The Exploration of Smart Object Design Method — Applying User Experience Five Elements for Smart Object Design from Theory Research to Design Practice

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Abstract. The smart object are the products that combines sensors, actuators, memory capabilities, and they can exchange information with a smart phone, allowing users to control them at a distance and to collect data in everyday life. It gradually become the daily necessities around us and it is changing our life into a new age. Technology becomes a vital force to enhance the experience of smart objects. Therefore, technology and user experience had become the elements for smart objects design, this trend also making the design methods (Rowland, etc. 2015) to change from traditional non-smart products to smart products. This research was intended to discuss a new approach to design a smart product by referenced the five elements of user experience theory that proposed by Jesse James Garrett, which is based on user experience of web design. And we assume to use this theoretical model to physical interactive smart objects design, to find whether it could guide to the process of product design from the aspect of user experience, to explore the feasibility and possibility to transform it from the virtual product to the tangible product. What’s more, we conducted a smart product design practice as an experiment to verify this hypothesis. Thus, this paper is discussing this theory research as well as the process and the result of this practice.

1. Introduction

This research was intended to discuss a new approach to design a smart product. We began our analysis with the research of design methods in traditional product design and smart object design and we considered that designing a smart object need to be more emphasis on designing the experience of the user. Because of that, we referenced the five elements of UX theory that proposed by Jesse James Garrett[1], which is based on UX of web design. And we assume to use this theoretical model to physical interactive smart objects design, to find whether it could guide to the process of product design from the aspect of UX, to explore the feasibility and possibility to transform it from the virtual product to the tangible product. After the theory investigation, we conduct a design practice of design a smart pill box for elders, it is a simple function product for a user group who have the least knowledge of technology, therefore we could focus on the process and find the possibility of using the five elements of UX theory to design a smart product.

2. The design of smart objects

2.1. The characteristic of smart objects
The concept Smart Object had been proposed in the 1990s by the term ubiquitous computing originated, from smart tangible objects to smart virtual objects, in contrast to smart virtual objects used in virtual worlds, the smart objects are described as "objects connected to the Net; objects that can sense their users and display smart behavior." And in the 2010s, smart objects are being proposed as a key enabler for the vision of the Internet of Things[2].

Therefore, with the rapid development of IoT and other modern technologies, smart objects become a rising commodity in our life. Conversely, nowadays, most of the smart objects are be designed out based on the traditional products which just integrated with new technology, such as smart watches, smart glasses, smart phones and so on. These objects make up our brave, new connected world. The types and numbers of these devices are growing by the day, to a possible 50 billion objects by 2020, according to the Cisco report[3].

In a sense, when designing these products, designers add new technologies to the traditional products and make them smart, which means that in more cases, the interaction design incorporates into the product design field. However, since the difference from the traditional products, smart objects enhances the interaction with not only people but also with other smart objects[4]. Therefore, the interactive features of smart objects should also consider how to combine the needs of users with advanced intelligent technologies to find the corresponding points and find the proper way of interaction, so that people can fully enjoy the convenience of intelligent products. This is to say when designing smart objects, designers should pay more attention to the process of Human-Product interaction and the UX when users using the product beyond functions.

2.2. Technology as a new issue to be concerned in smart product design

As we discussed above, the product becomes smart by digital technology, the technology is the force to realize new features and functions, the function of smart objects is richer and more intelligent than the traditional ones, which means that the users may more active to interact with the product in a form of visible or invisible, such as data monitoring, app interaction and cloud analysis. In this respect, designing smart objects is a creative activity to think about how to use appropriate technology to satisfy the specific need for specific users, and products are the physical expression of the solutions. Comparing with traditional non-smart product design, to concern the digital technology application is a challenge of smart objects design, and promoting designers to produce new design methods. For instance, a designer should to possess more knowledge about the technologies they intend to use, including their features, operating principles, and implementation approaches, technology application is one of the main objects to concern through the entire design process, from the appropriateness to feasibility, and have to discuss and cooperate with the relevant engineer more frequently. Design should provide the connective tissue between people and technology, we must consider the outputs of these technologies — what people need and want[3].

