Human interface design for controlling home appliances with cellular phones

Haeinn Lee
Iowa State University

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Human interface design for controlling home appliances with cellular phones

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Haeinn Lee

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Sunghyun Ryoo Kang, Major Professor
Roger Baer
Patrick Patterson

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Graduate College
Iowa State University

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Haeinn Lee

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ABSTRACT

In spite of having highly developed technology, the majority of people feel too uncomfortable with the technology to use it efficiently. This problem is intimately linked with the interface design of the products. The role of interface design is to enable communication between people and the technical product such as a cellular phone, computer, or PDA. To use the product successfully, the interface design should be easy to use. The objective of this thesis is to create a practical and user-friendly interface design for a wireless device to control home appliances. In order to control home appliances with a cellular phone, the author suggests a natural (intuitive) interface design that is friendly and attractive to users, based on their experience, and effectively uses graphic elements such as layout, icon, color, and text. As part of this natural (intuitive) interface design, the author suggests using a wheel key to control a cursor system for navigating a cellular phone screen. A usability test was conducted to determine problems people have while using the prototype. The results of the usability test indicated that the user interface was successful, and participants were satisfied with the prototype.
CHAPTER 1. INTRODUCTION

Various technologies in our world today are improving our daily lives and becoming more widely used. This is especially true for cellular phones, which are improving with increasing speed due to improving computer and technology communication. In the past, the cellular phone has been used mainly as a telephone, but now people use it as a camera with the capabilities to connect to the Internet. This prospect opens the possibility for these devices to manage all kinds of information equipment. Additionally as computers are miniaturized and become more economical, they are becoming more ubiquitous. In the past, people have implemented the real world in computers and simulated it, but now, small computers are implemented into physical objects and are scattered all over the world in various and useful applications. In particular, much interest has been directed toward wireless technology, which is sparking another new revolution in our society.

With cameras and web integration, wireless technology is already moving beyond simple phone communication, but in the future, wireless devices will have various uses. For example, people could access the Internet using the cellular phone, control home appliances, control the temperatures of our homes, protect our homes from robbery, and perform a variety of other functions. These things are not imaginary, but will happen in the near future. In fact, the wireless technology has already been developed to produce these products. At this time, a cellular phone is being produced with a camera, Internet capabilities, and the functionality to control home appliances. This product will be released in the near future.

However, this product’s interface is a text-based, menu-driven interface design that appears to have no interest in usability. As a result, it is very technical in its operation, which
makes it very inconvenient and complicated, thus limiting its distribution. According to a research paper of *WAP Usability* by Jakob Nielsen (2004, p.40), a cellular phone user commented “It’s tortuous to read because you are reading a teeny little screen, it is actually quite painful to read, and unpleasant”. Jakob Nielsen mentioned that it is not surprising cellular phone users do not want to read a lot of text. This illustrates that the user interface has not been sufficiently developed and needs more work.

Actually human interface design has received much attention and numerous studies have attempted to find and explore what makes a good interface. However the majority of these studies had a general perspective and was not very specific, so that people feel too uncomfortable to use the technology efficiently. Therefore, my aim in this research is to approach a more practical, and visual point of interface design based on people’s experience and graphic elements in order to make a user-friendly interface design. This is not only designing the interface to make it eye-catching, but also designing the interface to work with people’s natural inclinations in terms of their experience. Therefore, my research project would address the use of cellular phones to control home appliances with a friendly interface design that will make the technology easier to use.

The literature review will include 1) Wireless Technology 2) The element of human interface design 3) Human interface design in cellular phones. The first chapter will provide the technical conditions involved in the development of human interface design. The second section of human interface design aspect helps user aware what is design elements of human interface design in wireless/cell-phone, and what about existing examples of problems, and display design etc. The third section of design elements in wireless/cell-phone describes certain distinction between designs in small screen vs. web based design in the computer
screen, also what is the possibility and limitation for the small screen. Thus author will show some examples of existing screen design to control home appliances.

The procedural of this thesis, author will create a prototype for the human interface design to control the home appliances. Consider the design element by using the criteria developed in the literature review, author will apply those facts into my human interface design, and simulate a prototype in computer screen. After create the prototype, author will conduct a usability test which is one of the most important methods for finding users’ practical suggestions, and finding problems. Through this usability testing, author will examine the use of interface design; simple, efficient, and easy to learn.
CHAPTER 2. LITERATURE REVIEW

A. Wireless technology

1. The overview of wireless application technology

   Electrical Numerical Integrator and Calculator (ENIAC), which was developed in 1946, was the starting point of the computer age. History of computers is less than 60 years, however, peoples’ lives changed rapidly with computer technology. After A. Graham Bell invented the telephone in 1890, communication was mainly focused on message which transmitted by voice. However, the Internet has risen dramatically over the past decade and transformed our lives as part of the information revolution. Figure 2.1 shows the number of Internet users. According this graph, Internet usage is increasing every year, and it has not reached saturation (KRNic search engine 2004)

![Figure 2.1 The number of Internet users from 1994 to 2004](image)
According to Clark, the Internet is used for computer communication and related areas. In the beginning, people used it for the transmission of computer data or electronic mail. After T.B. Lee invented the World Wide Web in 1993, the Internet and its usage was increased. Now it is used for additional purposes such as E-commerce, education, and administration.

