doc_4	0	0	0	0	0	1	0	1	1	1

Figure 4.3. The example of data preprocessing

Third, clustering analysis was conducted to classify users' emotional experiences. Distances between episodes were visualized by SOM, and intimate ones were grouped into a cluster. SOM projects data into a two-dimensional map by an ordered dimensionality-reducing mapping (Kohonen, 1990). Each map unit or neuron is represented by its weight of a vector form from the input spaces. By iteratively calculating and comparing distances, similar units are located close (Appendix A.2).

The SOM was conducted by MATLAB R2014b utilizing SOM Toolbox v2.1 (Vatanen et al., 2015) in this study (Appendix A.2). Also, 1505-unit map (35*43) with hexagonal grids was generated by using SomVis (Appendix A.2). The average of quantization error, which is the squared distance between an observed data and its corresponding centroid, was 0.939.

Finally, a frequency analysis was conducted for each cluster to interpret clusters which were represented with highly frequent terms. Qualitative interpretation examined more detailed context of use or reasons for emotions.

4.2.2 Results of DRM

4.2.2.1 Mean emotion rating by situation of the smart TV-viewing

A key difference between the proposed DRM and the previous DRM was that the activities consist of primary (features of the smart TV) and secondary activities (specific activities while watching TV) in the former. Also, in this study we investigated the reasons for the users' emotions. The results showed which types of users' activities and emotions were generated while watching smart TV.

To show the results, Table 4.2 presents the emotion ratings of situations, grouped by the type of primary activity. The values shown in Table 4.2 are the average ratings of particular experiences. In the case of using main features of the smart TV, both home makers and single workers were primarily focused on what's on TV (broadcasting) (Table 4.2).

Table 4.2 shows a large difference between positive and negative emotion. They experienced more positive emotions such as 'happy/enjoy', 'interested', 'empathetic', and 'comfortable', compared to negative ones. Also, both the home makers and the single workers rarely used the feature functions of the smart TV. There are no significant differences ($p > 0.05$) of mean emotion rating and the frequency of the primary activities between the home makers and the single workers.

From the Table 4.3, it was found that the participants did some secondary activities which are not related to the TV contents while watching TV more than others which are related to the TV contents. Having a conversation unrelated to the TV contents was the only secondary activity which the participants did no more than having a conversation related to the TV contents.

Table 4.2. Mean emotion rating by situation (Primary activities)

Primary activities		**Respondent**	**Mean emotion rating**		**Occurrence (n)**	**Percentage (%)**
			Positive	**Negative**		
Consuming contents	Broadcasting	Home maker	3.88	1.78	125	38.46
		Single worker	4.08	1.78	146	44.51
	VOD	Home maker	4.69	1.50	18	5.54
		Single worker	4.58	2.59	16	4.88
Consuming contents using external devices	By direct connection	Home maker	4.46	1.63	23	7.08
	By wireless connection	Home maker	5.63	1.38	2	0.62
		Single worker	6.18	1.43	10	3.05
Feature function	News	Single worker	3.58	2.58	3	0.91
	Travel	Single worker	6.00	1.75	1	0.30
	Food	Single worker	6.00	1.75	1	0.30
	Health	Home maker	4.75	2.38	2	0.62
	Weather	Home maker	2.75	1.81	4	1.23
		Single worker	4.95	3.15	5	1.52

Table 4.2. (Continued)

Primary activities		**Respondent**	**Mean emotion rating**		**Occurrence (n)**	**Percentage (%)**
			Positive	**Negative**		
Manipulation	Volume control	Home maker	3.99	1.90	94	28.92
		Single worker	4.71	1.86	105	32.01
	Video control	Home maker	4.29	1.18	14	4.31
		Single worker	5.48	2.00	10	3.05
Setting	Speaker	Home maker	5.66	1.32	11	3.38
		Single worker	5.21	2.75	12	3.66
	Display	Home maker	4.46	3.29	6	1.85
		Single worker	7.00	1.00	1	0.30
	Channel	Home maker	4.78	1.86	22	6.77
		Single worker	3.63	2.92	12	3.66
	General	Home maker	4.00	1.75	4	1.23
		Single worker	5.29	2.21	6	1.83

Note. Positive emotion is the average of 'Happy/Enjoy', 'Interested', 'Empathetic', and 'Comfortable'. Negative emotion is the average of 'Tense/Stressed', 'Sad/Lonely', 'Imitated', and 'Tired'. Episodes for which respondent reported multiple activities were included in each of the corresponding computations.

Table 4.3. Mean emotion rating by situation (Secondary activities)

Secondary activities		Respondent	Mean emotion rating		Occurrence (n)	Percentage (%)
			Positive	**Negative**		
Related to the TV contents	On the phone	Home maker	3.71	2.18	7	2.15
		Single worker	5.00	1.47	8	2.04
	Conversation	Home maker	4.75	1.90	39	12.00
		Single worker	4.78	1.39	44	11.22
	SNS	Home maker	3.63	1.88	2	0.62
		Single worker	6.00	1.00	1	0.26
	Internet	Home maker	5.08	2.00	3	0.92
		Single worker	5.13	2.31	8	2.04
Unrelated to the TV contents	Relaxing	Home maker	4.90	1.75	34	10.46
		Single worker	4.56	2.17	57	14.54
	On the phone	Home maker	3.96	1.81	48	14.77
		Single worker	4.67	1.28	29	7.40
	Conversation	Home maker	4.36	2.36	25	7.69
		Single worker	4.09	1.38	47	11.99

Table 4.3. (Continued)

Secondary activities		Respondent	Mean emotion rating		Occurrence (n)	Percentage (%)
			Positive	Negative		
Unrelated to the TV contents	SNS	Single worker	3.81	2.06	4	1.02
	Internet	Home maker	4.38	2.43	14	4.31
		Single worker	4.36	1.41	30	7.65
	Eating/Drinking	Home maker	4.25	1.85	63	19.38
		Single worker	4.66	1.75	77	19.64
	Reading books/newspapers	Home maker	3.92	2.00	3	0.92
		Single worker	3.50	2.00	8	2.04
	Napping	Home maker	4.07	1.96	7	2.15
		Single worker	5.22	1.09	8	2.04
	Exercising	Home maker	2.63	2.13	2	0.62
		Single worker	4.44	1.53	9	2.30
	Dress up/Make up	Home maker	3.38	1.40	13	4.00
		Single worker	3.50	3.13	6	1.53

Table 4.3. (Continued)

Secondary activities		**Respondent**	**Mean emotion rating**		**Occurrence (n)**	**Percentage (%)**
			Positive	**Negative**		
Unrelated to the TV contents	Taking care of children	Home maker	3.06	1.47	8	2.46
		Single worker	5.88	1.69	4	1.02
	Entertaining	Home maker	3.67	1.28	9	2.77
		Single worker	5.13	1.19	8	2.04
	Shopping	Home maker	4.67	2.67	3	0.92
	Housework	Home maker	3.68	1.80	29	8.92
		Single worker	4.60	1.35	36	9.18
	Working	Home maker	4.04	2.23	12	3.69
		Single worker	4.25	2.50	4	1.02
	Checking e-mail	Home maker	3.94	2.25	4	1.23
		Single worker	3.69	2.00	4	1.02

Note. Positive emotion is the average of ‘Happy/Enjoy’, ‘Interested’, ‘Empathetic’, and ‘Comfortable’. Negative emotion is the average of ‘Tense/Stressed’, ‘Sad/Lonely’, ‘Imitated’, and ‘Tired’. Episodes for which the respondent reported multiple activities were included in each of the corresponding computations.

Most participants felt positive emotions more than negative emotions while doing these activities. Only 10.46% of home makers and 14.54% of single workers were simply concentrating on TV without secondary activities, respectively. In the case of most secondary activities except 'conversation' and 'on the phone' unrelated to the TV contents, there are no significant differences ($p > 0.05$) of the mean emotion rating and the frequency between the home makers and the single workers.

Table 4.4 presents the emotion ratings of the situations grouped by devices used while watching TV. Both the home makers and the single workers were usually using smartphones while watching TV. Most participants felt positive emotions more than negative emotions while doing these activities. There are no significant differences ($p>0.05$) between the home makers and the single workers except 'desktop'. In the case of 'desktop', 3.96% of home makers and 13.28% of single workers were using their desktop while watching TV, respectively.

The participants usually had the smart TV-viewing experiences with someone (Table 4.5). Only 33.51% of home makers and 28.09% of single workers had the smart TV-viewing experiences being alone, respectively. As shown in the Table 5, most participants enjoyed watching TV with their spouse, children, and parents and also felt positive emotions more frequently.

From the Table 4.6, it was explained that why users were experiencing positive or negative emotions with TV-viewing activities. The main reasons were 'characteristics of contents', 'types of secondary activities', 'TV viewing environment', and 'presence of interaction partners'. Also, there are no significant differences of the frequency between the home makers and the single workers.

Table 4.4. Mean emotion rating by situation (Used devices while watching TV)

Used device	Respondent	Mean emotion rating		Occurrence (n)	Percentage (%)
		Positive	Negative		
Smartphone	Home maker	4.00	1.78	81	80.20
	Single worker	4.66	1.94	84	65.63
Desktop	Home maker	5.38	2.13	4	3.96
	Single worker	5.01	1.84	17	13.28
Laptop	Home maker	4.25	1.70	15	14.85
	Single worker	3.94	1.28	22	17.19
Tablet	Home maker	5.00	3.25	1	0.99
	Single worker	5.60	1.45	5	3.91

Note. Positive emotion is the average of ‘Happy/Enjoy’, ‘Interested’, ‘Empathetic’, and ‘Comfortable’. Negative emotion is the average of ‘Tense/Stressed’, ‘Sad/Lonely’, ‘Imitated’, and ‘Tired’. For each situation, the table shows the mean emotion ratings and the number of episode’s occurrence reporting at least one episode of that type. Episodes for which the respondent reported multiple activities were included in each of the corresponding computations.

Table 4.5. Mean emotion rating by situation (Interaction partners)

Interaction partner		**Respondent**	**Mean emotion rating**		**Occurrence (n)**	**Percentage (%)**
			Positive	**Negative**		
Without whom	Alone	Home maker	3.59	1.53	63	33.51
		Single worker	4.25	2.26	50	28.09
With whom	Spouse	Home maker	3.80	1.50	49	26.06
		Single worker	4.84	1.54	53	29.78
	Children	Home maker	4.35	1.62	38	20.21
		Single worker	4.71	1.21	20	11.24
	Parents	Home maker	4.29	2.66	19	10.11
		Single worker	3.93	1.81	44	24.72
	Brothers/Sisters	Home maker	4.94	2.89	9	4.79
		Single worker	4.40	3.00	10	5.62
	Relatives	Home maker	6.25	2.00	1	0.53
		Single worker	6.00	2.25	1	0.56
	Friends	Home maker	5.31	2.06	9	4.79

Note. Positive emotion is the average of 'Happy/Enjoy', 'Interested', 'Empathetic', and 'Comfortable'. Negative emotion is the average of 'Tense/Stressed', 'Sad/Lonely', 'Imitated', and 'Tired'. For each situation, the table shows the mean emotion ratings and the number of episode's occurrence reporting at least one episode of that type. Episodes for which the respondent reported multiple activities were included in each of the corresponding computations.

Table 4.6. The reason of the emotion for the smart TV-viewing

Reason	**Occurrence (n)**		**Percentage (%)**	
	Home maker	**Single worker**	**Home maker**	**Single worker**
Characteristics of contents	109	126	40.82	43.45
Type of secondary activity	54	47	20.22	16.21
TV-viewing environment	44	43	16.48	14.83
Interaction partner	26	24	9.74	8.28
Function/Specification	23	25	8.61	8.62
Usability of manipulating	11	25	4.12	8.62
Total	267	290	100%	100%

Note. Episodes for which the respondent reported multiple reasons of emotion were included in each of the corresponding computations.

4.2.2.2 Results of the frequency of smart TV-viewing by time

The diurnal patterns of the number of episodes for the smart TV-viewing experiences were also compared. From the Figure 4.4, it was figured out that the frequency of the smart TV-viewing experiences changed over time. With minimum time unit of 30 minutes, each episode was encoded one if it occurred in pertinent period. Mean number of episodes was estimated by averaging the episodes occurred in the weekday and the weekend, respectively.

Comparing the patterns of watching TV on weekdays to weekend, the homemakers usually watched TV from 800 to 10:00 on weekdays, whereas they usually watched TV from 18:00 to 20:00 on a weekend. Also, in the case of single workers, they usually watched TV from 20:00 to 23:00 on weekdays unlike a weekend.

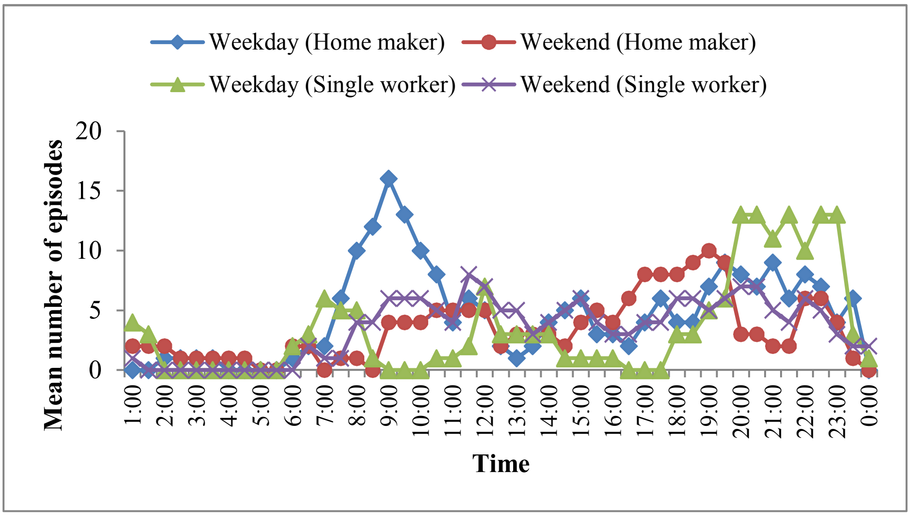


Figure 4.4. Diurnal patterns of mean number of episodes by time

There are also some similarities and differences between the home makers and the single workers. The frequency of the smart TV-viewing experiences of the home makers and the single workers showed a similar pattern on the weekend unlike weekdays. On the weekend, both the home makers and the single workers usually watched TV later in the morning and earlier in the evening than the weekend. On the weekdays, the single workers usually watched TV earlier in the morning and later in the night than the home makers.

4.2.3 Results of clustering analysis

To investigate clusters of TV episodes, the collected data was analyzed by the SOM, which is illustrated in Figure 4.5.

The result of SOM was illustrated in a 1505-unit map (35*43) with hexagonal grids. The map shows the neurons containing 330 episodes in which similar episodes were mapped onto the similar place. Only considering darker cells indicate a closer relationship, fifteen clusters were evaluated. The average of quantization error, which is the squared distance between an observed data and its corresponding centroid, was 0.939. Through utilizing SOM, various contexts of watching TV could be identified, and 15 groups were classified.