2.3. Smart objects focus on UX

As we discussed above, with the interactive operation character of smart objects, users have to operate these products frequently to form interaction, however, with the different education, cultural background and habits, users are totally different, especially using the technology related product. It reflects that the UX is a critical factor and competitiveness for a smart object. However, the situation of UX is not good enough for the users when they use this kind of product. The UX of many IoT products is some way off the level expected of mature consumer products[5], it is another reason for developing better UX in design. Therefore, UX and interaction design have to be concerned as an important strategy for the producer.

Meanwhile, after a research of UX design methods, we found that designing a smart object is mainly about investigating the user, the function of the product and the scenario. As an instance, a consumer journey map is a diagram that explores the multiple or invisible steps taken by consumers as they engage with the service in which allows designers to frame the consumer’s motivations and needs in each step of the journey, creating design solutions that are appropriate for each. In other words,
designing a smart interactive object is the process of designing a UX of a product which requires a deep understanding of the real needs of the user from the user's perspective.

3. The theoretical model of elements of UX in physical smart objects

3.1. Analysis of the elements of UX
As we design the entire process of UX, we need to take into account every possibility of every action a user may take and also to understand the user's expectations at each step of the process. Jesse James Garrett proposed the theoretical model of elements of UX in his book *The Elements of UX: User-Centered Design for the Web and Beyond*. He breaks down the task of designing UX for website into five planes, the surface plane, the skeleton plane, the structure plane, the scope plane and the strategy plane (Figure 1).

![Figure 1](image_url)

**Figure 1.** The theoretical model of elements of UX

On the top of the model is surface plane. That is a plane in which you could see a series of web pages, made up of images and text. It provides a way that you feel the product which includes how to arrange these information elements and how to present them in a designed way. Beneath that surface is the skeleton of the site: the placement of buttons, controls, photos, and blocks of text. The skeleton is designed to optimize the arrangement of these elements for maximum effect and efficiency. The elements of structural plane determine the various features of the site and the way how functions combine, reasonable arrangements for the distribution of information structure as well as the distinction between the importance of information. These elements can be implemented into the interactive design and information architecture part of the product. The elements of scope plane define the way in which the various features and functions of the site fit together. The scope of the site could be more detailed through these elements and they help to define the need clearly at the same time, such as brand demand, technology demand. And at last, the elements of strategic plane solve the problem of the business scope of a website and the features of it. This plane includes the goal of product and the user needs, the elements in this plane is the foundation of a decision-making process of UX.

These five planes, strategy, scope, structure, skeleton, and surface provide a conceptual framework in which we can talk about the problems of UX and different tools to solve them on different planes. Although this theoretical model is designed and summarized for web design, we argue that the essence of UX which be used in physical smart objects is similar in most of these phases, even all of them.

3.2. UX five Elements and the smart product design process
According to the analysis of these elements, we found that on the lowest plane, we don’t need to concern with the final shape of the site, product, or service at all—we only need to care about how the site will fit into our strategy, the same as meeting the needs of our users in a physical product. More than that, on the highest plane, in surface plane, we are only concerned with the most concrete details of the appearance of the product. In other words, each plane has an independent character and meanwhile it is dependent on the planes below it (Figure 2).

Given this, we assume to use the theoretical model of elements of UX into the design process of physical smart object. We would like to use this theoretical model to evaluate and measure the UX in the design process of physical smart objects, comparing the design practice with the theoretical model, and then summarize the design process and its method.

3.3. Using UX five Elements to design a smart object

After the theory research, we started our design practice, and to find emerging issues which can be designed in our society. We found that in this information age, the traditional medical industry in some aspect that how to use information technology to enhance the experience of treatment of patients, improve the quality of service management and tracking, and reduce the medical cost and other aspects are very backward. Furthermore, in recent years, with the advent of mobile health, combined with the use of wearable devices by users, mobile medical services can be moved over the Internet to adjust the configuration of existing medical resources and improve the quality of medical services.