Likewise, advanced technology that is related to the Internet promises the influx of ubiquitous generation, so that computers can be scattered all over the world and exchange information with each other. The Internet is connected with computer equipment such as computers, printers, cellular phone and PDAs, but in the future, there will be a variety of equipment that can be connected to the Internet. For example, the Internet can be connected with cameras, so that people can use a watch to display what the cameras record. Also we can use the Internet to remotely control home appliances such as heaters and air conditioners from outside of home. Along with various kinds of sensors, a USN (Ubiquitous Sensor Network) can be connected with the Internet and used for the compilation of data. Furthermore, a factory’s equipment can be connected with the Internet as part of an automatic operation system. (Etrick 2003; A. R. Al-Ali and M. Al-Rousan May 2004)

Along with the Internet, wireless communication also experienced strong growth. Originally, voice communication was primarily available with wire-based telephone networks, but wireless communication technology such as Code Division Multiple Access (CDMA) developed and is starting to spread all over the world, and mobile telephone has evolved to become a basic commodity in the United States and many parts of Europe, as well as Asia.
The world’s largest manufactures of mobile phones predict that there will be 1 billion telephones in use in five years time. Currently, mobile communication is still mostly synonymous with voice telephony, but this is almost certain to change pending new mobile data communication technologies being deployed, increasing data speeds and improving usability (Bjork, Bretan, et al. p.1)

Along with the increase in subscribers, cellular phone technology has improved in its capabilities. Cellular phone technology has passed through the first and second generations, and now it is in the third generation shows in Figure 2.2 (Gigap Kwan Feb 2004)

![Figure 2.2 Changes in cellular phone technology for each generation](image)

The first generation was used for voice communication and was based on an analog signal. The second generation added the capabilities of data forwarding and E-mail which was based on a digital signal. The third generation improved wireless communication speeds up to 2 Mbps (10 times faster than the second generation). This speed increase allowed sending movie files in a cellular phone network. The fourth generation will operate with an integrated...
network of combined wired, wireless, broadcasting, and satellite technologies. (Gigap Kwan Feb 2004)

Figure 2.3 shows how cellular phones used in different areas. (Jongbae Bu Jan 2003)

As previously mentioned, cellular phones were used initially for voice communication, but now users demand more capabilities. For example, the demands for text messaging has increased in recent years. Also, technological advances such cellular phones with built-in cameras create new uses. In the case of the camera-phone, its memory is more than 32MB, so that, if people consider on a picture as 100KB, we can take more than three hundred pictures. (Jongbae Bu Jan 2003)

Figure 2.3 Various cellular phone applications
In addition, people are now using cellular phones as a remote control. Figure 2.4 illustrates using a cellular phone to control home appliances that are connected to the Internet. (Heeja Kim 2003)

![Controlling home appliances using a cellular phone](image)

**Figure 2.4 Controlling home appliances using a cellular phone**

2. Research on cellular phone technology

Figure 2.5 shows the development of cellular phone technology. (Jongryung Seo Nov 2000) In the second generation, people were used to a black LCD and a low functionality for data transmission. Using WAP, it was possible to use a low-level wireless Internet. In the change to the 2.5 generation, cellular phones started to have a color LCD. Furthermore, cellular phones with a built-in GPS (Global Positioning System) were possible to aid navigation. Finally, cellular phones with cameras appeared in the 2.5 generation. In the third generation, cellular phones can have a TFT LCD screen, a highly efficient CPU, and large
memories that allow people to see movie files and hear MP3 files. Henceforth, people can predict that many things such as virtual reality or a variety of text message recognition capabilities are going to be present in the fourth generation. (Electronic and information newspaper 2003)

![Figure 2.5 The sequence of cellular phone technology](image)

3. **Identification of problems of current wireless technology for a user’s need**

Figure 2.6 shows that the main method for using a cellular phone as a remote control is to implement a menu-driven interface design. (Donggyun Kim 2001) Also mostly the product’s interface is provided with text-based, menu-driven interface design that appears to have no interest in usability. As a result, it is very technical in its operation, which makes it very inconvenient and complicated, thus limiting its distribution. According to a research paper of *WAP Usability* by Jakob Nielsen, a cellular phone user commented “It’s tortuous to read because you are reading a teeny little screen, it is actually quite painful to read, and unpleasant”. Jakob Nielsen mentioned that it is not surprising cellular phone users do not want to read a lot of text. This illustrates that the user interface has not been sufficiently
developed and needs more work. Therefore, the objective of this thesis is to create practical and user friendly interface design, at the same time, for wireless device to control home.

![The design of a menu driven interface](image)

**Figure 2.6 The design of a menu driven interface**

B. The elements of human interface design

1. The importance of experience and emotion design in human interface design

   Today the focus is mainly on technology not on the people using the technology. Especially current cellular phone interface is a text-based, menu-driven interface design that appears to have no interest in usability. Therefore, it operates technically well, but it is inconvenient and has not been sufficiently developed, so that people have problems using the interface design smoothly. This problem is intimately linked with the interface design of the product. Interface design is the ways that people accomplish tasks with a product, what they do and how it responds (Raskin 2000, p.2). The role of interface design is that it is the method of communication between people and technical products. The users’ ability to finish their task successfully is due to the performance of the interface design. Then what is human
interface design? Human interface design is designing an environment that creates user satisfaction. The resulting interfaces are easy, natural, and pleasant to use. This means not only designing the interface to make it eye-catching, but also designing the interface to work with people’s natural inclinations in terms of their experience and emotional response. Briefly, the designer should create an interface that people really need, enjoy, and comfortable to use.

One of the most laudatory terms used to describe an interface design is to say that is ‘intuitive,’ and this term can be replaced with the ordinary but more accurate term ‘familiar’ (Raskin, 2000, p.195). Moreover, researchers state clearly that natural and intuitive design is the one of the goals for interface design. Accordingly, to design as intuitively and naturally as possible, the designer should consider the user’s experience and emotions, so that the user can predict the structure of the interface and be able to use the interface easily and proficiently. Furthermore, the designer needs to help the user develop habits that improve the flow of their task (Raskin 2000).

With these interface design improvements, the result is a design that is easier to learn and remember. According to Information Appliances & Beyond (Bergman 2000), ease of learning the interface and remembering the interface for the long term are more important than any other factors because the user must be able to get tasks done quickly and efficiently. These facts are all relative to the user’s experience and emotional responses because interface elements that are familiar and engage people cognitively will be easier to remember and use. Therefore, when designers create an interface design, they need to take into consideration the user’s experience and emotions so that the user can predict the best way to accomplish the desired task from observing several graphical cues. It will be a successful interface design if
users can correctly predict how to use the interface by viewing graphical cues and then manipulating the interface to achieve the task. The book *Visual Interface* described the importance of predictability. Interface design should simplify the communication task by preparing the user to respond to a number of familiar patterns in a predictable manner. Then the interface will be easier to learn, easier to remember, and easier to apply correctly when a quick decision is required. For example, the critical nature of the information being conveyed means that traffic signage must be familiar enough to be processed accurately even in the absence of focused attention (Mullet, Sano 1995).