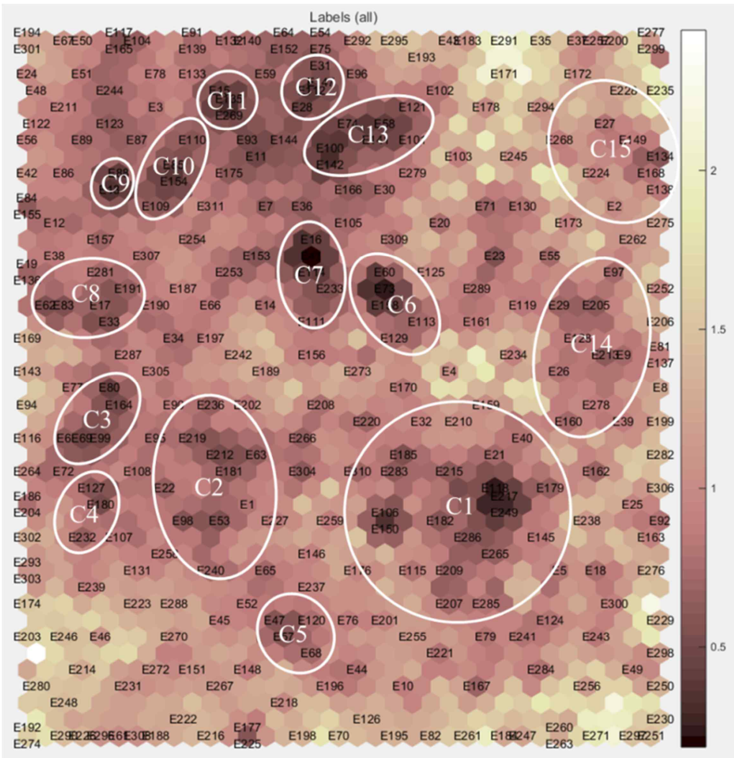


Figure 4.5. The result of SOM

According to the results of frequency analysis, keywords of episodes were extracted from each cluster (Table 4.7). Also, the results show that various emotions of user experience were reported. Episodes in each cluster incorporated various feelings such as comfortable, tired, irritated, tense, interested, angry, stressed, pleasant, enjoyable, and satisfied.

Table 4.7. The result of frequency analysis

Cluster	# of Episodes (n)	Most Frequent Keywords (n)
C1	19	Comfortable (19), Rest (7), Family (3)
C2	15	Tired (15), Irritated (11), Favorite (2)
C3	5	Concentrate (5), Tense (2)
C4	3	Housework (3), Concentrate (3)
C5	4	Meal (5), Family (3), Conversation (2)
C6	5	Everyday life (5), Interest (2)
C7	5	Entertainment show (5), Actor (5)
C8	6	Interest (5), Concentrate (4), TV Drama (3)
C9	2	Interest (2), Entertainment show (1)
C10	4	Documentary (4), Anger (3), Stress (2)
C11	3	Stress (3), Rest (1)
C12	4	Sound (3)
C13	7	Enjoy (5)
C14	12	Pleasant (12), Comfortable (4), Rest (4)
C15	9	High-definition TV (9), Satisfy (8)

Episodes in C1 were related to the context that subjects take a rest while watching TV with family while episodes in C2 showed subjects being tired and irritated by TV contents. C3 represents episodes that TV viewers were absorbed by TV contents. Group C4 and C5 have much relation with secondary tasks including housework, dining, and conversation. Episodes from C6 to C8 describe the motivation of watching TV, which are usual interest, cast, and story of drama.

Episodes in C9 mainly show positive experience on entertainment programs while those of C10 are related with negative feelings by watching current affairs or documentary. Episodes in C11 have relation with resting stress by watching TV whereas participants in C12 watch TV in an absent sort of way like doing secondary task. C13 and C14 were primarily characterized by positive feelings of subjects, which were affected by TV contents and comfortable environment respectively. C15 mainly considers satisfied emotion because of specification of smart TV including high definition of smart TV and quality of sound. The descriptions of each cluster are illustrated in Figure 4.6.

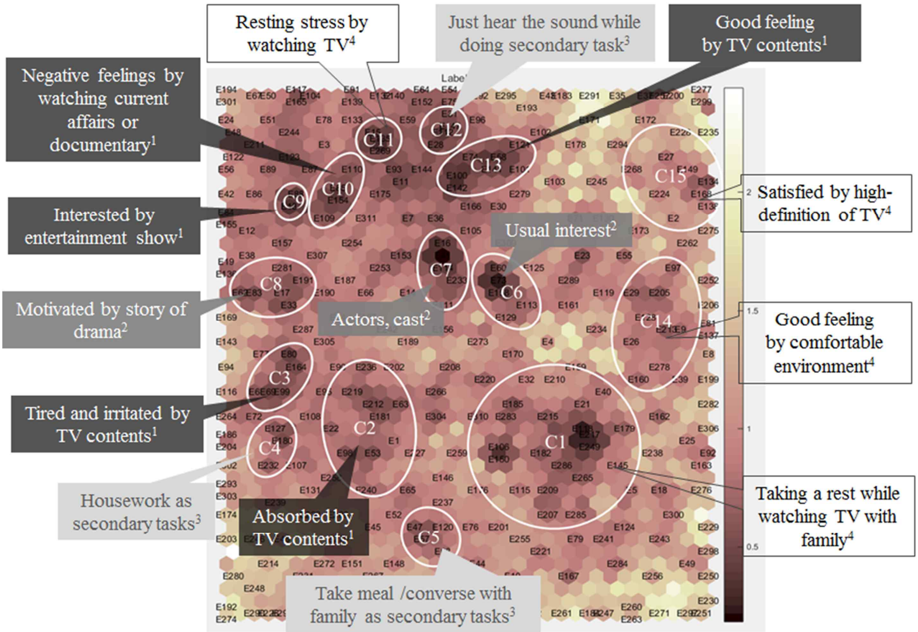


Figure 4.6. Descriptions of each cluster (1: Motivated by TV contents, 2: Emotion occurred by TV contents, 3: Emotion affected by secondary task, 4: Emotion affected by environment)

In some clusters of Table 4.7, there are clusters with similar keywords; episodes in C1 and C14 mainly focus on comfort and resting environment, but participants in C1 were usually with their family. Participants in C8 and C9 were interested in TV contents, but genre was varied. Both C3 and C4 mentioned ‘concentration’. C3 showed TV viewers who concentrated in TV on the other hands C4 presented viewers couldn’t concentrate by housework. C10 and C11 were characterized by the term stress. Episodes in C10 mentioned stresses were occurred by TV contents while C11 presented stresses were relieved by watching TV in a comfort mood. Episodes in C6 and C8 presented the motivations of watching TV. In other words, they were interested in the theme in usual and the interest was incurred by story of TV.

By observing classified clusters, various reasons for the emotion were revealed between different clusters. Groups C2, C3, C6, C7, C8, C9, C10, and C13 showed emotion occurred by contents of TV program whereas emotion in C1, C2, C11, C14 occurred by TV-watching environment. In addition, episodes in C2 and C15 revealed emotion was occurred by TV specification and functions, and emotions in C4, C5, and C12 were dominated by secondary tasks.

By analyzing the two-dimensional map, episodes in close relationships were grouped, but isolated episodes were not counted. Therefore, only major tendencies were identified. Through analyzing the result, it will help developing new functions or services for major consumers. For example, as the result revealed positive emotions were occurred when TV viewers were interested in the TV contents or actors and satisfaction of consumers will increase if TV recommends programs that were related to the areas of interest or actors of whom they are favor That is, new function or service of smart TV could be derived by user-centered approach, rather than solely focusing on usability, UX, or HCI. Therefore, SOM will be a useful tool to observe users' needs in various fields.

4.3 Discussion

Like the previous diary studies on TV, this study aimed to figure out TV consuming pattern over the period of time. In this chapter, observing more natural context of use in the smart TV-viewing experiences was focused. Especially, the user experiences of the home makers and the single workers were compared.

Previous studies have commonality that they tried to understand users' TV viewing behaviors and their consequences, but they are distinguished by research objects. Quantitative research techniques usually examine researchers' hypotheses and UI issues, while qualitative techniques reveal the issues that designers couldn't identify (Chorianopoulos, 2006).

Meanwhile, diary methods observe longitudinal behaviors and emotions. Kubey (1986; 1996) conducted a study using the ESM on TV uses for evaluating frequency of events, motivations, and emotions. More recently, Depp et al. (2010) applied the DRM to highlight relationship between age and TV viewing behaviors.

While those existing studies identified only the primary activities as TV contents, it is possible to evaluate more detailed results by classifying functions of TV itself. Moreover, investigating the secondary activities provided more natural context of use.

The results of this study revealed social characteristic of TV. In about 66% of episodes obtained from the home makers, it was reported that they watched TV with someone else, and in about 36% of them, they watched TV with doing secondary activities which were interactive such as 'conversation', 'on the phone'. As TV is one of the most frequently utilized devices enabling family members enjoy altogether, these results were revealed.

According to the results, there were some similarities and differences between the home makers and the single workers. Both turned out to have more positive emotions than negative emotions in most cases. The results reflected mood management theory; watching TV alleviates negative feelings by reducing stressful thoughts (Zillmann, 1994; Anderson et al., 1996).

As a reason of the emotions, 'characteristics of contents' were the most influential factor (40.82%; 43.45%), and 'type of secondary activities' followed (20.22%; 16.21%) for both the home makers and the single workers. The result showed there was no significant influence of the secondary activities (p > 0.05), as Csikszentmihalyi and Kubey (1981) also pointed out. The result demonstrates that watching TV is perceived as a strong leisure activity, influencing both groups to have the positive feelings. In addition, TV viewers were engaged in TV, describing that the contents of the broadcasting are the most influencing factor in including emotion.

Also, there was no significant difference (p > 0.05) in the mean emotion rating and the frequency of the secondary activities between the home makers and the single workers, but the diurnal patterns of watching TV were different. As to the time analysis, in the weekdays, both the home makers and the single workers usually watched TV in the morning and the night. The reason for such behaviors that people watch TV in the early morning and night had been identified as a habit rather than a gratification (Rosenstein & Grant, 1997).

However, a number of homemakers' episodes marked a peak in the morning, while that of single workers' episodes appeared at night. Episode descriptions, which were taken before initiating the questionnaires, helped us in identifying the life patterns of the two groups. In general, the home makers prepared breakfast in the earlier morning, and took rest after seeing their spouse and kids off. The episodes of them mainly occurred in this period. In the case of the single workers, time was not enough to enjoy until night time. However, on the weekend, the groups showed similar TV viewing patterns, since their life pattern became alike.

There were also some similarities and differences in the frequency of the use of smart TV's features and devices. Although the smart TV applications provided many services, it was found out that the features of smart TV were rarely used by both the home makers and the single workers. It can be interpreted that the users utilize the smart TV like other ordinary TVs.

Also, most of the home makers and the single workers did not use gesture or voice recognition interface to manipulate the smart TV. It can be explained by bad usability of interfaces and lack of contents needed as other researchers concluded previously (Shin et al., 2014).

Furthermore, the existing smart TV applications are very similar with those of smartphone, which are not needed for TV viewers. It seems that manufacturers considered the context of use not enough and just adopted something successful in smartphones to the smart TV.

Some results of this study can be explained by further study. From the results, in the case of the smart TV-viewing experiences with interaction partners, the percentages of ‘children’ and ‘parents’ were different between the home makers and the single workers. It can be changed according to the family types and members.

However, we did not consider the types and members of the family, so the reason and the results can be explained through further studies. Also, in the case of the smart TV-viewing experiences with used devices, the percentage of ‘desktop’ was different between the groups. The results can be differed according to presence of a desktop or the location of the desktop in the home. Further studies with observing the smart TV-viewing according to types or members of family, or characteristics of layout of the house are expected to be helpful in understanding diverse contexts of use.

Chapter V

DEVELOPING SMART PRODUCT IDEA/CONCEPT

5.1 Overview

Several previous studies (Henkemans et al., 2010; Queiros et al., 2013) identify a general focus on integrating specific technologies into smart products instead of identifying the users' needs to satisfy them. This tendency, combined with an industry dominated by suppliers lead to an approach that is "technology-push, rather than demand-pull", lacking in user centric design and user friendly applications (Henkemans, et al. 2010). Thus, it is necessary to identify users' needs and reflect them in the development process of new products/services. To address this issue, in this chapter, a methodology that develop new ideas/concepts according to users' needs within a relation matrix against product smartness.

5.2 Method

The overall procedure of developing idea/concept for new smart products/services is presented in Figure 5.1. In phase I, product smartness is identified. In phase II, which can be done in parallel with phase I, users' needs are identified through observing and analyzing UX. The results from the two phases are integrated in phase III, where new ideas/concepts for smart products/services are developed with relationship analyses.

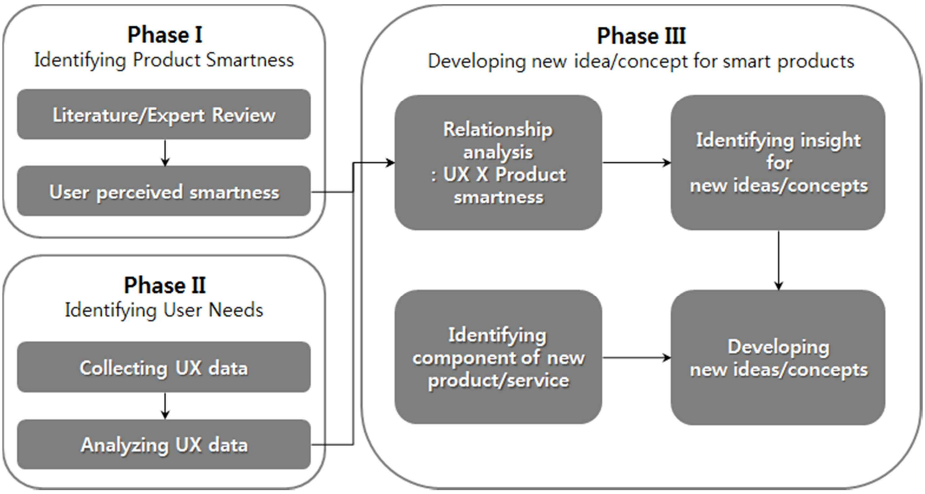


Figure 5.1. The overall process of development of new idea/concept for smart products/services

5.2.1 Phase I: Identifying product smartness

In this stage, functions of smart products are identified and classified. As it explained in Chapter 3, literature review and expert interview are conducted to collect product smartness in general. Then, the collected dimensions of product smartness are categorized into several groups.

5.2.2 Phase II: Identifying user needs

In this phase, users' needs for products/services are identified through observing and analyzing user experience (UX). As it explained in Chapter 4, the day reconstruction method (DRM) is conducted to observe UX and the clustering analysis is conducted to analyze users' emotional experiences using the self-organizing map (SOM).

5.2.3 Phase III: Developing new idea/concept for smart products

New ideas/concepts for smart products are developed based on relationship analysis. The procedure of new idea/concept generation by the relationship analysis is illustrated in Figure 5.2.

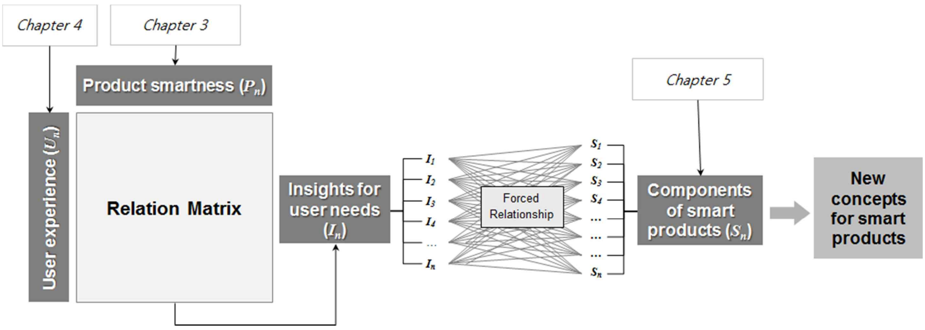


Figure 5.2. Procedure of new idea/concept generation by the relationship analysis

First, the relation matrix is utilized. The UX of smart products with the product smartness (which is identified in Chapter 3) output insights for user implicit needs of smart products/services. Through the results of relation matrix, the possibilities of user needs can be emerged (Figure 5.3).