Another serious issue we found is that the elderly who is the core medical treated group in our society can rarely use the Internet and mobile devices. Even though it seems very easy to get to know the smart object for us, but for the old generation is still a problem. Besides, it is well-known that the diseases most of the elderly suffer from requiring regular medical referral or examination for seeking medical advice from the doctor. If we can monitor physical condition through the mobile medical technology, which can help them save the time and effort to run to the hospital for minor illnesses. Because of that, the pill box as the most important stuff around them every day and we also give this design a name “Walking Pill” which mean a pill box can be brought everywhere and every time. How to intelligentise it with their familiar user habits, has become the purpose of this design practice.

4. Design process of the Walking Pill by using five elements of UX

4.1. Phase one: Strategy Plane in Walking Pill

The strategy of a product is the main core of the whole UX process, just like we always concern about the real needs of the user when we design a physical product. Knowing both what we want the product
to accomplish for our organization and what we want it to accomplish for our users informs the decisions we have to make about every aspect of the UX [4]. In the design practice of Walking Pill, from the beginning, we define the product objectives and user needs in this plane which could be considered as the foundation for every decision in our process as we design the UX[6][7].

After the topic been decided, firstly we started from the research of background of the medical system in China and tried to find out the existing and emerging issues in it. According to the research of background, we found that a quarter of the elderly population are suffering from chronic diseases in China and people over the age of 60 accounted for the majority which is a serious problem for the society at the moment (Figure 3).

**Figure 3.** Background of current state of health care treatment in China

Furthermore, we analysed the competitive products in the market. Because of the development of technology, now we have dozens of smart medical products but most of them are lack of humanistic care. We argue that combining science and emotion will be a chance to build a closer relation between people. Some of the smart devices are too complicated for elderly which means they should learn and remember steps before learning how to use it which makes them anxiety and depressed.

In response to these problems found above, we made a preliminary summary in which the product objectives and user needs of strategy plane are gradually clear. With this clear sense of what we want and what our users want, we can figure out how to satisfy all those strategic objectives and move on to the next plane (Figure 4).
4.2. Phase two: Scope Plane in Walking Pill

On this plane, strategy becomes scope when we translate user needs and product objectives into specific requirements for what content and functionality the product will offer to users[4]. Different from strategy plane, we start from the abstract question of “Why are we making this product?” that we dealt with in the strategy plane and build upon it with a new question: “What are we going to make?”. We argue that on this plane we will mainly think about how to define the need of the user and as a result, a product that was an ever-changing mishmash of features in various stages of completeness will appear.

When the scope plane is used in web design, this plane is divided into two parts, the Web as a vehicle for functionality and the Web as an information medium starts coming into play. Content and functionality seem just about as different as two things could be, but when it comes to defining scope, they can be addressed in very similar ways. Transform this to the design practice of Walking Pill, we can easily find that a conclusion based on functionality and user needs has been draw. Walking Pill can be considered as a smart pill-box with sensors to detect life characteristics which is designed for the elderly who has chronic diseases and has the function of Internet connected.

Secondly, according to the scope plane in web design, another point is that the functions of the product need to be prioritized. In response to the functions that we preconceived, we argue that Walking Pill can not only remind the elderly to take medication accurate by light and voice, but also can through the built-in sensor to measure the life characteristics of them such as heart rate, blood glucose, blood pressure, etc. What's more, it works with an app which can be connected to the Internet and these data will promptly inform the family members and doctors via an app. Apart from that, this cooperation system also includes a personal medical cloud database from which doctors can keep track of the physical data of the user.

That’s the definition of Walking Pill that we proposed on this plane.

4.3. Phase three: Structure Plane in Walking Pill

After the requirements have been defined and prioritized, we have a clear picture of what will be included in the final product. Therefore, the problem that we need to solve in this plane it that how the pieces fit together to form a cohesive whole [4].