This thesis addresses cellular phone screen interface design and its environment which the user will use the cellular phone. Because cellular phones are often used outside, the user would find concentrating on the task more difficult due to environmental factors such as noise. In this case, the most important aspect of interface design is that the user must be able to make quick decisions while using familiar design patterns without thinking carefully. The familiar “look and feel” of standard GUI environments such as the Macintosh Desktop or Microsoft Windows helps users to know what to expect when a new dialog box appears. The consistent appearance, placement, and meaning of important visual cues make it easier for users to interpret and respond to new situations as they arise (Mullet 2001, p. 145). From the book *Human computer interaction*, visual comprehension can be summarized as “what you see depends on what you look at and what you know” (Mullet 2001, p. 247).

**Emotion design in human interface design**

As Donald Norman pointed out in the book *Emotional Design*, attractive designs certainly should be preferred over ugly ones. Attractive designs always make people feel
good, which makes them think more creatively. So those attractive and eye-catching designs are created with graphic elements such as color, type, layout, and icons. These graphic elements will be covered more detail in the next chapter. If designers want to catch a user’s attention, they cannot ignore the emotional component. For example, using color to evoke emotion is by far the most common form of color usage. We do not live in a black-and-white world like the one portrayed by the film *Pleasantville*. Rather, we live in a colorful world that is filled with emotions, feelings, and associations (Rockport publishers 2004, p.95).

Therefore let us look at emotional design from a general point of view. According to *Emotional design* by Donald Norman, Emotions aid in decision making. Positive emotions are critical to learning, curiosity, and creative thought, and current research is starting to investigate the role of emotion. Researchers have discovered that when people feel good; they are better at brainstorming. Also someone who is relaxed and in a pleasant mood is more creative and more able to overlook and cope with minor problems with a device especially if the device is fun to use. “We also need to build products that bring joy and excitement, pleasure and fun, beauty, to people’s lives” (Norman 2004, HCI 19(4)). Therefore, creating positive emotions in users is an important part of interface design that should not be missed by designers. In this regards, Frank Splillers points out *What does emotion have to do with design*:

Emotion is one of the strongest differentiators in user experience namely because it triggers unconscious responses to a product, website, environment or interface. Our feelings strongly influence our perceptions and often frame how we think about or refer to our experiences at a later date. When we think about emotion design and usability, we typically think of it as “keeping the user happy.” This includes designing to minimize the common emotions related to poor usability such as frustration, annoyance, anger and confusion. (Spillers 2004)
Donald Norman suggested three elements that are important to emotional design. As mentioned before, their attractiveness produces positive emotions, causing mental processes to be more creative and more tolerant of minor difficulties. The three levels of mental processing lead to three corresponding forms of design: visceral, behavioral, and reflective. Each plays a critical role in human behavior and an equally critical role in the design, marketing, and use of products. Visceral design is about how shape and form matter and how the physical feel and texture of the materials matter. Visceral design is all about immediate emotional impact. It has to feel good and look good. Therefore visceral design is about initial reactions, so that it really relies on good graphics, cleanliness, and beauty. Behavioral design is not about appearance. It focuses on the importance of functionality, understandability, usability, and physical feel; it is about ease and effectiveness of use. Therefore designers have to consider what users need, and that users immediately notice important elements. Lastly, reflective design is about message, about culture, and about the meaning of a product or its use. When designing a human interface design, the designer should consider these three forms of emotional design. Therefore, “users are more likely to see the forest than the trees, to prefer the big picture and not to concentrate upon details” (Norman 2003).

**Experience design in human interface design**

The paper *Visual design principles for usable interfaces*, when discussing experience design says, “The heart of interface design is in the definition and creation of design of the user’s experience. What is it really like for people facing the monitor, using a cell phone or an ATM?” Although the introduction rate of new technological devices is expanding everyday, the users’ ability to understand, uses, and integrate new information and
technology has not grown at the same rate. "Making the most appropriate media choices, whether it is images, animation, or sound to explain complex ideas to widely varied audiences is no easy task" (Watzmann 2003, p.280). It is definitely hard to research every single user’s experience, but designers can get an overall image of the general experience design from existing definitions of experience design.

AIGA defines the term *experience design* as:

- A different approach to design that has wider boundaries than traditional design and that strives for creating experiences beyond just products or services.
- The view of a product or service from the entire life cycle with a customer, from before they perceive the need for it to when they discard it.
- Creating a relationship with individuals, not targeting a mass market.
- Concerned with invoking and creating an environment that connects on an emotional or value level to the customer.
- Built upon both traditional design disciplines in the creation of products, services, as well as environments in a variety of disciplines

Another definition by Nielsen Norman Group, a usability consulting company created in 1998 by the user experience experts Donald Norman, Jakob Nielsen, and Brudce Tognazzini, states that:

User experience encompasses all aspects of the end-user’s interaction with the company, its services, and its products. The first requirement for an exemplary user experience is to meet the exact needs of the customer, without fuss or bother. Next comes simplicity, an elegance that produces products that are a joy to own and a joy to use. True user experience goes far beyond giving customers what they say they want, or providing checklist features. In order to achieve high-quality user experience in a company’s offerings, there must be a seamless merging of the services of multiple disciplines, including engineering, marketing, graphical and industrial design, and interface design (Nielsen Norman Group, 2005).
When comparing the two definitions of experience design, a few common concepts can be found. The purpose of experience design is to create a ‘familiar,’ ‘intuitive,’ and ‘joyful’ design, not a single product or service. Everything the user encounter during the process: the environment, the products, the interface and other factors such as sound, and touch is crucial for creating a positive user experience. In order to make design pleasurable, experience design requires an integrated combination of many disciplines. Besides, a familiar and intuitive experience design should be useful (functionality), usable (usability) and pleasurable (pleasure, joy, fun, excitement, etc). (Wang 2005)

Suzanne Watzmann in *Visual Design Principles for Usable interfaces* discusses several guidelines for designing the user experience. First, use an effective and appropriate medium; interactive media viewed on screens have quite different characteristics and potential. Brenda Laurel mentioned that interactive media is more about the experience rather than showing information itself. Second, use consistent and appropriate visual language. This means we have to consider using clear and obvious metaphors and interface elements that are consistent with the visual style of other parts of the interface. Then user will be able to make quick decisions while using familiar design patterns without thinking carefully. These approaches to design are based on the user’s experience. Third, use consistent navigation aids. The advantage of using consistent navigation aids is as follows:

Using familiar visual elements leverages existing knowledge. Graphic standards support this as well. When using a familiar hierarchical layout, grid structure, and menu, button design, it is much easier to remember the zones in which like kinds of information appear. This ensures that whatever visual cues are applied can take advantage of the user’ experience and save time for the designer. (Watzmann 2003, p.281)
When designing the human interface, base the design on the user’s experience or expectation. The designer has to consider the perceptual and cognitive background of the users. Cognitive psychology is the study of how our minds work, how we think, how we remember, and how we learn. Perception is not simply the act of seeing. It is the combination of information obtained through our senses (seeing, hearing, tasting, smelling, and touching) with knowledge stored in memory. Perceptual systems will demand attention. This may be the result of changes in light, sound, movement, color, or complexity of the information being processed (Mandel 1997, p.37-38). For example, an animated screen background program is fun to watch. However, if the user works in a window while the animated background is running, his or her sensory system is doing a lot of unnecessary work. This extra visual processing may even cause eye strain and fatigue. It is not necessary to know cognitive psychology a professional psychologist, but at least, we have to understand the user’s mindset and general character.

2. Introduction of existing several golden rules of human interface design

This chapter will focus on an overall perspective of human interface design. Well-known interface design experts talk about general rules to make successful interface design. From a personal point of view, however, there are no rules, only guidelines. The reason is that human interface design is intimately linked with human emotion and experience, which change according to many different factors such as culture, industry, background, and situation. Therefore, the guidelines presented here are not rules that people have to follow; they are references to help designers to create good interface designs that provide a beautiful and enjoyable experience to the user.
The golden rule of design: Don’t do to others what others have done to you. Remember the things you don’t like in software interfaces you use. Then make sure you don’t do the same things to users of interfaces you design and develop. (Leonard 1996, p.47)

Users should have successful experiences with an interface design, and each positive experience increases familiarity with the interface and encourages them to expand their knowledge of the interface. Well-designed interfaces, like good educators and instructional materials, should build a teacher-student relationship that guides users to learn and enjoy what they are doing (Mandel 1997, p.48). There are three golden rules that Theo Mandel states following:

1. Place users in control of the interface
2. Reduce users’ memory load
3. Make the user interface consistent (Mandel 1997, p.48).

The interface should also give the users some flexibility to do their tasks quickly, comfortably, and efficiently, and the first principle enables users to feel satisfied after finishing their tasks. There is one good example Theo Mandel states:

Wise designers let users do their work for them rather than attempting to figure what they want. After designing a complex of buildings, an architect was supposed to design the walkways between the buildings; He did not assume that he knew how users would really use the walkways between buildings. So he didn’t design the walkways between buildings. Rather, he had fields of grass planted between the buildings. It is rumored that he even posted signs saying, “Please walk on the grass.” A few months after the buildings were completed; he came back and saw the most worn paths where people walked across the grass between buildings. Then he knew where he should put the walkways (e.g. Mandel 1997, p.52).

This is a good example of letting users be in control. The architect observed their behavior and created a design that let people know where they want to go and determine how to get there. Following are five principles that Theo Mandel discusses which help designers
accomplish the first golden rule “Place users in control of the interface.” The first golden rules are following:

1. Allow users to change focus

Interfaces should be designed so that users are able to quit their current actions or tasks and either continue later or save them in the current state. It’s easy to forget that users may not want to complete what they themselves started!

2. Provide immediate and reversible actions, and feedback

Unfortunately, users don’t have much patience, when they are working with an interface. If designers don’t provide any feedback to users, they immediately quit from where they were working. Provide users with some indication that an action has been performed, either by showing them the results of the action, or acknowledging that the action has taken place successfully.

3. Provide meaningful paths and exits

Allow users to navigate easily through the interface, and provide ways for them to get to any part of the interface they want to go. Also, since users can move easily forward or backward, through the interface structure, make them comfortable by providing some context of where they are, where they’ve been, and where they can go next. Those paths and exits help users relax and enjoy exploring the interface of the design rather than making users frustrated.

4. Accommodate users with different skill levels

Don’t sacrifice expert users for an easy-to-use interface for casual users. You must provide fast paths for experienced users. “Nothing drives experienced users crazy like having to go through too many steps to perform an action they use all the time and would like to perform using one step” (Mandel 1997, p.60).
5. Allow users to customize the interface
Users feel more comfortable and in control of the interface if they can personalize it with their favorite colors, patterns, fonts, and background graphics (Mandel 1997, p.52–62).

The second golden rule, which is “Reduce users’ memory load,” is related to how people store and remember information. The second golden rules are following:

1. Rely on recognition, not recall
Do not make users memorize. Provide natural and familiar items, people can use long-term memory to recognize rather than having to recall information.

2. Provide visual cues
A necessary role of any graphical user interface is to help users know where they are, what they are doing, and what they can do next. Visual cues serve as reminders for users.

3. Provide defaults, undo, and redo
Providing defaults, undo, and redo enable users to explore the interface design without fear. With undo and redo buttons, mistakes can be undone without serious consequences.

4. Provide interface shortcuts
“Once users are familiar with an interface design, they will look for shortcuts to speed up commonly used actions.” (Mandel 1997, p.68)

5. Use real-world metaphors
Choosing an appropriate metaphor is one of the hardest parts of interface design. Using real world metaphors make users more comfortable and the interface more familiar.

6. Promote visual clarity
Grouping items on a menu or list, numbering items, and using headings and prompt text create visual clarity. The general principles of organization, continuity, gestalt, and so on
should be followed. Presented information should be prioritized and ordered so users can understand how it is organized (Mandel 1997, p.62~71).

The third golden rule “Make the interface consistent. Consistency is a key aspect of usable interfaces.” (Mandel 1997, p.72) Users depend on consistency in interface design to quickly and easily find information. Furthermore, a consistent design is helpful to designers by saving them time as well. The third golden rules are following:

1. Maintain consistency within and across products
   Consistency applies at several levels; especially the presentation level and behavior level. Consistency in presentation means that users should see information and objects in the same logical, visual, or physical way throughout the interface design. Consistency in behavior of interface controls such as buttons, lists, and menu items should not change within or between interface designs.