Product Smartness (P_n)

Main dimension	Sub dimension		
Autonomy	Proactivity	Machine learning	Productivity
Adaptability	Context-awareness	Reactivity	Maintainability
Multi-functionality	Organization	Entertainment	Informative
Connectivity	Networkability	Sociability	Scalability
Personality	Identity	Customization	Natural interaction

O indicates that there could be significant relation between U_n and P_n for insight of user implicit needs.

Relation matrix

	Autonomy	Adaptability	Multi-functionality	Connectivity	Personality
U_1			O		
U_2	O				
U_3				O	
…	…	…	…	…	…
U_n					O

Figure 5.3. Illustration of the relationship analysis

Then, new concepts are developed based on utilizing insights for users' implicit needs and essential components of smart products. Developed insights for users' implicit needs are forcedly connected to essential components of smart products for idea/concept generation.

Essential components of smart products are defined by literature review. Miche, Schreiber, and Hartmann (2009) proposed a high level view of the architecture for smart products (Figure 5.4).

Every smart product can comprise input and output capabilities, actuators to trigger its built-in functionality, sensors, as well as product-specific data. According to the architecture of smart products, it is figured out that user, input/output device, interaction module, and ubiquitous data store are essential components for smart products.

Janzen and Maass (2008) and Aitenbichler et al. (2007) addressed that natural interaction with users and other products is the key component of smart products. Thus, the essential components of smart products could be users, connected device (input/output), data (what kind of information/how to acquire), and interaction (interaction flow).

New ideas/concepts for smart products could be described in more detail by the essential components of smart products.

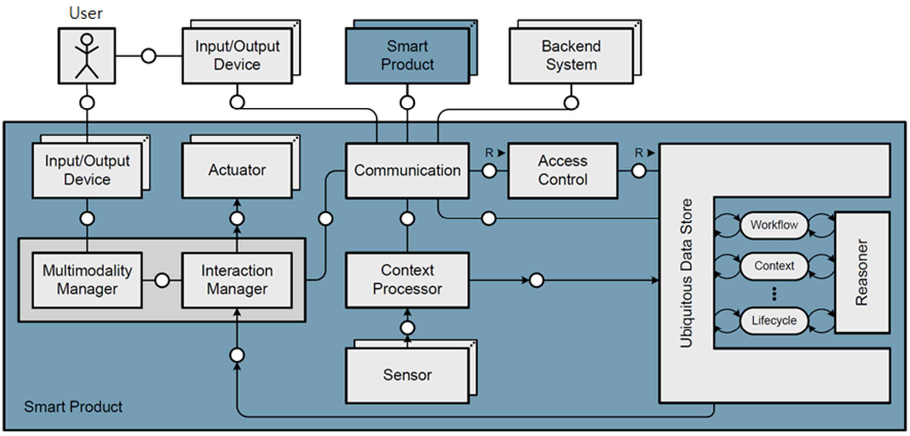


Figure 5.4. Simplified overview of the architecture for smart products (Miche, Scheiber, & Hartmann, 2009)

5.3 Case Study

To apply and validate the proposed framework in a practical setting, a case study on developing new ideas/concepts for smart TV is conducted.

Smart TV, a television with integrated interactive internet capabilities, takes the same stream. While the smart TV is predicted to be the heart of IoT-environment (Yusufov & Kornilov, 2013) and the ownership rate reaches 35% of U.S. households (Park's Associate, 2014), smart functions are rarely used. Obrist, Bernhaupt, and Tscheligi (2008) said, to make the consumers interactively use TV, functions should fit into users' conventional routines, not forcing to replace users' existing behaviors. Thus, new idea/concept for smart TV should be developed with considering users' implicit needs.

5.3.1 Phase I: Identifying product smartness

In this stage, functions of smart products are identified and classified. As it explained in Chapter 3, literature review and expert interview are conducted to collect product smartness in general. As a result, five dimensions of product smartness are extracted (P_1: Autonomy, P_2: Adaptability, P_3: Multi-functionality, P_4: Connectivity, and P_5: Personalization).

5.3.2 Phase II: Identifying user needs of smart TV

The user experiences of smart TV were collected by conducting the DRM. The results of DRM are discussed in Chapter 4. According to the results of DRM, several user experiences of smart TV were collected as exemplified in Figure 5.5.

- ✓ *U1: Do secondary activities such as housework while watching TV*
- ✓ *U2: Communicate with family or friend while watching TV*
- ✓ *U3: Prefer to watch TV contents according to usual interest, cast, and genre*
- ✓ *U4: Miss live broadcast which I usually watch*
- ✓ *U5: Watch external contents (which is not live broadcast) on TV using USB or wireless connection*

Figure 5.5. An example of collected user experiences of smart TV

5.3.3 Phase III: Developing idea/concept for smart TV

Based on the tasks structures in 5.2.3, a relationships analysis was conducted to identify insights for new idea/concept of smart TV with consideration on user needs and product smartness. The relationships analysis was conducted in a matrix format as displayed in Table 5.1 and Figure 5.6. Each relationship indicates that possibility and potential needs for user experiences of product smartness.

Table 5.1. Relationship analysis between user experience (U_n) and product smartness (P_n)

	P_1	P_2	P_3	P_4	P_5
U_1		O		O	O
U_2		O	O	O	
U_3	O	O	O		O
U_4	O	O	O	O	
U_5				O	

Note: O indicates that there could be significant relation between U_n and P_n for insight of user implicit needs.

	Autonomy	Adaptability	Multi-functionality	Connectivity	Personalization
U_1	Proactivity Machine learning	Context-awareness		Networkability	Natural interaction
U_2		Context-awareness Reactivity	Organization	Sociability	
U_3	Proactivity Machine learning	Reactivity	Entertainment Informative		
U_4	Proactivity Machine learning	Reactivity	Entertainment Informative	Networkability	
U_5				Scalability	

Figure 5.6. The results of the relationship analysis

According to the results of the relationship analysis, a total of seven insights for new ideas of smart TV were extracted (Table 5.2).

Table 5.2. Insights for new idea of smart TV

UX	Insights of user needs	Related product smartness
U_1	I_1: Is it possible to connect with other products?	P_4 (Networkability)
	I_2: Is it possible to recognize 'leave TV on'?	P_2 (Context-awareness)
U_2	I_3: Is it possible to share a part of contents with friends?	P_4 (Sociability)
U_3	I_4: Is it possible to recommend contents?	P_3 (Informative)
U_4	I_5: Is it possible to record the popular contents?	P_1 (Proactivity)
	I_6: Is it possible to inform reruns of missed contents?	P_3 (Informative)
U_5	I_7: Is it possible to share the contents with other devices?	P_4 (Scalability)

Next, detail concepts of new ideas were developed using the extracted insights for new idea/concept of smart TV. Each insight was described in more detail according to the components of smart products (User, Device, Data, and Interaction). Several concepts for specific goal or task under certain context combined by essential components of smart products can be enumerated (Table 5.3). Prior to concept development, users should be identified. Then, other settings, such as devices, data, and interaction are identified. Multiple concepts can be developed for a single insight.

After setting the concept components, actual concepts are created by analyzer. Concept describes the activities of users, including contextual information about goals, expectations, actions, and reactions. The example of developed concept is depicted in Figure 5.7.

Table 5.3. Concept generation using components of smart products

Insight	User	Device	Data	Interaction
I_1	Homemaker	Washing machine	Functional condition	Wireless LAN, Bluetooth
I_2	Homemaker	TV	On/off condition	Monitoring technologies
I_3	Anyone	Mobile phone	information about cast, stuff	Image recognition
I_4	Anyone	TV	User preference	Behavior analysis
I_5	Anyone	TV	popularity of content	Mining web data
I_6	Single worker	TV	EPG	Mining web data
I_7	Anyone	TV, Mobile, PC	Contents	Wireless LAN, Bluetooth

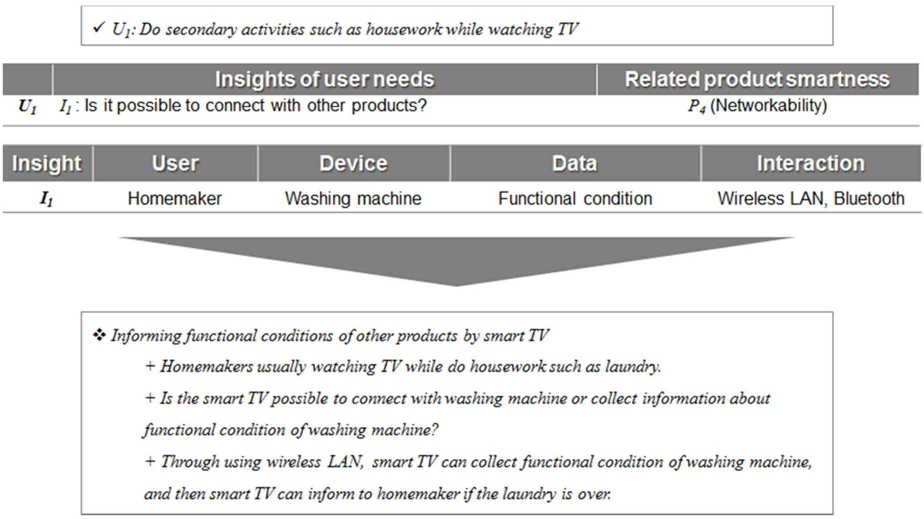


Figure 5.7. The example of developed new concept for smart TV

5.4 Discussion

Idea generation is the creative process of generating, developing, and communicating new ideas, where an idea is understood as a basic element of thought that can be either visual, concrete, or abstract (Gänshirt, 2007). In the step of idea generation, identifying user needs plays a crucial role. Therefore, in this chapter, a methodology that develops new smart product/service concept is proposed with conducting a case study.

The overall procedure of developing idea/concept for new smart products/services is as follow. In phase I, product smartness is identified in Chapter 3. In phase II, users' needs are identified through conducting DRM on observing the smart TV-viewing and clustering collected user experiences using SOM in Chapter 4. The results from the two phases are integrated in phase III, where new ideas/concepts for smart products/services are developed with relationship analysis. From the case study of developing new idea/concept for smart TV, a total of seven detail concepts were developed with five extracted user experiences of smart TV.

Although, the proposed method is useful to develop new ideas/concepts considering user needs and product smartness, the validation of proposed method should be conducted in the future study. There have been many studies about evaluating effectiveness of ideation method. Many researchers have made their efforts on improving ideation quality (effectiveness). Ideation quality is the degree to which an idea generation technique produces ideas that are helpful in attaining a goal. It pertains to the relative merits of an ideation process or intervention rather than to the value of a particular idea. Shah et al.'s (2003) four ideation metrics (quantity, quality, novelty, and variety) is usually used to evaluate the quality or effectiveness of idea generation method (Dahl & Moreau, 2002; Jensen et al., 2009; Yang, 2009; Nagai, Taura, & Mukai, 2009; Charyton et al., 2011; Linsey et al., 2011; Kudrowitz & Wallace, 2012). Through those evaluation methods, the proposed framework could be validated in the future.

Chapter VI

EVALUATING SMART PRODUCT IDEA/CONCEPT

6.1 Overview

Despite the strategic importance of effective new product development as a source of competitive advantage, most new product development activities fail to achieve their anticipated level of market success. Thus, Eliashberg et al. (1997) report a major complaint that most of the products developed tended to be marginal contributors to the firm's portfolio, rarely involving very new or "breakthrough" ideas. Also, many firms have been struggling with selecting/evaluating new ideas of product/service. Though many studies on evaluating ideas of new product have been conducted, those have been mainly focused on the creativity, novelty, and completeness of ideas. In this chapter, a framework that evaluates new smart product/service ideas or concepts was proposed considering idea quality and product smartness.

6.2 Analysis of Relationship between Idea Quality and Satisfaction on New Idea/Concept

This chapter is aimed to understand the idea quality for new smart product idea/concept and how these elements affect the satisfaction to new ideas/concepts. Therefore, previous studies on idea quality are discussed. Then, a theoretical model for idea quality was developed. Also, the model was assessed for exploring the relationship between the idea quality and satisfaction.

6.2.1 Conceptual model and hypothesis

The procedure of identifying idea quality is as follow. First, previous studies related to explain product smartness were collected and discussed in Chapter 2.2.3. Next, in-depth interviews of experts were performed. The interviewees, who are specialized in product design and ergonomics, are presented in Table 6.1.

The interviews were conducted for about an hour especially about appropriateness of collected elements of idea quality. Interview method is to record and organize interviewees' explanations about whether each element of idea quality (abstracted from previous studies) actually influence to satisfaction on new idea/concept. Finally, according to the results of literature review and expert interview, the dimensions of idea quality were re-organized.

Table 6.1. Participants of expert interview for idea quality

#	Gender	Career
1	Male	Ph.D. in Ergonomics, Professor for 20 years
2	Male	Ph.D. in Ergonomics, Director, Electronics company for 17 years
3	Female	Ph.D. in Ergonomics, Designer, Electronics company for 11 years
4	Male	Ph.D. in Ergonomics, Developer, Electronics company for 8 years
5	Male	Ph.D. in Ergonomics, Developer, Electronics company for 8 years

As a result, collected dimensions of idea quality could be re-categorized into three main dimensions as follow: Workability, Relevance, and Attractiveness. The description of each dimension of idea quality is defined in Table 6.2.

Table 6.2. Description of idea quality main dimensions

Idea quality	**Description**
Workability	An idea/concept can be easily implemented and be acceptable to users.
Relevance	An idea/concept applies to the stated problem and will be effective at solving the problem.
Attractiveness	An idea/concept is attractive if it is novel and provides excitement and interest to users.

Previous studies related to development and evaluation of idea quality dimensions were re-categorized according to three main dimensions (Table 6.3).

Workability is related to how an idea is feasible (Shah et al., 2000; 2003). It could be categorized into three sub dimensions: Feasibility, Adoptability, and Acceptability.

MacCrimmon and Wagner (1994) claimed that the concept of workability is composed of two aspects: easy to be implemented and not violate known constraints. Diehle and Stroebe's (1987) definition of feasibility (preciseness and ease of implementation given available constraints) includes both aspects of feasibility/workability, which have also been recognized by other authors who have used this definition in other studies (Gallupe et al., 1992). Cady and Valentine (1999) define quality as, among other things, the degree to which an idea can be successfully adopted by users. In addition, that idea must not violate known constraints. Valacich, Dennis, & Connolly (1995) use implementability, while Cooper et al. (1998) use social acceptability.

Table 6.3. Re-categorization of main dimension of idea quality

Reference	**Workability**	**Relevance**	**Attractiveness**
Taylor et al. (1958)	Feasibility, Probability	Effectiveness, Significance, Generality	
Lamm & Trommsdorff (1973)	Feasibility	Effectiveness	
Durand & VanHuus (1992)	Detail, Depth	Appropriateness, Clarity	Originality
MacCrimmon & Wagner (1994)	Workability	Relevance, Thoroughness	Novelty
Cady & Valentine (1999)	Adoptability, Non-violation of known constraints	Applicability, Ability to solve the problem, How well described	Novelty, Excitement
Mumford (2001)	Workability	Logical, Potential plausibility	Novelty, Unusualness
Potter & Balthazard (2004)	Feasibility	Relevance, Specificity	Novelty

Table 6.3. (Continued)

Reference	Workability	Relevance	Attractiveness
Dean et al. (2006)	Workability	Relevance, Specificity	Novelty
Linsey (2007)	Technical feasibility, Implementability		
Amabile (1982)	Technical cluster		Creativity, Aesthetic judgement
Besener & O'Quin (1986; 1999)		Resolution, Elaboration and synthesis	Novelty
Christiaans (2002)	Technical quality	Goodness of example	Creativity, Interest, Attractiveness
Horn & Salvendy (2006; 2009)		Importance	Novelty, Affect

Relevance is related to that an idea should apply to the stated problem and must be expected to solve the problem. It could be categorized into three sub dimensions: Completeness, Effectiveness, and Applicability.