In traditional software development, such as web design, the discipline involved in creating a structured experience for the user is known as interaction design. And through the information
architecture can help us to build the further UX of product. Interaction design and information architecture are all emphasis on defining patterns and sequences in which options will be presented to users. Therefore, we believe that when we design a smart object, on this plane, we need to think about the structure of the product, as an instance, how many parts should be involved and what is the workflow of them and even consider about the connection between different parts. The structure of Walking Pill is below:

The whole system consists of three parts: Pill box, database machine and app. Pill box is the terminal part in this system. By carrying the it all the time, it can measure the physical data of the user at any time and these data will be uploaded to the cloud database in which could be shared with family members and doctors. As the base and charging station which is always at home, the database machine is responsible for the data transmission cooperation and update with the Walking Pill. Besides, there’s also an App especially designed for the user’s children. They can monitor their parents’ physical data through this app. If something wrong, the voice function can help them send a voice message to the terminal device—Walking Pill and it will be played immediately to remind their parents in which humanistic care between patient and their children can be reflected. (Figure 5).

**Figure 5.** The composition and structure of Walking Pill

4.4. Phase four: Skeleton Plane in Walking Pill

On the skeleton plane, we need to define what form that functionality will take which means our concerns exist almost exclusively at the smaller scale of individual components and their relationships. In web design, the skeleton plane consists of three parts, interface design, navigation design and information design. Three parts are always closely bound together and among this, we usually define the framework through interface design, such as the familiar realm of buttons, fields, and other interface components. And navigation design need to provide users with the ability to go places or a direction and then try to communicate ideas to the user by information design [4].

When we design the app as an apart of Walking Pill, especially for the children of the elderly, we always concern about the connection between app and the terminal device—pill box, try to think over the functions that the user need in the app as well as the further instructions triggered by app. Our interface design in total consists of three parts: Home page, for watch the overall physical data transmitted from the pill box terminal includes blood pressure page, blood sugar page, heart rate page and steps page. The data pages can be triggered by touching the diagram to track the details of these four main sectors. As for the function page, the children of the elderly who will be the user of app in most cases, could send the voice message to the pill box terminal through this page. Furthermore, the voice transmission function is better able to help children push their care through the mobile app to the pill box which will playing the voice message automatically after received it, it the concern of technology application (Figure 6).
To more concern about the usage of the pill box, the elderly is our audience group who has the special needs of feeling, hearing and touching. There is a button on the top of pill box in order control reminder stop and play. More than that, taking into account the reasons for the hearing loss of some elderly people, we also added a breath light design feature into the device, which will also light up while the voice plays.

4.5. Phase five: Surface Plane in Walking Pill

This plane is a plane that we need to turn our attention to the combination of all the elements, such as content, functionality, and aesthetics in order to produce a finished design that pleases the senses while fulfilling all the goals of the other four planes[4].

Every detail in the final form of a product can be perceived by the user. This determines at the end of the entire design process, how everything about our design will manifest to people’s senses and the five senses of human (vision, hearing, touch, smell, and taste) are the key factors to influence the success of experience for a product.

In our design practice, the main three parts that we used from these five senses are vision, hearing and touch. When we design the Walking Pill, we took into the consideration that the hearing and vision capability of the elderly are gradually tend to weak, so that we used voice and breathing lights to remind them to take medicine and also with the help of the screen to visually remind them of the types and quantities of medicine should be taken. On the other hand, when the elderly touches the Walking Pill, it will automatically turn to the monitoring mode and monitor physical data of the user at the same time. These data will be automatically transmitted to APP and the cloud which can be monitored by their children. From the “touch sense” point, we use silicone as the main material of Walking Pill, in order to give the user a touch sense of soft feeling. The change of patient's physical situation is recorded in little by little which is a long process. Therefore, we hope that the appearance of this device looks like a water-drop, in which attached a moral of day by day recording and with the
white color body shape, will give the user the most kind of sensory experience in the overall appearance (Figure 7).