2. Keep interaction results the same
   If users experience different results form the same action, they think they made a mistake instead of understanding that there was a problem with the product. Users think they must do things in exactly a certain way for the desired result to happen; otherwise they are not sure of the results. Therefore, the overall of a goal for most user interface designers has been to produce user-friendly interfaces. “A friendly interface encourages users to explore the interface to find out where things are and what happens when they do things, without fear of negative consequences”. (Mandel 1997, p.72~79)

Hence, Ben Shneiderman talks about the eight golden rules of interface design. However, this thesis will not examine these rules, because they are similar to Mandel’s rules. Ben Shneiderman also gave the guidelines for data display. A guideline document can help
by promoting consistency among multiple designers, recording practical experience, and incorporating the results of empirical studies.

**Consistency of data display**
During the design process, the terminology, abbreviations, formats, colors, capitalization, and so on should all be standardized and controlled by use of a written dictionary of these items.

**Efficient information assimilation by the user**
The format should be familiar to the operator and should be related to the tasks required to be performed with these data. This objective is served by rules for neat columns of data, left justification for alphanumerical data, right justification of integers, lining up of decimal points, proper spacing, used of comprehensible labels, and appropriate measurement units and numbers of decimal digits.

**Minimal memory load on user**
User should not be required to remember information from one screen for use on another screen. Tasks should be arranged such that a completion occurs with few actions, minimizing the chance of forgetting to perform a step. Labels and common formats should be provided for novice or intermittent users.

**Compatibility of data display with data entry**
The format of displayed information should be linked clearly to the format of the data entry. Where possible and appropriate, the output fields should also act as editable input fields.

**Flexibility for user control of data display**
User should be able to get the information from the display in the form most convenient for the task on which they are working. For example, the order of columns and sorting of rows should be easily changeable by users. (Smith and Moser, 1986. offer five high-level objectives for data display that remains vital; Source; Ben Shneiderman1998, p.80)

To get the user’s attention, information may be presented to user for the normal performance of their work, exceptional conditions or time-dependent information must be presented so as to attract attention. (Wickens 1998)

**Intensity**: Use two levels only, with limited use of high intensity to draw attention.

**Marking**: Underline, enclose in a box, point to with an arrow, or use an indicator such as an asterisk, bullet, or dash

**Size**: Use up to four sizes, with larger sizes attracting more attention.

**Choice of fonts**: Use up to three fonts
Inverse video: Use inverse coloring
Blinking: Use blinking displays (2 to 4 hertz) with great care and in limited areas
Color: Use up to four standard colors, with additional colors reserved for occasional use.
Color blinking: Use changes in color with great care and in limited areas.
Audio: Use soft tones for regular positive feedback and harsh sounds for rare emergency conditions. (Wickens 1998; Source; Ben Shneiderman 1998, p.81)

Well-known interface design experts who are Jakob Nielsen and Donald Norman recommended several golden rules. These guidelines are based on the needs and interest of user, with an emphasis of making interface usable and understandable.

1. Make it easy to determine what actions are possible at any moment
2. Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions.
3. Make it easy to evaluate the current state of the system.
4. Follow natural mappings between intentions and the required actions: between actions and the resulting effect; and between the information that is visible and the interpretation of the system state (D. Norman 1988, p.188)

Simple and Natural Dialogue
User interfaces should be simplified as much as possible, since every additional feature or item of information on a screen is one more thing to learn, one more thing to possibly misunderstand, and one more thing to search through when looking for the thing you want.

Speak the user’s language
As a part of user-centered design, the terminology in user interfaces should be based on the users’ language and not on system oriented terms.

Minimize user memory load
People have a much easier time at recognizing something that is shown to them than they have at having to recall the same information from memory without help.

Consistency
Consistency is one of the most basic usability principles. If users know that the same command or the same action will always have the same effect, they will feel more confident in using the system. (Lewis 1989)

Feedback
The system should continuously inform the user about what it is doing and how it is interpreting the user’s input. Feedback should not wait until an error situation has
occurred. The system should also provide positive feedback, and it should provide partial feedback as information becomes available.

**Shortcuts**

Even though if should be possible to operate a user interface with the knowledge of just a few general rules, it should also be possible for the experienced user to perform frequently used operations especially fast, using dialogue shortcuts.

**Clearly Marked Exits**

Users do not like to feel trapped by the computer. In order to increase the user’s feeling of being in control of the dialogue, the system should offer the user an easy way out of as many situations as possible.

**Prevent errors**

Even better than having the good error messages recommended in the previous section would be to avoid the error situation in the first place (Usability Heuristics; Jacob Nilsen 1993, p.115)

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3. **Effective information display using graphic elements in human interface design**

Human beings get information through their sight, hearing, smell, taste, and touch. Among the senses, we obtain the most information through sight. Murgio said information comes “1% through taste, 2% through touch, 4% through smell, 10% through hearing, and 83% through sight.” For example, when we describe a person’s appearance on paper, it would be very hard to describe it exactly through text, even if we express it throughout an entire book. However, if we take a video and show it to people, they immediately understand it. Similarly, visual information has strong power to communicate information. Therefore Meggs has mentioned that people have searched for ways to give visual form to ideas and concepts, to store knowledge in graphic form, and bring order and clarity to information. Therefore:

The goal of any visual device is to provide the quickest, most efficient path to understanding ideas, as well as to make it clearer and more compelling. Useful, effective graphics can act much like visual shorthand, particularly important when the
real estate of the page is limited. A good graphic can eliminate the need for text and communicate across cultures (Watzmann 2003, p.273).

Furthermore, according to Robert Jacobson’s book *Information Design*:

Subscribers to the Digest make frequent reference to graphics as aids in all manner of applications. Alan sacharff of Creative Leap International describes how he creates various sorts of models—“Physical, analog, symbolic, graphical, schematic, descriptive and pictorial”—to use in overheads, flip charts, and handouts (LOD5/96). He goes on to say that with graphics the “solution space can be suddenly expanded beyond its apparent physical reality.” In situations where many pages of explanatory text would otherwise be required, graphics can help us communicate complex matters visually and simply (Jacobson 1999, p.200).