Researchers have previously used completeness, applicability and effectiveness in relation to relevance. Complete and clear idea can be more useful for solving the problem. MacCrimmon and Wagner (1994) developed this dimension from U.S. Patent Office specifications, which require that ideas be “full, clear, concise, and exact.”

Other researchers have emphasized different aspects of the specificity dimension. For example, Durand and VanHuss (1992) judged ideas on the basis of clarity, depth, and amount of detail, whilst Cady and Valentine (1999) judged them by how well they were described. Some previous studies focused on applicability such as relation to topic (Aiken & Vanjani, 1997; Aiken, Vanjani, & Paolillo, 1996), usefulness for purpose (Fern, 1982), and appropriateness (Runco & Charles, 1993).

Attractiveness is related to the novelty of idea and users’ affection on idea. It could be categorized into three sub dimensions: Novelty, Interest, and Excitement.

Novelty is one of a key factor for the creativity of idea. MacCrimmon and Wagner (1994) defined a novel idea as one that had not been previously expressed. According to this definition, then, a novel idea is unique or, at least, rare. Also, affect is important to attract users to use products or services.

Based on the results of literature review and expert interview, more descriptions of sub dimensions are presented in Table 6.4.

Table 6.4. Descriptions of idea quality sub-dimensions

Dimension	Description
Feasibility	The degree to develop new technologies for implementation
Adoptability	The degree to adopt current technologies for implementation
Acceptability	The degree to which the idea is acceptable to use
Completeness	The degree to which the idea is detail and elaborate
Effectiveness	The degree to which the idea is logical and clear
Applicability	The degree to which the idea is appropriate
Novelty	The degree to which the idea is original and unique
Interest	The degree to which the idea is interesting
Excitement	The degree to which the idea is exciting

The hypotheses are developed as below.

H1. Idea quality (*H1a*: workability, *H1b*: relevance, *H1c*: attractiveness) has a significant positive influence on satisfaction of new ideas/concepts.

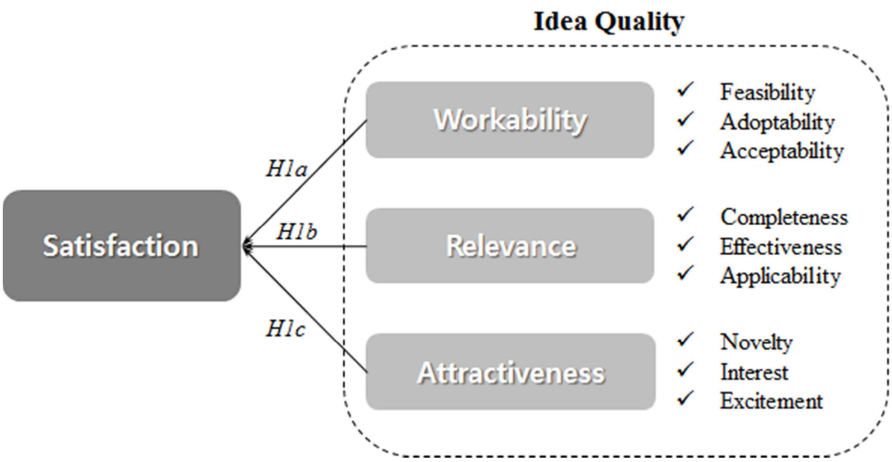


Figure 6.1. The conceptual model of idea quality

The conceptual model was developed as shown in Figure 6.1. This model argues that the idea quality has an impact on the satisfaction of ideas/concepts. The model further points out that the overall satisfactions of new ideas/concepts are based on their assessment of the idea quality dimensions for smart products.

6.2.2 Method

To validate the idea quality for new smart products/services and to explore the relationship between idea quality and satisfaction, the evaluation experiment was conducted.

Table 6.5. New ideas/concepts for smart products/services

Product	Description
Robot cleaner	Recognition of obstacles
	Recognizing and Informing dirty place
	Customizing schedule of cleaning
	Recognizing and Informing home condition (temperature, illumination, humidity)
Air conditioner	Recognizing the pattern of on/off
	Informing the temperature around the air conditioner
Oven	Informing the optimized recipe for the oven
	Informing the recipe according to cooking level
	Recommending the recipe according to context
	Helping for taking pictures of inside
Refrigerator	Informing where to clean
	Informing what kinds of food is insufficient
	Managing the temperature of a refrigerator
	Informing effective method to store and manage foods
	Mini- refrigerator
	Reducing noise of refrigerator
Washing machine	Informing the best day to do laundry
	Informing where to dry laundry

A total of 18 new ideas/concepts for smart products were evaluated (Table 6.5). Fifty one participants were recruited for the experiments. Among them, 31 participants have minimum 3 years experiences in product engineering and ergonomics research, and 20 participants have minimum 5 years experiences in designing and developing new products/services in electronic company. The participants were on average 29.51 years old.

The online survey system was used to build the questionnaire. The participants rated every idea quality sub dimensions (7-points scale) and overall satisfaction (7-points scale).

The collected data was analyzed using the statistic package software SPSS version 22.0. Data analysis of the experiment consists of two parts. The first part is about the reliability and the validity of the idea quality. The reliability as well as the validity of the questionnaire was verified through Cronbach's α values and factor analysis.

The second part aims to identify and explore the relationship between the idea quality and satisfaction of new ideas/concepts. Pearson correlation analysis was used to examine the correlation of the variables of dimensions. Also, multiple linear regression analysis was adopted to test the hypotheses.

6.2.3 Results

6.2.3.1 Scale reliability and validity

Cronbach's α is an index of reliability associated with the variation accounted for by the true score of the underlying construct. Construct is the hypothetical variable that is being measured (Hatcher, 1994).

The idea quality includes a variety of dimensions, and a higher reliability coefficient represents a higher correlation of respective dimensions, which illustrates higher internal consistence. As each idea quality was defined as multiple variables and evaluated by Likert scale, Cronbach's α statistic as a measure of reliability test was conducted.

Alpha coefficient ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from dichotomous (that is, questions with two possible answers) and/or multi-point formatted questionnaires or scales (i.e., rating scale: 1 = poor, 5 = excellent)

(Santos, 1999). When Cronbach's α value is greater than 0.6 ~ 0.7, it is referred to as high reliability; when the value falls between 0.6 and 0.35, it is considered as fair reliability, and the value smaller than 0.35 is taken as low reliability (Nunnaly, 2010).

Table 6.6. Results of factor analysis and reliability test for idea quality scale

Idea Quality		**Factor loadings**	**Eigenvalue**	**Extracted variance**	**Cronbach's α**
Workability	Feasibility	0.952	2.496	27.732%	0.790
	Adoptability	0.948			
	Acceptability	0.596			
Relevance	Completeness	0.516	1.553	17.255%	0.723
	Effectiveness	0.502			
	Applicability	0.535			
Attractiveness	Novelty	0.737	2.528	28.088%	0.858
	Interest	0.895			
	Excitement	0.896			

The results of the reliability analysis show that the Cronbach's α value of 'Workability' is 0.790, 'Relevance' is 0.723, and 'Attractiveness' is 0.858 (Table 6.6). Given its variables all reaching a level of high reliability, it illustrates that the overall consistence of the questionnaire of this study is in high reliability.

To show how valid a questionnaire is, it is necessary to measure variable characteristics (Chow, 2004). Since the questionnaire was designed by referring to the research scales developed by the researchers within and without, and modified by reviewing various kinds of literature, it would meet the requirement of content validity.

If factor in facet measurement is between 0.5 and 1.0, the values of respective dimensions are all greater than 1, and the accumulated explained variances of respective variables are all greater than 50 per cent, the overall measurement quality of the questionnaire is good and the questions in the questionnaire are appropriate, then the questionnaire has construct validity (Chiou, 2000).

As shown in Table 6.6, the eigenvalues of idea quality are all greater than 1, each facet's factor loading is between 0.500 and 0.900, and accumulated explained variances are greater than 50 percent. The Kaiser-Meyer-Olkin (KMO) overall measure of sampling adequacy (MSA) was 0.807, which falls within the acceptable level. In addition, the Bartlett's test of sphericity was 4787.553, $df = 36$, and significant at $p < 0.001$ which showed a significant correlation among the variables. It illustrated that the questionnaire used in this study meet the requirement of construct validity.

6.2.3.2 The relationship between the idea quality and satisfaction

Pearson's correlation analysis was conducted to confirm the correlation of two dimensions and the correlation coefficients of respective variables are shown in Table 6.7. As the results shown in Table 6.7, all of correlations are significant ($p < 0.05$). However, though workability has significant correlation with satisfaction, the coefficient value is quite low (0.210).

Table 6.7. Pearson Correlation matrix of idea quality and satisfaction

Idea quality	**Workability**	**Relevance**	**Attractiveness**	**Satisfaction**
Workability	1			
Relevance	0.298*	1		
Attractiveness	0.118*	0.733*	1	
Satisfaction	0.210*	0.815*	0.784*	1

Note: * correlation is significant at the 0.05 level (2-tailed).

To identify the importance of idea quality dimensions for satisfaction of new ideas/concepts, a regression analysis was conducted. The result of the regression analysis was shown as Table 6.8. The regression model for user satisfaction containing the three idea quality accounted for 74% of observed variance ($R^2 = 0.740$, $F(3,769) = 727.866$, $p < 0.001$). As shown in Table 6.8, all hypotheses except *H1a* were significant at least the 0.05 level, strongly supporting the proposed research model. *H1b* and *H1c* hypothesizing the association between idea quality and satisfaction were supported with standardized coefficient (β) of 0.515 and 0.405, respectively. Thus, according to the results, *H1* is partly supported.

Table 6.8. Multiple linear regression analysis for the influence of idea quality on satisfaction of new ideas/concepts

Model	**Idea quality**	β	t	p**-value**
Satisfaction	Workability	0.008	0.425	0.671
	Relevance	0.515	18.071	0.000
	Attractiveness	0.405	14.794	0.000

Note: $R^2 = 0.740$, $F\,(3,769) = 727.866$, $p < 0.001$.

6.3 Analysis of Relationship between Product Smartness and Satisfaction on New Idea/Concept

This chapter is aimed to understand how the elements of product smartness affect the satisfaction of new ideas/concepts. Therefore, as it discussed in Chapter 3, a theoretical model for product smartness was developed. Also, the model was assessed for exploring the relationship between the product smartness and satisfaction.

6.3.1 Conceptual model ad hypothesis

Based on the results of literature review and expert interview, the conceptual model of product smartness is developed in Chapter 3. The hypotheses are developed as below.

> *H2*. Product smartness (*H2a*: autonomy, *H2b*: adaptability, *H2c*: multi-functionality, *H2d*: connectivity, *H2e*: personalization) has a significant positive influence on satisfaction of new ideas/concepts.

The research model was developed as shown in Figure 5.2. This model argues that the product smartness has an impact on the satisfaction of ideas/concepts. The model further points out that the overall satisfaction of new ideas/concepts is based on its assessment of the dimensions of product smartness.

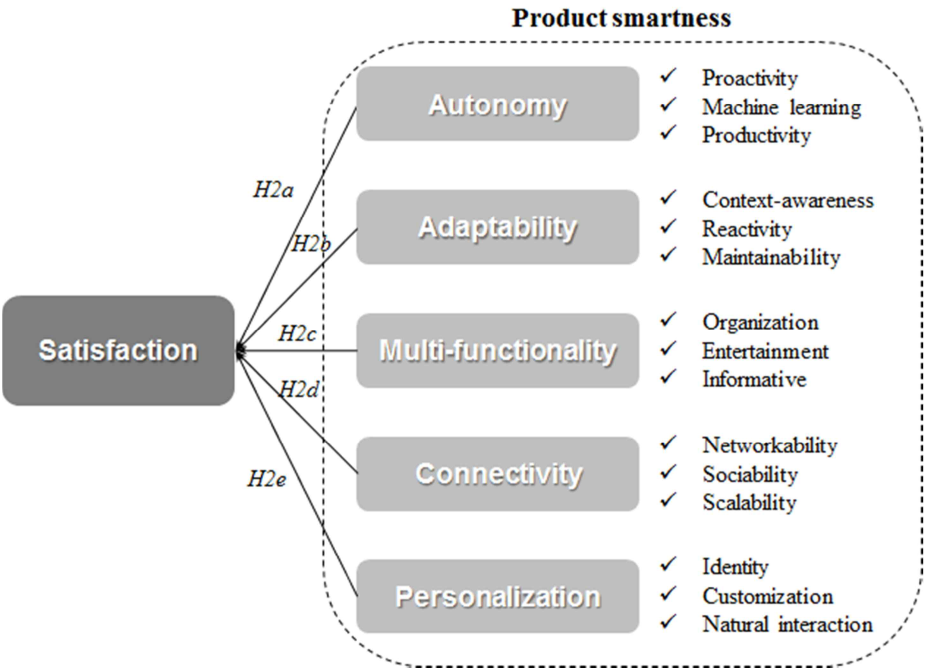


Figure 6.2. The conceptual model of product smartness

6.3.2 Method

To validate the dimensions of product smartness and to explore the relationship between these elements and satisfaction, the evaluation experiment was conducted.

A total of 18 new ideas/concepts for smart products were evaluated (Table 6.5, in the chapter 6.2.2). Thirty participants who have minimum 3 years experiences in product engineering and ergonomics research were recruited for the experiments. The participants were on average 29.67 years old.

The online survey system was used to build the questionnaire. The participants rated every sub dimensions of product smartness (7-point scale) and overall satisfaction (7-points scale).

The collected data was analyzed using the statistic package software SPSS version 22.0. The procedure and method of data analysis is same as Chapter 6.2.

The reliability as well as the validity of the questionnaire was verified through Cronbach's α values and factor analysis. Also, trough Pearson correlation analysis and multiple linear regression analysis, the relationship between the product smartness and satisfaction of new ideas/concepts were identified.

6.3.3 Results

6.3.3.1 Scale reliability and validity

The results of the product smartness reliability analysis show that the Cronbach's α value of 'Autonomy' is 0.781, 'Adaptability' is 0.893, 'Multi-functionality' is 0.718, 'Connectivity' is 0.783, and 'Personalization' is 0.684 (Table 6.9). Given its variables all reaching a level of high reliability, it illustrates that the overall consistence of the questionnaire of this study is in high reliability.

To show how valid a questionnaire is, the factor analysis was conducted. As shown in Table 6.9, the eigenvalues of product smartness are all greater than 1, each facet's factor loading is between 0.500 and 0.900, and accumulated explained variances are greater than 50 percent. The Kaiser-Meyer-Olkin (KMO) overall measure of sampling adequacy (MSA) was 0.848, which falls within the acceptable level.

In addition, the Bartlett's test of sphericity was 3067.465, $df = 105$, and significant at $p < 0.001$ which showed a significant correlation among the variables. It illustrated that the questionnaire used in this study meet the requirement of construct validity.