![Figure 7. Final design of Walking Pill](image)

5. The result and its evaluation

As a result, the design practice of Walking Pill has a total of three main design essentials:

Firstly, we intelligentised a normal pill box by integrating some of the technical characteristics of the wearable device in the moment as well as the concept of mobile medical treatment in which vested with emotional elements and five senses experience, try to enhance the UX quality of this product. Meanwhile, we transformed the pill box into an extension of the voice, vision and hearing sense of the user’s child and so that they can pay more attention to the changes of their parents’ physical data by smart phones.

Secondly, we combined with the concept of mobile medical and used big data, which is as an instance, big data transmission via cloud, data statistics and physical trend analysis. Data collected by the user terminal, which helps the doctor timely diagnose and timely adjust the dosage, makes targeted treatment according to different situations. Meanwhile, with the help of technology, it is also conducive to boost the bonds and exchange the feelings between patients, family members and doctors which also quite meaningful to eliminate the contradictions of relationship between doctors and patients.

Last but not least, we choose a daily carrier of the patient which they need to use every day and this design practice so that the mobile medical and its popularization can truly be achieved. By giving users a better experience, making the using process more convenient as well as provide users with better medical treatment through more comprehensive and specific services will be the future of development.
Through the design practice of walking pill, we try to apply the five elements of UX to the design of a physical smart object. In this design process, we constantly adjust the design process of smart object at different planes according to the definition of different planes, the content and theoretical models of them (Figure 8). As an instance, on the strategy plane, we mainly consider the new features of smart products which are different from traditional products, their audiences and other factors, as well as the users' demands. In short, we use a design brief, it was understandable and reasonable for everyone, especially for the designers, developers, project managers—the strategy document to make informed decisions about their work. When we move on to the next plane—scope plane, the scope is a limitation of not only the design process but also all the factors which are related to the design objective, in our design practice, the scope made us to define the features of our product, it will be a smart pill-box with sensors to detect life characteristics designed for the elderly who has chronic diseases and has the function of Internet connected. Based on that, we sorted the priority of functions according to the user needs and easily get to the final destination of scope setting. After the requirements have been defined, we have a clear picture of what will be included in the final product. Developing a conceptual structure for the product is what we do on structure plane, the pill box will include a smartphone application and a connected device in general. This plane also helps us to find out the constituent part of the whole object and define the different functions of them. Thus, the three main modules of Walking Pill are three parts—Pill box, database machine and app have been developed on this plane. For skeleton plane and surface plane, we developed the interaction process and workflow of the App. Moving up to the surface plane, the priority of design object changes. Through attention to information design, we determine how to organize and arrange the information elements of the app interface; through attention to visual design, we determine how that arrangement should be presented visually. More than that, we also introduce the concept of five senses which is significant for designing the appearance of Walking Pill. The shape of the product and the completeness of system is more valid by referencing the key elements on surface plane.

6. Conclusion
With the development of technology and society, people have higher requirements for living standards and quality of life. Therefore, the number and category of new emerging products are increasing. Traditional products in the origin design context has been technologically transformed, the emergence of new technologies spawned the continuous development of the smart product industry. It’s also obvious that the advent of smart products continues to simplify our lives and make many complex things become easier which is also a new challenge for designers to change their mind and to enhance the new knowledge.
According to the experiment of Walking Pill project, we try to transform and apply the UX five elements theory into the design of smart object. From the aspect of design, we have a hypothesis that these five elements including the entire design process more or less not only for website design but also for product design. Through the practice experiment, we find there are actually the connection between UX five elements and the smart object design process, and we always keep in mind to think the design process of Walking Pill with this UX five elements and try to integrate them together. Different from websites, the design process of smart objects contains multiple dimensions and more complex design essentials, especially the technology is the important issue to concern about, and have to use approaches to think its appropriateness and feasibility. Therefore, this design practice is a starting point for designers to propose an assumption that how to use other design methodology or theoretical model to design a smart object and no doubt it is quite essential to have more explorations of the smart object and experiments from other different aspects in the future work.

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