Robert Jacobson mentions that when information is presented in graphical form and concepts are given shape, relationships among the various elements are easier to see. Furthermore, as the graphic representation is further enriched with visual information, long-term memory is triggered and even more information and perceptions can be added (Jacobson 1999, p204). Graphics of all kinds are visible everywhere, they invade every moment of our life, attempt to attract our attention, inform us, and entice us to act. Whereas once text was king and was the only tool available for computer displays, the new easier-to-use computers now abound with icons, symbols, and graphic metaphors that encourage visual thinking. As mentioned in the first chapter, the importance of graphic design is emphasized in emotional design, too. According to *Emotional design* by Donald Norman, “attractive things make people feel good, which in turn makes them think more creatively.” To make a design attractive eye-catching is determined by how graphical elements such as color, type, layout, and icons are used. Therefore, the traditional approach of graphic design, which is intimately involved with designing information and graphics, can be a powerful way to communicate if used effectively.
To design the information using graphical elements is also important part in human interface design. Robert Jacobson defines the purpose of information design in his book *Information design*, and describes human interface design.

To develop documents that is comprehensible, rapidly and accurately retrievable and easy to translate into effective action. Also to design interactions with equipment that is easy, natural, and as pleasant as possible. This involves solving many problems in the design of the human computer interface. Therefore, the values that distinguish information design from other kinds of design are efficiency and effectiveness at accomplishing the communicative purpose. (Jacobson 1999, p.16)

“Graphic design is the first and the last part of the user interface observed by the user” (Nielsen, 1994). Immediately when beginners start to look at a new software package they are confronted by its visual design and the profusion of icons, windows, panes, and dialog boxes. Even after becoming expert users, people still have to look at the icons and other visual design elements of their favorite software everyday (Nielsen, 1994), People usually think of graphic design placing pretty pictures and using gorgeous typography so that the communication’s appearance is more attractive. To be sure, a nice visual appearance is one of the important ways that we can catch a user’s attention, but it is not all. Jacob Nielsen said that in *The Design of the visual interface*, “graphic design in the user interface is not just matter of aesthetics.” There is much more at stake than simply pretty pictures, and good graphic design can significantly improve the communication value of the interface, leading to increased usability (Nielsen 1994). As a simple example, using certain color combinations are known to reduce the readability of screen text. Therefore, graphic design in the user interface is more related to ease of learning, efficiency of use, memorability; fewer user errors, and greater subject satisfaction. The visual treatment most effectively realizes the communication goal. Therefore, graphic elements are of great practical importance to
interface design. Since the topic of this thesis is human interface design in cellular phone screens, this thesis will focus more on several graphical elements that are needed in small screen interface design. For the screen design, designers have to consider Screen Layout, Typography, Icons, Color, Menu Design, Button Design, and Sound.

**Screen layout**

The starting point in screen interface design is layout. Layout is the most important graphic element that affects the overall design. Before designers can create the layout, they have to decide several things about the information in the interface: the content of the information, how much information will be put in the screen, determine the importance of the information, classify the information, and decide on a layout (Japanese human interface group 2003, P 19). For example, if it is the designer’s purpose that people should operate the system as quickly as possible, the designer will make fewer levels of hierarchy, and put a lot of information in one screen. On the other hand, if it is the designer’s purpose that people should operate the system precisely, the designer will make several levels of hierarchy and put a little of information in one screen so users make fewer errors. If people use a grid system when they design a layout, they create a cleaner and simpler design. Designing a layout using a grid system should follow these principles:

- When people decide the grid layout system, it is better consider the margin from the end of the top and button, and left and right. For unity of visualization, designers have to unify all margins for all pages.
- The information that placed in a window or screen has to be grouped according to its purpose.
- Decide the placement area for each group placed and keep the same grid.
• Each categorized information needs to be placed on the left end or center, so that it is not distracting.
• The borders for the categorized information are indicated by outline, color, and margin. (Japanese human interface group 2003, P 103)

One more point that needs to be made about the grid system; Clear layout comes from a grid system. “A grid is a system for distribution of visual elements in a clearly intelligible order” (Watzmann 2003, p.273). If the grid system has consistency, it reduces the effort needed to read and understand the interface. Therefore, a consistent grid improves usability. For example, if a user can anticipate a button that is always placed in the same location or that help is accessed in the same manner, the time required to understand each page is reduced and ultimately improves success. “Placement of all visual elements such as buttons and help are specified on the grid” (Watzmann 2003, p.273).

**Icon**

“Icons, those familiar little pictures used to identify buttons and other objects, are a shibboleth of modern interface design” (Raskin 2000, p.168). Icons are another visual cue that helps users locate and remember information. Apple computer, which is well known in the field of icon design, states that:

> Icons can contribute greatly to the clarity and attractiveness of an application. The use of icons also makes it much easier to translate programs into other languages. Wherever an explanation or label is needed, consider using an icon instead of text. (Apple Computer 1985, p.I-32)

Specially, icons are simply symbols based on a more complicated image. So it is important to an icons style simple and consistent. Raskin points out that “Icons can contribute to visual attractiveness of an interface and, under the appropriate circumstances, can contribute to
clarity”. (Raskin 2000, p.168) Besides, William Horton says in *The icon book*, “I’ve used systems with graphical user interfaces for a decade and would prefer to click on an understandable image than to enter technojargon commands even if I could remember how to spell them” (Horton 1994). Icons in interface design are used more widely these days. According to Loding, there are four reasons:

- Images (icons) make natural communication with people. Compared to text, icons are harder to understand right away, but it makes user friendly.
- People have excellent ability to remember an image.
- Using images get better results for learning and recognizing meanings compared with language.
- Images have the ability to communicate with international audiences.

Therefore, if icons are used well, they are best technique to use in interface design. What then makes good icon design? *The human computer interaction handbook* states, “If an icon is memorable with minimal reinforcement, then it is successful. If after several times a user cannot remember the meaning of particular icon, then it is of no value and should be eliminated. If a set of icons is being designed, there must be consistency of style” (Watzmann 2003, p.274). In addition, it is essential that icons

- Are visually distinct.
- Do a good job of representing the appropriate concept (Raskin 2000, p.170).