Table 6.9. Results of factor analysis and reliability test for product smartness

Product smartness		**Factor loadings**	**Eigen value**	**Extracted variance**	**Cronbach's α**
Autonomy	Proactivity	0.796	3.046	20.31%	0.781
	Machine learning	0.86			
	Productivity	0.664			
Adaptability	Context-awareness	0.732	3.181	21.20%	0.893
	Reactivity	0.844			
	Maintainability	0.826			
Multi-functionality	Organization	0.769	2.036	13.58%	0.718
	Entertainment	0.521			
	Informative	0.713			
Connectivity	Networkability	0.882	1.888	12.59%	0.783
	Sociability	0.775			
	Scalability	0.573			
Personalization	Identity	0.738	1.378	9.19%	0.684
	Customization	0.638			
	Natural interaction	0.744			

6.3.3.2 The relationship between the idea quality and satisfaction

Pearson's correlation analysis was conducted to confirm the correlation of product smartness and satisfaction are shown in Table 6. 10.

As the results shown in Table 6.10, all of the significant correlations might show that the product smartness influences one another. For example, the positive correlation between 'Autonomy' and 'Adaptability' might indicate that smart products perceived as autonomous would also be more likely to be perceived as being adaptable. Although, all dimensions of product smartness have positive significant correlation with satisfaction of new idea/concept for smart products, 'Multi-functionality' has weak correlation with satisfaction (0.260).

Table 6.10. Pearson Correlation matrix of product smartness and satisfaction

Product smartness	**1**	**2**	**3**	**4**	**5**	**6**
1. Autonomy	1					
2. Adaptability	0.469*	1				
3. Multi-functionality	0.101	0.077	1			
4. Connectivity	0.322*	0.340*	0.383*	1		
5. Personalization	0.181	0.309*	0.049	0.134	1	
6. Satisfaction	0.719*	0.640*	0.260*	0.588*	0.464*	1

Note: * correlation is significant at the 0.05 level (2-tailed).

To identify the importance of dimensions of product smartness for satisfaction of new ideas/concepts, a regression analysis was conducted. The result of the regression analysis was shown as Table 6.11. The regression model for user satisfaction containing the five dimensions of product smartness accounted for 71% of observed variance ($R^2 = 0.709$, $F\ (5{,}534) = 259.880$, $p < 0.001$).

As shown in Table 6.11, all hypotheses except *H2c* were significant at least the 0.05 level, strongly supporting the proposed research model. *H2a*, *H2b*, *H2d*, and *H2e* hypothesizing the association between product smartness and satisfaction were supported with standardized coefficient (β) of 0.496, 0.315, 0.110 and 0.145, respectively. Thus, according to the results, *H2* is partly supported.

Table 6.11. Multiple linear regression analysis for the influence of product smartness on satisfaction of new ideas/concepts

Model	**Product smartness**	β	t	***p*-value**
Satisfaction	Autonomy	0.496	6.316	0.000
	Adaptability	0.315	3.850	0.000
	Multi-functionality	0.136	1.845	0.070
	Connectivity	0.110	2.178	0.043
	Personalization	0.145	2.030	0.046

Note: $R^2 = 0.709$, $F\ (5{,}534) = 259.880$, $p < 0.001$.

6.4 Discussion

In this chapter, a framework of evaluating new idea/concept for smart products was developed. Idea quality metrics were collected from previous studies, and then they were re-organized into three dimensions: Workability, Relevance, and Attractiveness.

To validate the conceptual model, an evaluation experiment was conducted. From the results of the experiment, the reliability and validity of idea quality dimensions were proved. Also, the relationship between idea quality and satisfaction on new idea/concepts were identified through the regression analysis. To investigate the relationship between product smartness and satisfaction on new idea/concepts for smart products, the conceptual model and hypothesis of product smartness was developed.

The results of idea quality and product smartness are shown in Figure 6.3. In the idea quality, 'Relevance' is relatively more important than the others (β = 0.515). It is found that 'Workability' has no significant influence on satisfaction. These results could indicate interesting points. Even though developed new idea/concept is difficult to be implemented or acceptable to users, users and developers will be satisfied if the idea/concept is relevance and attractive. Therefore, to develop successful new products or services, it could be recommended that designers and developers should consider effectiveness, applicability, novelty of new idea rather than technical feasibility. In other words, identifying user needs and develop creative idea is important in new product development process.

In the product smartness, 'Autonomy' is the most important factor for satisfaction of new idea/concept (β = 0.496). However, 'Multi-functionality' shows no significant influence on satisfaction of new idea/concept. It can be explained by that multi-functionality increases the complexity and risk that consumers perceive (Rijsdijk & Hultink, 2009). Thus, too high level of multi-functionality is perceived as significantly less compatible.

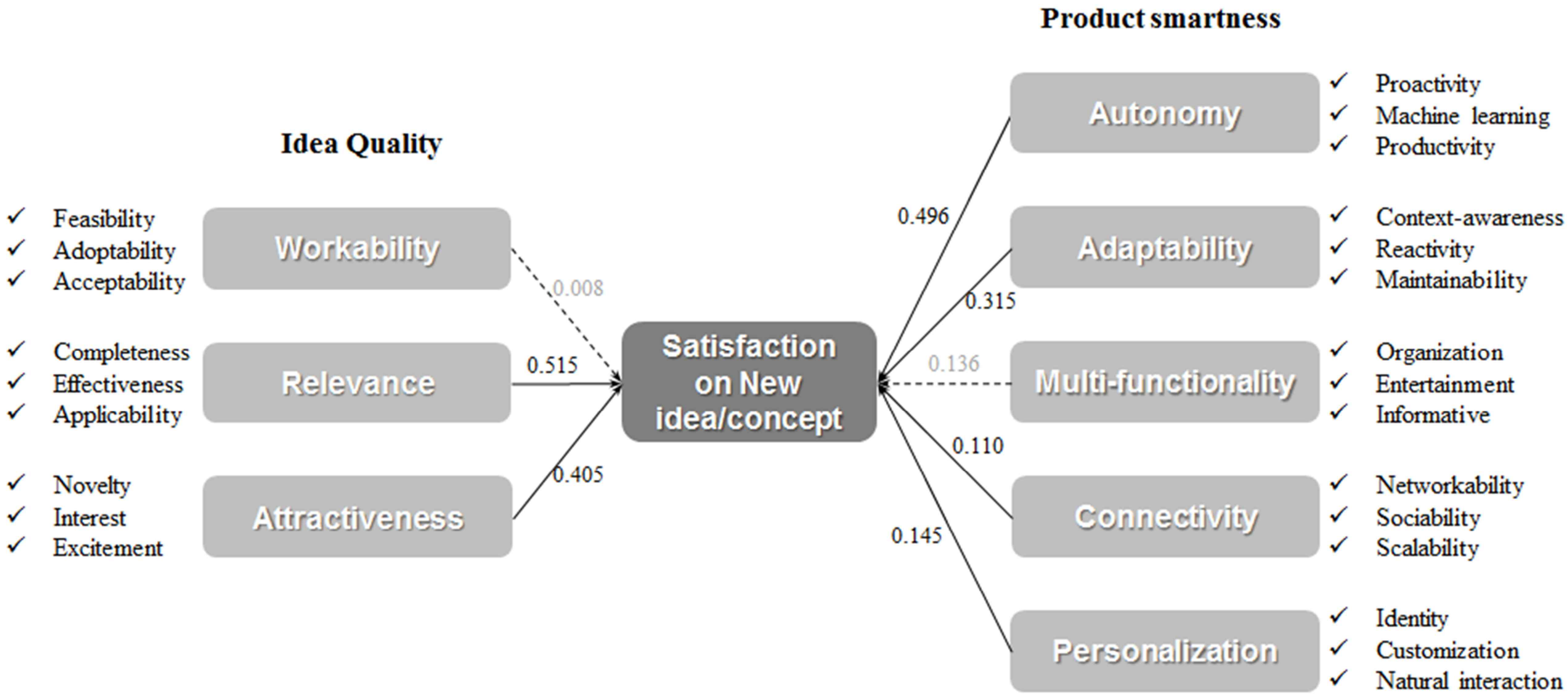


Figure 6.3. Satisfaction model of new idea/concept based on idea quality and product smartness

These results suggest that the benefits of adding functions to a product are limited. Consumer research may provide insight into what level of multi-functionality is acceptable for consumers and what level demands too much adaptation. In line with findings of such research, developers may want to implement their ideas for multi-functional products in a stepwise manner and to provide consumers with the opportunity to get used to certain levels of product smartness.

Proposed satisfaction model of new idea/concept based on idea quality and product smartness can be helpful for identifying the basic relationship. Through the proposed model, the important factors on satisfaction of new idea/concepts were identified. However, in the proposed model, there could be more mediate variables such as perceived product smartness.

Although figuring out the relationship between dimensions of product smartness and satisfaction is important, the relationship between the overall perceived product smartness and satisfaction is also important. It is possible that high perceived product smartness does not always satisfy users (Rijsdijk & Hultink, 2009). Therefore, investigating more mediate variables could be helpful for identifying the influence factors on satisfaction of new ideas/concepts in the further research.

Also, in this study, Pearson correlation analysis and multiple linear regression analysis were conducted. However, there could be two sources of numerical errors in the measurement of perceived dimensions of idea quality and product smartness in this study. First, the semantic differential scale gives ordinal data, and the calculation of mean values is strictly not permissible (Stevens, 1946). In other words, the measurement scales are not necessarily linear. Second, the regression analysis assumes a linear relationship between the rating of dimensions and satisfaction, while it is accepted that these are more likely to be related by a power law (Chen et al., 2009). Therefore, it is possible that the regression models might not capture some important relationships.

Chapter VII

DISCUSSION AND CONCLUSION

7.1 Summary of Findings

This study stated an understanding on smart products and a methodology of development for new idea/concept of smart products. Especially, the dimensions of product smartness and idea quality were explained with conceptual model. The proposed models were validated by evaluating new idea/concepts of smart products. Findings of this study can be summarized into three main points.

First, the conceptual model of product smartness was identified based on the literature review and expert interview. As a result, five main dimensions of product smartness are selected (Autonomy, Adaptability, Multi-functionality, Connectivity, and Personalization).

To explore the relationship between product smartness and user positive or negative experiences, external data (Twitter) were collected by a data mining technique. Especially, smartphone is the case study. The results showed that experiences of connectivity derived lots of negative emotions. Also, besides five dimensions of product smartness, there were lots of experiences about user's habitual use and security issues.

Second, a methodology that observes and analyzes user experience is proposed with conducting a case study on smart TV. User experience of smart TV was observed by conducting a Day Reconstruction Method (DRM).

This study modified existing DRM in order to observe more natural context of use. Whereas existing DRM focused only on primary activities, simultaneous activities could be observed in a more structured form. With modified DRM, more specific context of use could be identified.

Also, to analyze collected user experience data more effectively and efficiently, the clustering analysis was conducted by a Self-Organizing Map (SOM). Since the SOM-based visualizations offer an intuitive aid for extracting concepts and insights from the collected data, users' implicit needs on smart TV could be identified.

Third, a methodology that develops new smart product/service concept is proposed with conducting a case study. The overall procedure of developing idea/concept for new smart products/services is as follow.

In phase I, product smartness is identified. In phase II, users' needs are identified through conducting DRM on observing the smart TV-viewing and clustering collected user experiences using SOM. The results from the two phases are integrated in phase III, where new ideas/concepts for smart products/services are developed with relationship analysis. From the case study of developing new idea/concept for smart TV, a total of seven detail concepts were developed with five extracted user experiences of smart TV.

Finally, new idea/concept for smart products was evaluated based on the metrics of idea quality and product smartness. Through the evaluation experiment, the relationship between idea quality, product smartness, and satisfaction on new ideas/concepts of smart products were identified.

Idea quality metrics were collected from previous studies, and then they were re-organized into three dimensions: Workability, Relevance, and Attractiveness. To validate the conceptual model, an evaluation experiment was conducted. From the results of the experiment, the reliability and validity of idea quality dimensions were proved. Also, the relationship between idea quality and satisfaction on new idea/concepts were identified through the regression analysis.

In order to consider product smartness in evaluating new idea/concepts, the conceptual model and hypothesis of product smartness was also developed. From the evaluation experiments of idea quality and product smartness, the satisfaction model of new idea/concept was identified. ‘Relevance’ is the most important factor in idea quality, and ‘Autonomy’ is the most important factor in product smartness.

7.2 Contribution of this Study

In the academic area of new product development and user centered design, multi-disciplinary approaches have been addressed. Literature review of this study cover various scope of research area including computing technologies, product engineering, user centered design, new product design, product innovation, and creativity. Various theories and previous research related to smart products and new product/service development are investigated and discussed in this study. Especially, product smartness, observing user experiences and analyzing UX in identifying user needs, idea generation and idea evaluation in new product development process are thoroughly reviewed in terms of their limitations and possibilities.

To identify user implicit needs, naturalistic observation method and efficient clustering analysis is introduced. The DRM is known to be in a mediate position of observation in naturalistic setting and controlled settings (Hyldegård, 2006). It has its benefits on observing users' experience for long term, and able researchers to obtain quantitative as well as qualitative data (Kahneman et al., 2004).

Also, clustering analysis can be helpful for analyzing enormous observed data more efficiently and effectively. Especially, the SOM can be used to carry out the classification tasks effectively. The SOM provides the possibility to gain some idea from the structure of the data by observing the map due to the topology preserving nature of the SOM (Alahakoon, Halgamuge, & Srinivasan, 2000). The SOM-based visualizations offer an intuitive aid for extracting concepts and insights from the collected data.

Therefore, through DRM and SOM, it is possible to collect and analyze user experiences efficiently and effectively. Also, those methods could be utilized not only in developing new ideas/concepts for smart products, but also in other products. Furthermore, identified user needs by those methods could be utilized effectively in the other methods of idea generation.

Also, this study proposes a methodology that develops new idea/concepts for smart products. The suggested framework for identifying insights of user needs and developing new idea/concept could be useful for both of practitioners and researchers. Therefore, this study will motivate researchers and practitioners to develop and improve smart products and its applications.

Finally, this study provides an understanding of product smartness and idea quality with relation to satisfaction on new idea/concepts. Then, based on the literature review and expert interview, a conceptual model is suggested. This study is significant in that it incorporated product smartness, a qualitative indicator for representing smart products that has been acknowledged as important, as a factor of idea quality. This study can be expected to contribute in designing and developing new smart products or services.

7.3 Limitation and Further Research

The limitation of this study and further research are as follow.

First, in this study, to explore the relationship between product smartness and user positive or negative experiences, external data (Twitter) were collected by a data mining technique. Especially, smartphone is the case study. However, although the results showed quite interesting points, only smartphones were investigated in the case study. Thus, it is short in logical evidence to generalize the results to all types of products. Smartphones can serve as a good sample since they are one of the successful smart products with rich experience. It is however less than enough for the results to be generalized to a full set of diverse products. Other products should be studied to figure out the possibilities of generalization of those results in the future.

Also, in this study, dimensions of product smartness were defined by literature and expert review. To validate the conceptual model of product smartness, it is needed to investigate perceived product smartness by conducting user evaluation. In the perspective of affective engineering, user perceived smartness could be identified by affective adjectives which users usually use in the further research.

Second, it is possible to miss minor users' needs. From the results of SOM, SOM can miss minor issues which are not included in any clusters. Sometimes minor experiences can provide useful insights for new product development. Therefore, practitioners and researchers should be careful to miss valuable insights while using the SOM.

Third, though proposed framework for developing new idea/concept in this study is useful, the validation of proposed method should be conducted in the future study. There have been many studies about evaluating effectiveness of ideation method. Therefore, through those evaluation methods, the proposed framework of developing new idea/concept could be compared with previous methods and be verified in the future.

Finally, the models of idea quality and product smartness need more verification. The suggested model included contents provided by previous studies as well as theoretical assumption made on researchers' opinions. However, since the evaluation experiment was conducted with experts and researchers, user research for verification of the models was not conducted. For more complete results, the model of idea quality and product smartness will need verification by user research.

Also, there could be more mediate variables such as perceived product smartness. Although figuring out the relationship between dimensions of product smartness and satisfaction is important, the relationship between the overall rating of perceived product smartness and satisfaction is also important. It is possible that high perceived product smartness does not always satisfy users (Rijsdijk & Hultink, 2009). Therefore, investigating more mediate variables could be helpful for identifying the influence factors on satisfaction of new ideas/concepts in the further research.

Also, Pearson correlation analysis and multiple linear regression analysis were conducted to explore the relationships. However, there could be two sources of numerical errors in the measurement of perceived dimensions of idea quality and product smartness in this study. First, the semantic differential scale gives ordinal data, and the calculation of mean values is strictly not permissible (Stevens, 1946). In other words, the measurement scales are not necessarily linear. Secondly, the regression analysis assumes a linear relationship between the rating of dimensions and satisfaction, while it is accepted that these are more likely to be related by a power law (Chen et al., 2009). Therefore, it is possible that the regression models might not capture some important relationships. In the future research, more statistical analysis could be conducted to figure out more relationships.

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APPENDIX A

ANALYSIS TOOL

A.1 SOCIAL Metrics

SOCIAL metrics is a software tool which is developed by DaumSoft (http://socialmetrics.co.kr). Daumsoft, one of the leading social media analysis and consulting firms in Korea, provided the social media data for the current study. SOCIAL metrics can be helpful for analyzing big data by mining data of Korean twitters and blogs. It enables to collect twitter data and show the frequency of keywords by user's search keyword. It can also classify mining data into eight characteristics of word (person, community, place, product, property, brand, interest, and emotion).

Figure A.1 is the snapshot of main view of SOCIAL metrics. This tool provides significant Twitter-related statistics including the ranks of popular keywords among posted messages, total amounts of each keyword, other search words closely related to popular keywords, the analysis of social sentiment trends extracted from posted messages, and the daily amounts of messages posted on Twitter for each keyword. Social Metrics is available for both blog and Twitter, but in this study only Twitter data was used.

Figure A.1. The snapshot of main view of SOCIAL metrics

A.2 Self-Organizing Map (SOM)

A.2.1 Document classification (text classification)

To identify latent user needs, text classification should be executed before other steps. There are three typical main text mining tasks (exploratory data analysis, information extraction, and document classification).

In statistics, exploratory data analysis is an approach to analyzing data sets to summarize their main characteristics, often with visual methods. It was promoted by Tukey (1997) to encourage statisticians to explore the data, and possibly formulate hypotheses that could lead to new data collection and experiments. In the text mining tasks, it uses text to form hypotheses, and analyzes data with qualitative interpretation by observing people until there is no new insight (Swanson & Smalheiser, 1997).

Information extraction is the task of automatically extracting structured information from unstructured and/or semi-structured machine-readable documents (Cowie & Lehnert, 1996). In most of the cases this activity concerns processing human language texts by means of natural language processing (NLP). It learns information through text data, and semi-automatically creates domain specific knowledge bases then uses standard data mining techniques.

Document classification (text classification) is to assign a document to one or more classes or categories. Documents may be classified according to their subjects or according to other attributes (such as document type, author, printing year etc.). In the text mining tasks, it can be useful intermediary step for information extraction and can also analyze textual data quantitatively (Nasukawa & Nagano, 2001).

There are many methods for document classification such as ground theory, content analysis, latent semantic analysis, and self-organizing map. Grounded theory is a systematic methodology in the social sciences involving the construction of theory through the analysis of data (Martin & Turner, 1986). As researchers review the data collected, repeated ideas, concepts or elements become apparent, and are tagged with codes, which have been extracted from the data. As more data is collected and re-reviewed, codes can be grouped into concepts, and then into categories. However, it can be biased by researchers, and miss syntactical and semantic information embedded in the text (Thomas & James, 2006).

Latent semantic analysis (LSA) is a technique in natural language processing of analyzing relationships between a set of documents and the terms they contain by producing a set of concepts related to the documents and terms (Dumais et al., 1998). The key insight in LSA was to reduce the dimensionality of the information retrieval problem (Dumais, 2004). LSA assumes that words that are close in meaning will occur in similar pieces of text. It compares the documents in the low-dimensional space. However, it can not show good performance on small set of text data and can lead to the results on the mathematical level, but have no interpretable meaning in natural language (Hofmann, 1999).

Self-Organizing map (SOM) is useful to gain idea by observing the resulted map due to its topology preserving nature. It can learn and detect regularities and correlations in the inputs, and predict responses from input data. Also, it can generalize Principal components analysis (PCA) nonlinearly and researchers can easily interpret with visual output (Visually identify the clusters from the map) by using the SOM. The training utilizes competitive learning among the neurons of the output layer. The neurons are placed in 2D-lattice and are selectively tuned to various input patterns. The process of learning is three steps as follow (Figure A.2). First step is ‘competition’. The main equation and notation of ‘competition’ is below:

$$x=[x_1, x_2, \ldots, x_m]^T, \; w_j=[w_{j1}, w_{j2}, \ldots, w_{jm}]^T, \quad j=1,2,\ldots,l$$

Also, smallest distance is called $i(x)$ and is given by:

$$i(x)=\arg\min_j \|x - w_j\|,\ j=1,2,\ldots,l$$

The neuron *(i)* that satisfies the above condition is called best-matching or winning neuron for the input vector *x*.

Second step is 'cooperation'. In this step, the winning neuron effectively locates the center of a topological neighborhood. Finally, synaptic adaptation is needed. Every node within the best matching unit (BMU)'s neighborhood has its weight vector adjusted.

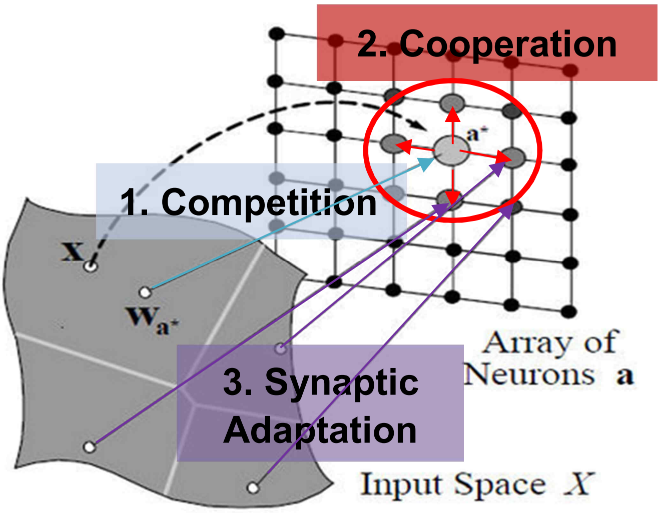


Figure A.2. The process of learning of Self-Organizing map

A.2.2 Package tools for self-organizing map (SOM)

In this study, two package tools were used for conducting the self-organizing map (SOM). One is SOM Toolbox 2.1 and the other is SomVis.

SOM Tool box 2.1 is a function package for MATLAB implementing the Self-Organizing Map algorithm and more (http://www.cis.hut.fi/projects/somtoolbox). Numerous people have participated in the making of SOM Toolbox. In addition to the people listed in the copyright notice, Kimmo Kiviluoto, Jukka Parviainen, Mika Pollari have participated in it, not to mention those who have contributed code, given bug reports or other feedback. The common factor is to have been employed in the laboratory of Information and Computer Science in the Helsinki University of Technology.

SOM Tool box 2.1 can train SOM with different network topologies and learning parameters, and compute different error, quality and measures for the SOM. Also, it can visualize SOM using u-matrices, component planes, cluster color coding and color linking between the SOM and other visualization methods. It provides correlation and cluster analysis with SOM. SOM Toolbox also features other data analysis methods related to vector quantizer (VQ), clustering, dimension reduction, and proximity preserving projections.

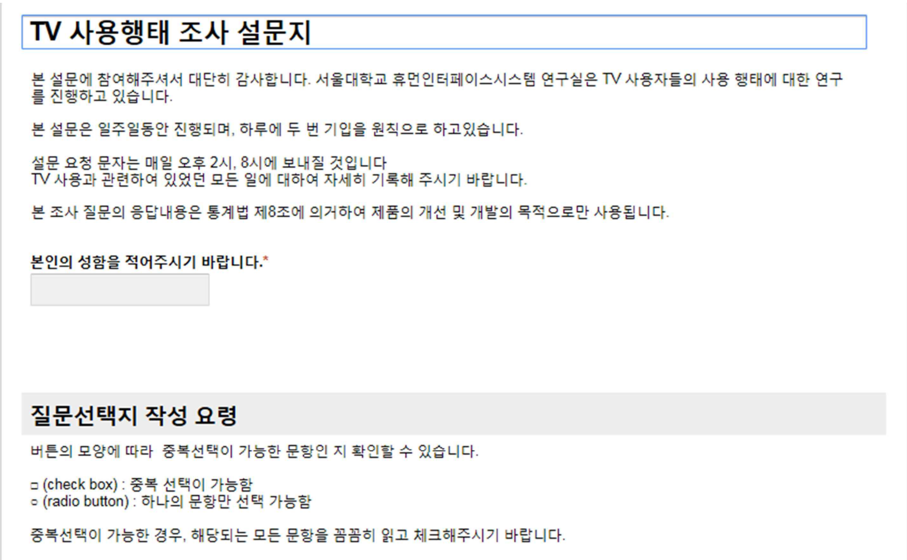
SomVis is developed by the laboratory of Spatial Data Mining and Visual Analytics in the University of South Carolina (http://www.spatialdatamining.org/software/somvis). SomVis is an integrated software tool that is able to perform multivariate analysis, dimensional reduction, and data reduction (summarizing a large number of input data items in a moderate number of clusters) with the Self-Organizing Map (SOM). Also, it can encode the SOM result with a systematically designed color scheme and visualize the multivariate patterns with a modified Parallel Coordinate Plot (PCP) display and a geographic map (GeoMap). SomVis can also support human interactions to explore and examine patterns. Computational and visual methods, once combined together, can mitigate each other’s weakness and collaboratively discover complex patterns in large geographic datasets, in an effective and efficient way.

APPENDIX B

Questionnaires

B.1 Day Reconstruction Method (DRM)

DRM for observing smart TV-viewing was conducted by using online survey system (Google Docs). The snapshots of detail view of online survey systems are as follow.



TV 사용행태 조사 설문지

본 설문에 참여해주셔서 대단히 감사합니다. 서울대학교 휴먼인터페이스시스템 연구실은 TV 사용자들의 사용 행태에 대한 연구를 진행하고 있습니다.

본 설문은 일주일동안 진행되며, 하루에 두 번 기입을 원칙으로 하고있습니다.

설문 요청 문자는 매일 오후 2시, 8시에 보내질 것입니다
TV 사용과 관련하여 있었던 모든 일에 대하여 자세히 기록해 주시기 바랍니다.

본 조사 질문의 응답내용은 통계법 제8조에 의거하여 제품의 개선 및 개발의 목적으로만 사용됩니다.

본인의 성함을 적어주시기 바랍니다.*

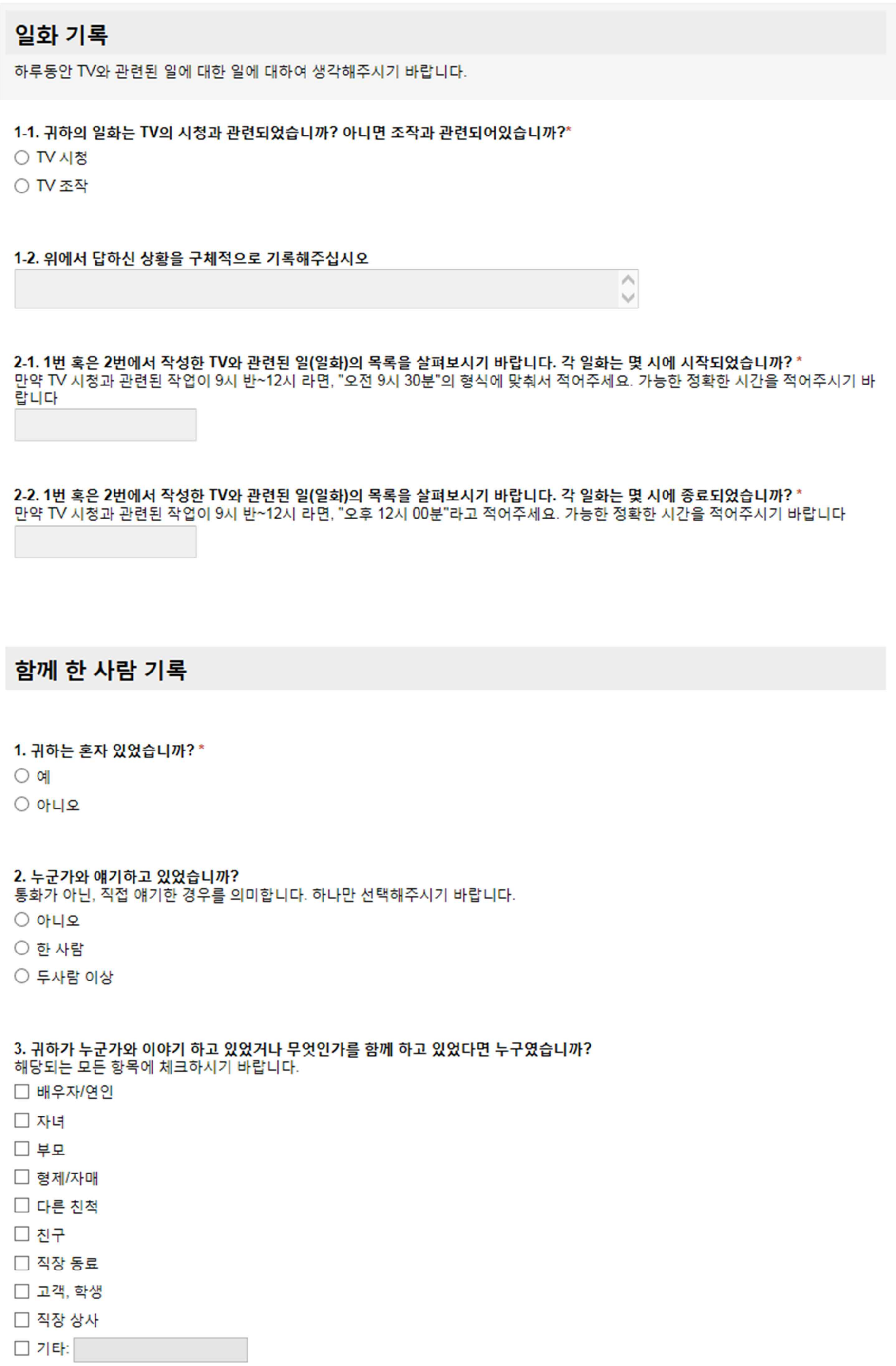
질문선택지 작성 요령

버튼의 모양에 따라 중복선택이 가능한 문항인 지 확인할 수 있습니다.

□ (check box) : 중복 선택이 가능함
○ (radio button) : 하나의 문항만 선택 가능함

중복선택이 가능한 경우, 해당되는 모든 문항을 꼼꼼히 읽고 체크해주시기 바랍니다.

Figure B.1. The front page of DRM online survey system



일화 기록

하루동안 TV와 관련된 일에 대한 일에 대하여 생각해주시기 바랍니다.