Color use in an icon is also an important consideration. Many interface designers do not care about color use in an icon. They focus the icon shape, line thickness, and image consistency. Of course, those characteristics are important considerations as well, but color requires careful use. Horton points out that “color coding can fail if you use too many colors or if there are too many icons in easy color.” He specifies that if the icons are close together, the
designer should use no more than seven colors. If they are scattered about, the designer should use no more than four colors (Horton 1994; Raskin 2000, p.172). The designer should remember these issues when creating a design. I believe that the best benefit of icon design is that an icon can be designed to be very small, so an icon would work well with small screen design.

**Typography**

“Typography is at the very heart of visual design” (Watzmann 2003, p.265).

In printing visual design, typography is the first and most important part of design. It even can dominate the whole design, so that it becomes the overall of design impression. However, typography cannot be a dominant part of the interface design; it is more related with legibility and readability. The typographic choice affects legibility, and the choice of typeface immediately impacts whether a communication is read and how it is perceived. Typeface designed for screen use can increase legibility as well as providing perceptual cues about the approachability and quality of an interface (Watzmann 2003, p.268). The legibility and readability of a screen design is definitely related to typeface.

**Legibility**

As discussed in typography, legibility is the ability to read the information on the page. The page can be a screen, and as such, has special considerations. Color, size, background, movement, viewing environment, lighting, resolution, all plays a critical part in legibility.

**Readability**

Readable screens demand use of clear visual representations and concise unambiguous text. A design can imply meaning by the placement of elements in particular areas, or zones allotted for certain types of information. This makes the screen easier to comprehend and more accessible. It also makes optimal use of a limited space (Watzmann 2003, p.282).
Furthermore, “typeface can be used to set a mood” (Watzmann 2003, p.268). For example, an old-fashioned typeface can make a more classic and romantic feeling. A typeface with extreme think and thin strokes in the letterform can look more fashionable and polished. It would look great in a brochure, but it would render a web page unreadable.

If there are too many different kinds of typefaces in the interface design, the user will get confused and find the number of typefaces to be distracting. Limit variation in typography to a few sizes from one or two families, so that the design is more consistent and clear.” A good choice makes the task of reading more enjoyable and effortless rather than frustrating and fatiguing” (Watzmann 2003, p.268).

Color

Color is the most powerful element of visual communication. People can use color to enhance communication. We do not live in a black and white world; rather we live in a colorful world where colors are linked with emotions, feelings, and associations (Rockport Publishers 2004). There are several benefits in using color:

- **Aids organization**: establish character through consistency. Like font use, limit color use to communicate real differences.
- **Gives emphasis**: Color highlights elements of importance. (You read this first, didn’t you?) Color’s highlighting benefit is quickly exhausted and devolves into a colorful mess.
- **Provides direction**: Warm colors move elements forward while cool colors move elements back, so a warm tone should be given to display type that is in front of an image to increase the illusion of spatiality. (White 2002, p.67)

Furthermore, “color evokes immediate and forceful responses, both emotional and informational. Because color is a shared human experience, it is symbolic as well” (Watzmann 2003, p.277). So color can easily be used to evoke people’s emotions and be part
of an interface design solution based on their experience and emotions. Color can clearly be designed into an interface with its mood influencing properties in mind. Warm colors, for example, generally provoke “active feelings,” whereas cool colors are “much less likely to cause extreme reactions” (Levy 1984, p 88). Through the human experience, there are appropriate principles for color use. For example, Watzmann mentioned in her paper *Visual design principles for usable interfaces*, that in the early days of the software industry, research showed that a particular blue worked well as a background color. Now, however, depending on the calibration of the monitor as well as environmental lighting, that particular blue could be a disaster. In fact, that particular blue can often vibrate if type of a particular color is placed on this background. Therefore, what must designer need to be considered are the variations in every viewing situation and how these variations affect contrast among the various elements on the page as well as overall legibility and readability.

**Sound**

Sound is not a visual element, but it is an important element in the interface design for feedback or to let the user know about the status of a continuing action. However, when people use a sound in their interface design, they have to think about the environment. For example, let’s think about a design for a cellular phone screen interface. The cellular phone is an outdoor device, so that relying on sound for feedback is not appropriate. If the designer uses a sound as feedback for accomplishing a task, the user may find hearing the sound difficult because of loud ambient noise. The user most likely would miss the sound, and they might wonder if the task was performed. Therefore, sound is one of the ways to give user
feedback, but should be used only after considering its advantages and disadvantages for likely environmental conditions.

**Navigation cues**

When people are traveling, many systems such as maps, road signs, and landmarks aid people in finding their destination. Similar systems must be in place for interface designs so that users can have a sense of place that enables them to know where they are, where they have been, and how to move elsewhere (Watzmann 2003, p.281). These systems help people find the way easily and quickly. Systems such as maps, road signs, and landmarks are called ‘Navigation cues’ in interface design. Navigation cues include menus, button design, and hierarchical structure. To increase ease of use and focus on user needs, designers have to consider how to enable people to navigate an interface design easily. Therefore, the designer must make organizing a clear hierarchy design into a high priority. Then, the designer must pay attention to the importance of page architecture and menu design, both of which are required for the user to navigate promptly, correctly, and easily. Menu design visualizes the page architecture and helps users to navigate interface designs efficiently. Watzmann gives some advice that: (Watzmann 2003, p.281)

Using familiar visual elements leverages existing knowledge. Graphic standards support this as well. When using a familiar hierarchical layout, grid structure, menu design, and button design, it is much easier to remember the zones in which like kinds of information appear. This ensures that whatever visual cues are applied can take advantage of the user’ experience and save time for the designer.

The ultimate goal to navigating in interface design is that “the user should not frequently be confused or get lost in cyberspace” (Lazar 2002). Therefore, users can enjoy navigating and finding information that meets their needs promptly, correctly, and easily.
C. Human interface design in cellular phones

1. Difference between small screen and large screen in the digital technology

Until now, most of people usually dwell upon about the computer user interface design projects in which large color palettes, high spatial resolution, and large-size displays are presumed to be available. (Marcus, Ferrante, et al. 1998, p.96) These user interface design projects almost exclusively designed for use with desktop computers. However, as mentioned above, the digital mobile telephone has evolved to become a basic commodity in the United States and many parts of Europe, as well as Asia.