1-1. 귀하의 일화는 TV의 시청과 관련되었습니까? 아니면 조작과 관련되어있습니까?*

○ TV 시청

○ TV 조작

1-2. 위에서 답하신 상황을 구체적으로 기록해주십시오

2-1. 1번 혹은 2번에서 작성한 TV와 관련된 일(일화)의 목록을 살펴보시기 바랍니다. 각 일화는 몇 시에 시작되었습니까? *

만약 TV 시청과 관련된 작업이 9시 반~12시 라면, "오전 9시 30분"의 형식에 맞춰서 적어주세요. 가능한 정확한 시간을 적어주시기 바랍니다

2-2. 1번 혹은 2번에서 작성한 TV와 관련된 일(일화)의 목록을 살펴보시기 바랍니다. 각 일화는 몇 시에 종료되었습니까? *

만약 TV 시청과 관련된 작업이 9시 반~12시 라면, "오후 12시 00분"라고 적어주세요. 가능한 정확한 시간을 적어주시기 바랍니다

함께 한 사람 기록

1. 귀하는 혼자 있었습니까? *

○ 예

○ 아니오

2. 누군가와 얘기하고 있었습니까?

통화가 아닌, 직접 얘기한 경우를 의미합니다. 하나만 선택해주시기 바랍니다.

○ 아니오

○ 한 사람

○ 두사람 이상

3. 귀하가 누군가와 이야기 하고 있었거나 무엇인가를 함께 하고 있었다면 누구였습니까?

해당되는 모든 항목에 체크하시기 바랍니다.

☐ 배우자/연인

☐ 자녀

☐ 부모

☐ 형제/자매

☐ 다른 친척

☐ 친구

☐ 직장 동료

☐ 고객, 학생

☐ 직장 상사

☐ 기타:

Figure B.2. The second page of DRM online survey system

주요 활동 기록

해당되는 모든 활동에 표시하세요

1. 어떤 방송 프로그램을 시청하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 실시간 전파 방송 시청 (공중파, 케이블 ..)
- ☐ 온라인 VOD / 녹화된 컨텐츠 시청
- ☐ 외부입력 기기를 통한 시청 (DVD플레이어, 비디오 ..)
- ☐ SmartShare(LG) 또는 AllShare(삼성) 시청
- ☐ 기타:

1-1. 외부입력 기기를 사용하셨다면, 어떤 컨텐츠를 이용하셨습니까?
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 사진
- ☐ 음악
- ☐ 동영상

1-2. SmartShare나 AllShare를 사용하셨다면, 어떤 컨텐츠를 이용하셨습니까?
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 사진
- ☐ 음악
- ☐ 동영상

2. 시청 중 TV 부가기능 중 무엇을 조작하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 시청 중 다른 TV의 기능을 사용하지 않았음
- ☐ 음량 조절
- ☐ TimeShift(LG) - 실시간 녹화기능
- ☐ 영상 제어 (재생/일시정지/빨리감기/뒤로감기/배속 조절)

3. 방송 프로그램을 어떻게 검색하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 매번 보는 프로그램이라 번호를 알았음
- ☐ 채널 변경을 하다가 우연히 보게 됨
- ☐ 인터넷 매체에서 방송 관련 정보를 접한 후 보게 됨
- ☐ 신문 등 방송 매체에서 관련 정보를 접한 후 보게 됨
- ☐ 방송 광고를 통해 보게 됨
- ☐ 주변인의 추천을 통해 보게 됨
- ☐ 방송 목록에서 제목에 흥미를 느껴 보게 됨
- ☐ 자주 보는 채널로 돌렸다가 보게 됨
- ☐ 프로그램 상관없이 켜놓음
- ☐ 기타:

4. TV설정 기능 중 어떤 기능을 사용하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 사용하지 않았음
- ☐ 화면 설정 (명암/밝기/비율 등)
- ☐ 스피커 설정 (이퀄라이저, 스테레오 설정 등)
- ☐ 네트워크 설정 채널 설정 (선호채널/자동채널설정 등)
- ☐ 일반 설정 (언어/자막/시간 등)

5. TV의 부가기능 중 어떤 기능을 사용하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ App 사용
- ☐ 웹 브라우저
- ☐ SNS
- ☐ 사용하지 않았음

5-1. 부가기능 중 App을 사용하셨다면, 어떤 컨텐츠를 이용하셨습니까?
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ 뉴스
- ☐ 게임
- ☐ 교육
- ☐ 동영상
- ☐ 건강
- ☐ 날씨
- ☐ 기타:

6. 어떤 방법으로 TV를 조작하셨습니까?*
해당되는 모든 항목에 체크하시기 바랍니다.

- ☐ TV 본체 직접 조작
- ☐ 리모컨
- ☐ 음성인식
- ☐ 동작인식 (제스쳐)
- ☐ 기타:

Figure B.3. The third page of DRM online survey system

부차적 활동 기록 (복수 응답 가능)

TV를 시청하시면서 했던 모든 활동에 대해 체크해주십시오.

예를 들어, 'TV 시청과 동시에 스마트폰으로 TV 드라마 주인공이 입고 있는 옷에 대해 검색을 하면서 과자를 먹었다'면,

1번 문항에는 → 스마트폰
2번 문항에는 → 음식을 먹거나 음료를 마시는 중이었다.
[방송내용과 관련된 내용] 인터넷을 하고 있었다. (검색과 블로그, 커뮤니티, 까페 활동 등에 한함)

해당되는 모든 곳에 체크하시면 됩니다.

1. TV를 시청하는 동시에 어떤 기기를 사용하였습니까? *
해당되는 기기를 모두 선택하시기 바랍니다. (중복 선택 가능)

- ☐ 스마트폰
- ☐ 노트북
- ☐ 데스크탑
- ☐ 태블렛
- ☐ 다른 기기를 사용하지 않았다
- ☐ 기타:

2. TV를 시청하는 동시에 무슨 일을 하고 있었습니까? *
전체 목록을 모두 주의 깊게 읽고 나서 해당되는 모든 곳에 체크하시기 바랍니다. (중복 선택 가능)

- ☐ 휴식을 취하였다. / TV 시청 외 다른 일을 하지 않았다.
- ☐ [방송내용과 관련된 내용] 전화로 통화를 하고 있었다. / 문자(카카오톡)를 하고 있었다.
- ☐ [방송내용과 관련 없는 내용] 전화로 통화를 하고 있었다. / 문자(카카오톡)를 하고 있었다.
- ☐ [방송내용과 관련된 내용] 주위 사람과 대화하는 중이었다.
- ☐ [방송내용과 관련 없는 내용] 주위 사람과 대화하는 중이었다.
- ☐ [방송내용과 관련된 내용] SNS를 하고 있었다.
- ☐ [방송내용과 관련 없는 내용] SNS를 하고 있었다.
- ☐ 음식을 먹거나 음료를 마시는 중이었다.
- ☐ 독서를 하고 있었다. / 신문을 읽고 있었다
- ☐ [방송내용과 관련된 내용] 인터넷을 하고 있었다. (검색과 블로그, 커뮤니티, 까페 활동 등에 한함)
- ☐ [방송내용과 관련 없는 내용] 인터넷을 하고 있었다. (검색과 블로그, 커뮤니티, 까페 활동 등에 한함)
- ☐ 수면을 취하였다. / 졸고 있었다.
- ☐ 운동 중이었다.
- ☐ 몸단장을 하고 있었다.
- ☐ 자녀를 돌보고 있었다.
- ☐ 게임을 하고 있었다.
- ☐ 쇼핑을 하거나 장을 보고 있었다.
- ☐ 집안일을 하고 있었다. (청소, 빨래, 요리 등등)
- ☐ 일을 하고 있었다. (공부, 직장 업무 등등)
- ☐ e-mail을 사용하고 있었다.
- ☐ 기타:

Figure B.4. The fourth page of DRM online survey system


일화동안의 정서 기록

TV와 관련되어 선택된 일화가 일어나는 동안 귀하의 정서는 어떠하였습니까?
아래 제시된 척도에 각각 표시해주시기 바랍니다.
1은 해당 정서를 전혀 경험하지 않았다는 의미이고, 7은 해당 정서를 매우 강하게 경험하였다는 것을 의미합니다.
귀하가 경험한 바를 가장 잘 기술해주는 숫자 하나만 표시하시기 바랍니다.

1. 긴장감 / 스트레스를 느낌*
예) TV 화면이 갑자기 전환되어 스트레스를 받았음

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

2. 행복함 / 즐거움.*
예) 좋아하는 프로그램을 보아 행복함 및 즐거움을 느낌

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

3. 울적함/ 쓸쓸함*
예) 혼자 TV를 보고있으면서 쓸쓸함을 느낌

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

4. 흥미로운/열중하는*
예) TV를 켰는데 우연히 흥미로운 방송을 발견하여 열중하였음

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

5. 애정을 느낌/ 훈훈함*
예) 고화질의 스크린 및 좋은 음향 장비로 인하여 만족감을 느껴 TV에 애정을 느낌

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

6. 편안함 / 느긋함*
예) 휴식을 취하면서 TV를 보며 편안함을 느낌

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

7. 짜증남/화남*
예) 리모콘을 찾으러 돌아다니면서 번거로움을 느낌

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

8. 피곤함*
TV로 USB의 사진을 보는데 가로, 세로 전환을 하면서 피곤함을 느꼈음

1 2 3 4 5 6 7
전혀 못 느꼈다 ○ ○ ○ ○ ○ ○ ○ 매우 강하게 느꼈다

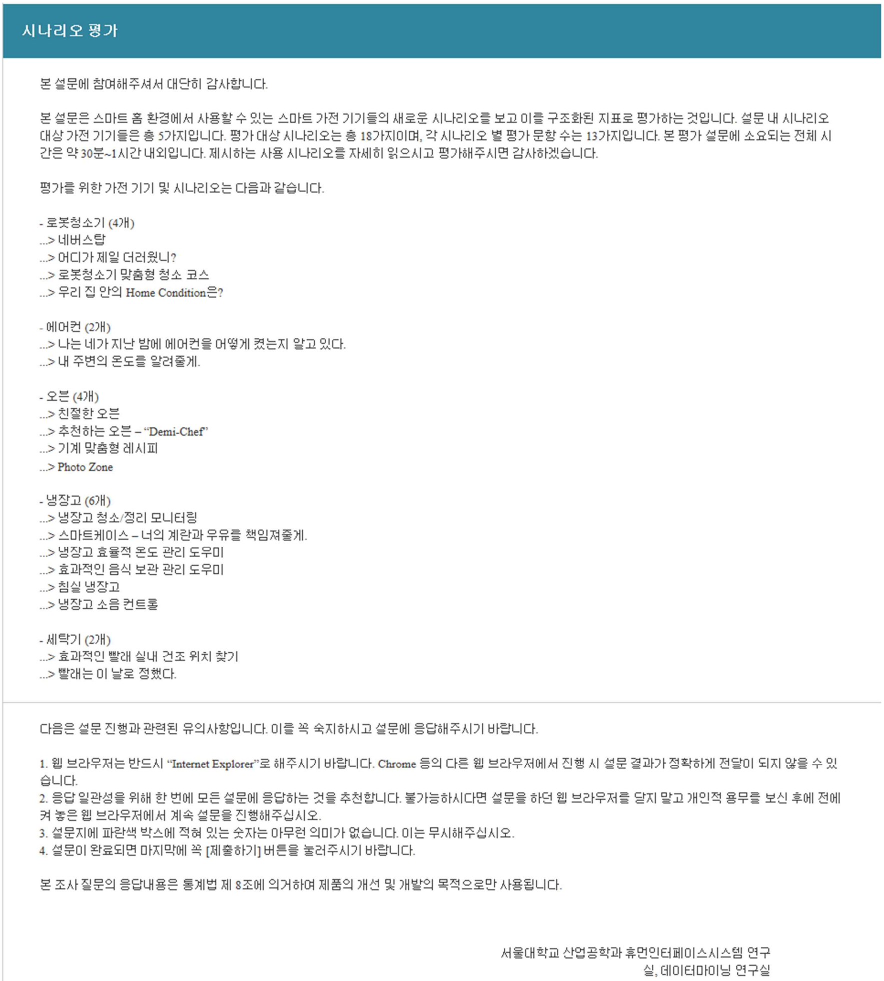
정서를 느낀 이유, 원인

위의 정서를 느낀 이유나 원인 등을 서술하여 주세요.*

Figure B.5. The last page of DRM online survey system

B.2 Idea Quality Evaluation Experiment

Idea quality evaluation was conducted by using online survey system (nownsurvey). The snapshots of detail view of online survey systems are as follow.



시나리오 평가

본 설문에 참여해주셔서 대단히 감사합니다.

본 설문은 스마트 홈 환경에서 사용할 수 있는 스마트 가전 기기들의 새로운 시나리오를 보고 이를 구조화된 지표로 평가하는 것입니다. 설문 내 시나리오 대상 가전 기기들은 총 5가지입니다. 평가 대상 시나리오는 총 18가지이며, 각 시나리오 별 평가 문항 수는 13가지입니다. 본 평가 설문에 소요되는 전체 시간은 약 30분~1시간 내외입니다. 제시하는 사용 시나리오를 자세히 읽으시고 평가해주시면 감사하겠습니다.

평가를 위한 가전 기기 및 시나리오는 다음과 같습니다.

- 로봇청소기 (4개)
...> 네버스탑
...> 어디가 제일 더러웠니?
...> 로봇청소기 맞춤형 청소 코스
...> 우리 집 안의 Home Condition은?

- 에어컨 (2개)
...> 나는 네가 지난 밤에 에어컨을 어떻게 켰는지 알고 있다.
...> 내 주변의 온도를 알려줄게.

- 오븐 (4개)
...> 친절한 오븐
...> 추천하는 오븐 – “Demi-Chef”
...> 기계 맞춤형 레시피
...> Photo Zone

- 냉장고 (6개)
...> 냉장고 청소/정리 모니터링
...> 스마트케이스 – 너의 계란과 우유를 책임져줄게.
...> 냉장고 효율적 온도 관리 도우미
...> 효과적인 음식 보관 관리 도우미
...> 침실 냉장고
...> 냉장고 소음 컨트롤

- 세탁기 (2개)
...> 효과적인 빨래 실내 건조 위치 찾기
...> 빨래는 이 날로 정했다.

다음은 설문 진행과 관련된 유의사항입니다. 이를 꼭 숙지하시고 설문에 응답해주시기 바랍니다.

1. 웹 브라우저는 반드시 “Internet Explorer”로 해주시기 바랍니다. Chrome 등의 다른 웹 브라우저에서 진행 시 설문 결과가 정확하게 전달이 되지 않을 수 있습니다.
2. 응답 일관성을 위해 한 번에 모든 설문에 응답하는 것을 추천합니다. 불가능하시다면 설문을 하던 웹 브라우저를 닫지 말고 개인적 용무를 보신 후에 전에 켜 놓은 웹 브라우저에서 계속 설문을 진행해주십시오.
3. 설문지에 파란색 박스에 적혀 있는 숫자는 아무런 의미가 없습니다. 이는 무시해주십시오.
4. 설문이 완료되면 마지막에 꼭 [제출하기] 버튼을 눌러주시기 바랍니다.

본 조사 질문의 응답내용은 통계법 제 8조에 의거하여 제품의 개선 및 개발의 목적으로만 사용됩니다.

서울대학교 산업공학과 휴먼인터페이스시스템 연구실, 데이터마이닝 연구실

Figure B.6. The front page of the online survey system for idea quality

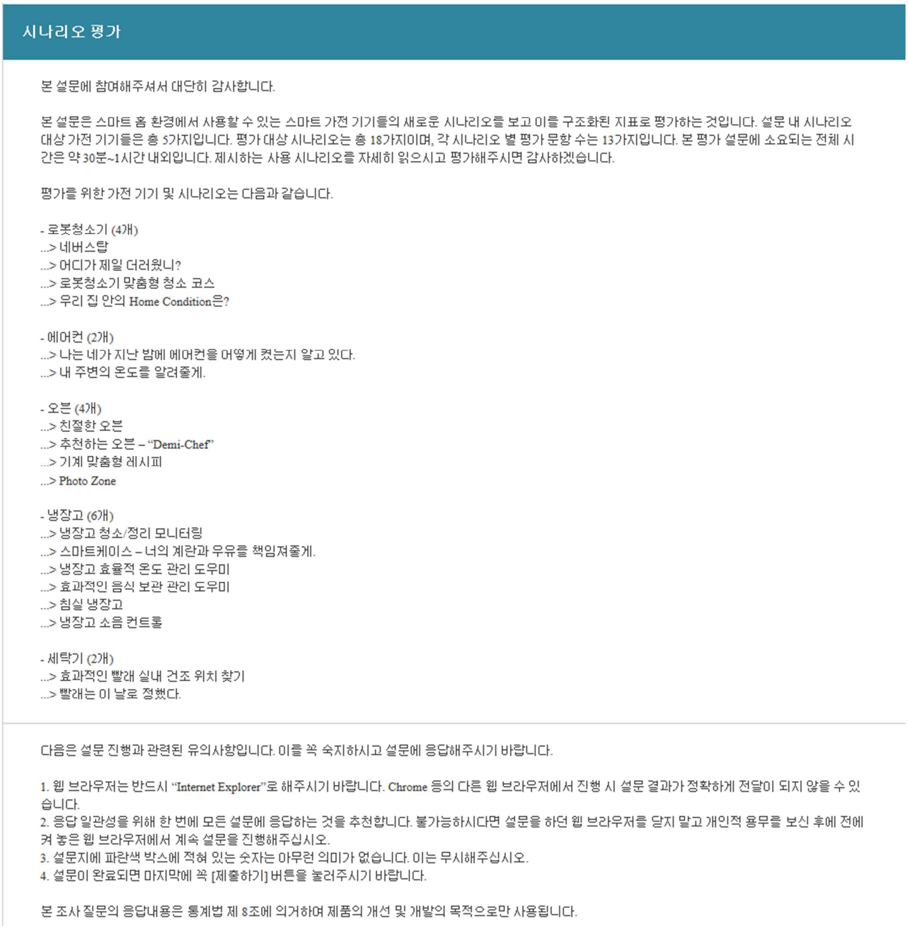
The evaluation metrics and descriptions are in Figure B.7. Each metrics were rated by participants using 7-Likert scale.

Evaluation Metric	평가 문항
Acceptability	해당 시나리오에서 사용자가 실제로 사용해본다면 그 사용 방식이 사용자에게 얼마나 적합하다고 생각합니까? 1. 매우 적합하지 않음. ↔ 4. 보통 ↔ 7. 매우 적합함
Adoptability	해당 시나리오를 실현하기 위한 기술들이 현재 얼마나 충분히 개발되어 있다고 생각합니까? 1. 매우 부족함. ↔ 4. 보통 ↔ 7. 매우 충분함
Feasibility	해당 시나리오를 실현하기 위한 부재 기술들(신기술)을 새로 개발하기가 용이합니까? 1. 매우 어려움. ↔ 4. 보통 ↔ 7. 매우 쉬움
Effectiveness	해당 시나리오에서 제시하는 해결 방안이 얼마나 논리적이고 효과적이라고 생각합니까? 1. 매우 부족함. ↔ 4. 보통 ↔ 7. 매우 충분함
Completeness	해당 시나리오에서 제시하는 해결 방안이 얼마나 구체적이고 명료하다고 생각합니까? 1. 매우 불명확함. ↔ 4. 보통 ↔ 7. 매우 명확함.
Applicability	해당 시나리오에서 나타나는 문제가 얼마나 해결이 필요하다고 생각하십니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7.매우 그렇다.
Interest	해당 시나리오에 대해 느끼는 전체적 흥미나 재미의 정도는 어느 정도라고 예상됩니까? 1. 매우 적음. ↔ 4. 보통 ↔ 7. 매우 많음.
Excitement	해당 시나리오에서 실제로 사용해본다면 느끼는 신나는 기분 또는 즐거움이 어느 정도라고 예상됩니까? 1. 매우 적음. ↔ 4. 보통 ↔ 7. 매우 많음.
Novelty	해당 시나리오에 대해 느껴지는 흔하지 않고 참신한 정도가 어느 정도입니까? 1. 매우 식상함. ↔ 4. 보통 ↔ 7. 매우 참신함.
Satisfaction	해당 시나리오에 대해 만족하는 정도가 어느 정도입니까? 1. 매우 불만족 ↔ 4. 보통 ↔ 7. 매우 만족

Figure B.7. Evaluation metrics for idea quality evaluation

B.3 Product Smartness Evaluation Experiment

Product smartness evaluation was conducted by using online survey system (nownsurvey). The snapshots of detail view of online survey systems are as follow.



시나리오 평가

본 설문에 참여해주셔서 대단히 감사합니다.

본 설문은 스마트 홈 환경에서 사용할 수 있는 스마트 가전 기기들의 새로운 시나리오를 보고 이를 구조화된 지표로 평가하는 것입니다. 설문 내 시나리오 대상 가전 기기들은 총 5가지입니다. 평가 대상 시나리오는 총 18가지이며, 각 시나리오 별 평가 문항 수는 13가지입니다. 본 평가 설문에 소요되는 전체 시간은 약 30분~1시간 내외입니다. 제시하는 사용 시나리오를 자세히 읽으시고 평가해주시면 감사하겠습니다.

평가를 위한 가전 기기 및 시나리오는 다음과 같습니다.

- 로봇청소기 (4개)
...> 네버스탑
...> 어디가 제일 더러웠니?
...> 로봇청소기 맞춤형 청소 코스
...> 우리 집 안의 Home Condition은?

- 에어컨 (2개)
...> 나는 네가 지난 밤에 에어컨을 어떻게 켰는지 알고 있다.
...> 내 주변의 온도를 알려줄게.

- 오븐 (4개)
...> 친절한 오븐
...> 추천하는 오븐 – "Demi-Chef"
...> 기계 맞춤형 레시피
...> Photo Zone

- 냉장고 (6개)
...> 냉장고 청소/정리 모니터링
...> 스마트케이스 – 너의 계란과 우유를 책임져줄게.
...> 냉장고 효율적 온도 관리 도우미
...> 효과적인 음식 보관 관리 도우미
...> 침실 냉장고
...> 냉장고 소음 컨트롤

- 세탁기 (2개)
...> 효과적인 빨래 실내 건조 위치 찾기
...> 빨래는 이 날로 정했다.

다음은 설문 진행과 관련된 유의사항입니다. 이를 꼭 숙지하시고 설문에 응답해주시기 바랍니다.

1. 웹 브라우저는 반드시 "Internet Explorer"로 해주시기 바랍니다. Chrome 등의 다른 웹 브라우저에서 진행 시 설문 결과가 정확하게 전달이 되지 않을 수 있습니다.
2. 응답 일관성을 위해 한 번에 모든 설문에 응답하는 것을 추천합니다. 불가능하시다면 설문을 하던 웹 브라우저를 닫지 말고 개인적 용무를 보신 후에 전에 켜 놓은 웹 브라우저에서 계속 설문을 진행해주십시오.
3. 설문지에 파란색 박스에 적혀 있는 숫자는 아무런 의미가 없습니다. 이는 무시해주십시오.
4. 설문이 완료되면 마지막에 꼭 [제출하기] 버튼을 눌러주시기 바랍니다.

본 조사 질문의 응답내용은 통계법 제 8조에 의거하여 제품의 개선 및 개발의 목적으로만 사용됩니다.

Figure B.8. The front page of the online survey system for product smartness

The evaluation metrics and descriptions are in Figure B.9. Each metrics were rated by participants using 7-Likert scale.

Evaluation Metric		평가 문항
Autonomy	**Proactivity**	해당 시나리오에서 제품의 기능이 얼마나 능동적으로 사용자가 원하는 바를 자동으로 수행해준다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다.
	Machine learning	해당 시나리오에서 제품이 사용자의 개입 없이 얼마나 스스로 학습하여 발전한다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Productivity	해당 시나리오에서 제품의 기능이 얼마나 사용자의 과업의 생산성을 높여준다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
Adaptability	**Context awareness**	해당 시나리오에서 제품이 얼마나 사용자의 사용 상황을 정확하고 자세하게 파악한다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Reactivity	해당 시나리오에서 제품이 얼마나 사용자의 input에 대하여 적절하게 반응한다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Maintainability	해당 시나리오에서 제품이 얼마나 적절하게 업그레이드 된다고 생각하십니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
Multi-functionality	**Organization**	해당 시나리오에서 제품이 얼마나 다양한 기능을 제공하여 사용자의 일상 생활에 도움이 될 수 있다고 예상됩니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Entertainment	해당 시나리오에서 제품이 얼마나 본래의 기능 이외에 재미를 위한 기능들을 제공해준 다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Informative	해당 시나리오에서 제품이 얼마나 사용자에게 유용한 정보들을 제공해준다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
Connectivity	**Networkability**	해당 시나리오에서 제품이 다양한 타 제품들과 연동이 많이 가능하다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Sociability	해당 시나리오에서 제품이 타 사용자와의 통신이 얼마나 유용하다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Scalability	해당 시나리오에서 제품이 다른 다양한 제품 및 사용자와의 통신에 얼마나 유연하게 대응한다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
Personalization	**Identity**	해당 시나리오에서 제품이 사용자의 개성을 얼마나 반영할 수 있다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Customization	해당 시나리오에서 제품을 얼마나 사용자가 자신에게 맞게 변경하고 설정할 수 있다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
	Natural interaction	해당 시나리오에서 제품이 얼마나 자연스러운 상호작용을 사용자에게 제공한다고 생각합니까? 1. 매우 그렇지 않다. ↔ 4. 보통 ↔ 7. 매우 그렇다
Satisfaction		해당 시나리오에 대해 만족하는 정도가 어느 정도입니까? 1. 매우 불만족 ↔ 4. 보통 ↔ 7. 매우 만족

Figure B.9. Evaluation metrics for product smartness evaluation

국문 초록

우리 주변에는 스스로 의지를 가지고 작동하는 제품들이 많다. 특히, 스마트 제품들은 정보를 수집하고, 처리하고, 생성하는 기능을 가지고 있다. 스마트 제품 디자인은 굉장히 많은 제품들에, 다양한 맥락에 적용되어 왔다. 이러한 스마트 제품은 사실 기술적으로 정의가 되어있기 보다는 주로 마케팅 측면에서 많이 사용되고 정의되었다. 따라서, 어떠한 제품을 스마트 제품으로 분류할 수 있는지 불명확하다. 임베디드 컴퓨팅 시스템 (Embedded computing system)과 마이크로 컨트롤러 칩 (microcontroller chips)이 굉장히 빠르게 발전하면서 스마트 제품의 정의도 계속 진화되고 있다. 지금까지 기존의 연구들에서도 스마트 제품에 대한 정의와 특성이 관점에 따라 서로 다르게 설명되어왔다.

본 연구의 목적은 스마트 제품의 특성 (product smartness)을 규명하고, 사용자의 니즈를 보다 효과적이고 효율적으로 파악하는 것이다. 또한, 이를 통해 스마트 제품을 위한 새로운 아이디어 및 컨셉을 개발하고, 평가하는 것이다. 새로운 아이디어 및 컨셉 개발을 위한 전체적인 과정은 다음과 같다.

첫째, phase I에서는 스마트 제품의 특성을 파악하는 것이다. 본 연구에서는 문헌 연구와 전문가 인터뷰를 통하여 스마트 제품 특성에 대한 가설 모형을 개발하였다. 연구 결과, 총 5가지의 스마트 제품 특성의 차원이 선정되었다 (Autonomy, Adaptability, Multi-functionality, Connectivity, Personalization). 또한, 스마트 제품 특성에 따라 스마트 제품에 대한 사용자 경험이 어떻게 달라지는 살펴보기 위해서, 스마트 폰을 대상으로 사용자 경험 데이터를 분석하였다. 스마트 폰 사용자 경험 데이터는 소셜 미디어 (트위터)에서 Social Metrics라는 프로그램을 사용하였으며, 수집된 사용자 경험 데이터를 사용자의 스마트 제품의 특성에 따라 분류하였다. 분류 결과, 모든 특성 차원에서 스마트 폰 관련 긍정적인 경험들이 많이 발생한 것으로 나타났으며, multi-functionality와 connectivity 차원에서만 부정적인 경험도 같이 많이 발생한 것으로 나타났다.

둘째, phase II에서는 DRM (Day Reconstruction Method)과 SOM (Self-Organizing Map)을 통해 사용자의 니즈를 분석하는 것이다. 보다 자연스러운 사용 환경에서의 사용자 경험과 장기적인 사용자 경험 데이터를 수집하기 위해서 DRM을 스마트 TV를 대상으로 수행하였다. 또한, 수집된 데이터들을 보다 효과적이고 효율적으로 분석하기 위해서 clustering 분석 기법의 하나인 SOM을 사용하였다. 분석 결과, 총 330개의 스마트 TV 사용 경험 데이터들을 수집하였고, 이를 총 15개의 집단으로 분류할 수 있었다.

셋째, phase III에서는 phase I과 II의 결과를 활용하여 스마트 제품 및 서비스를 위한 새로운 아이디어나 컨셉을 개발하는 것이다. 스마트 TV를 case study로 수행한 결과, 5개의 사용자 경험 에피소드를 사용하여 7개의 아이디어 및 컨셉을 개발하였다.

마지막으로, 새로운 아이디어들을 idea quality와 product smartness를 활용하여 개발자와 연구자들을 대상으로 평가하였다. 이를 통해, idea quality와 product smartness가 아이디어에 대한 전체 만족도와의 관계를 파악하였다. 이를 이해 우선, idea quality를 평가하는 지표들을 기존 연구와 전문가 인터뷰를 통해 개발하였다. 그리고 product smartness를 평가하는 지표들은 phase I에서 개발한 가설 모형을 사용하였다. 평가 결과, idea quality 지표 중에서는 ‘relevance’가 아이디어 만족에 가장 중요한 영향을 주는 것으로 나타났으며, ‘workability’는 유의하지 않은 것으로 나타났다. 또한, product smartness 지표 중에서는 ‘autonomy’가 가장 중요한 지표로 나타났지만, ‘multi-functionality’는 유의하지 않은 것으로 나타났다.

본 연구는 스마트 제품 관련 연구자와 개발자들에게 새로운 스마트 제품을 개발하거나 개선하는데 도움을 줄 수 있을 것으로 기대한다. 본 연구에서 제안하는 전체 단계를 따라 스마트 제품을 위한 신규 아이디어를 개발할 수도 있지만, 각 단계에서 사용한 방법들을 통해 다른 아이디어 개발 방법에 사용할 수도 있을 것이다. 또한, idea quality와 product smartness가 만족도에 어떠한 영향을 주는지 파악한 것을 통해서 전략적으로 아이디어나 제품을 개발할 수 있는데 도움을 줄 수 있을 것으로 기대해본다.

주요어: Smart Product, Product Smartness, User experience (UX), User Implicit Needs, Idea/Concept Generation, Idea/Concept Evaluation
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