The world’s largest manufactures of mobile phones predict that there will be 1 billion telephones in use in five years time. Currently, mobile communication is still mostly synonymous with voice telephony, but this is almost certain to change pending new mobile data communication technologies being deployed, increasing data speeds and improving usability (Bjork, Bretan, et al. p.1)

Therefore, Most of computer work can be moved on the mobile phone that can carry all around where people want to go. This means that people can be used the cell phone anywhere and anytime efficiently, this would be one biggest advantage. Furthermore, from the paper Past, Present, and Future of User interface software Tools mentioned about

We are at the dawn of an era where user interfaces are about to break out of the ‘desktop’ box where they have been stuck for the past 15 years. The next millennium will open with increasing diversity of user interfaces on an increasing diversity of computerized devices. These devices include hand-held personal digital assistants cell-phones, pages… (Myers, Hudson, et al.2000)

This is why designing a user interface in small screen is becoming more crucial in our daily lives. The things difference to consider in interface design between large screen and small screen is the limitation in screen size, graphics capabilities, processing speed, input, and scrolling capabilities (Kim, Albers 2001, p.195) Also the paper Using small screen space more efficiently states “Most of the interface objects used in desktop computing
environments – pull down or popup menus, multiple window, icons- consume a great deal of valuable screen space on the small screen.”(Kamba, Elson, et al. 1996, p.384) Beside since display size of the cellular phone is much smaller than that of desktop computers, designer can not put same as desktop interface environment. The amount of information that is visible at a time is reduced, so that, the number of sub-pages must be larger, or the content must be reorganized or modified. (Karkkainen, Laarni 2002, p.288) “Path lengths were shorter for small screen users that users who used the normal sized computer screen”. (Jones 1999, p.288) Even though the small screen users tended to use search facilities more often and made poorer choices than the large screen users. (Karkkainen, Laarni 2002, p.288)

In fact, users of the small screen were 50% less effective in completing tasks that the large screen subject. (Jones, Marsden, et al. 1999) On a desktop monitor, there is enough space to navigate, so people are easy to know “where I am”. However, it is hard to navigate on the small screen interface design. So that author needs to consider about what kinds of navigation devices can possibly using on the small screen. According the paper Interactive with big interfaces on small screens: a comparison of fisheye, zoom, and panning techniques, researchers carried out an experiment to compare different methods of navigation a large interface through a small screen. (Gutwin, Fedak 2004, p.152)

- Even at its best, navigating on the small screen is considerably slower than on the normal screen.
- Fisheye views and two-level zoom systems are both effective techniques for navigating interfaces, particularly if targeting and view switching can be improved
- User like the two-level zoom, even when its performance is less than optimal.
Furthermore, the severely limited size of the display would require an unacceptable amount of scrolling on the part of the viewer. (Bruijin, Spence, et al. 2002) Actually, small screen users used a very substantial number of scroll activities in attempting to complete the tasks. (Jones, Marsden, et al. 1999) One of the paper calls *Searching for optimal methods of presenting dynamic text on different types of screen*, this paper researched what is the most suitable method for different types of screen. There are five dynamic methods which are RSVP (rapid serial visual presentation) mode, present at a time at the center of screen. Vertical scrolling mode, leading mode that is text moved from right to left alone a single line, teletype mode that is an example of controlled-rate text in that one character is added to the line at a time, and window mode that is one line of text was displayed, and frame passed across the text and highlighted each word. The result is teletype was the most suitable method for reading from a laptop. “Vertical scrolling for mat was clearly a faster method than the normal page format” (Laarni 2002 p.221) Thus, vertical scrolling was the most suitable method for reading from a PDA and Cellular phone. Scrolling is not the best solution to look through all the information. However, somehow users will get used to scrolling and find it easy to deal with, especially for the small screen. It is a challenge to put information in a small cellular phone screen size that is only 2inches wide and 1.5 inches long. These small devices show interesting design challenges. The biggest challenge has been to create clear and intuitive ways to access all the features. So designers have to understand what is the possibility and limitation of the small screen interface design then they may help the user access all or enough of the content, so that their resulting understanding of the content is accurate.
2. Possibility and limitation of the small screen

‘A small screen is like a keyhole through which only a limited amount of information can be seen at a time.’(Laarini 2002, p.219) The development of small screen interface is challenged to the interface designer. In looking towards creating effective small screen interface design, people should understand the implication of characteristics and optimizing the small screen design’s limited real estate. The characteristics of a small screen device like cellular phone have an effect on both how information should be presented and how users interact with the small screen device. (Karkkainen, Laarini 2002, p.227) There are several small screen design strategies. Past work on the interface side has explored transparent interface objects, (Kamba, Elson, et al. 1996, p.383-390) the use of enhanced interaction techniques such as tilting to make up for reduced screen space (Rekimoto 1996, p.167-168), or the use of sound to reduce the dependence on visual data. (Brewster, et al. p.5-14) Changes to the data often involve creating summaries of documents that fit more easily on the small screen (Uyukkokten, et al. 2000, p.430-437), or using context and location awareness to show a subset of the data space. (Pascoe, Ryan, et al. 2000, p.417-437) Furthermore, Kampa presented a new method for increasing the available screen space of small screen. They showed that more information can be presented by using transparent widgets instead of a menu bar. (Kampa 1996) These suggestions are designing the interface to fit a small screen. But these suggestions are not fit the all situation; designer must understand what the purpose for your small screen interface design is.

Designing graphical user interface for small displays will debate the best way to design for cell-phone in which many characteristics are significantly limited, e.g., fonts, color resolution, navigation, and graphics.’(Aaron 1998, p.96) Beside, the typical small screen size
is 240 x 320, if the visible area of a small screen is 6x8 cm, its resolution is 99dpi. These interface characteristics call into question the evolving design requirements for small screen interfaces. In fact, developed the cellular phone technology, it really doesn’t matter of the color resolution. Here are several examples’ of cellular phone design that included high technology. Now days of cellular phone are have various colors, high resolution, and bigger screen size to compare with traditional cellular phone screen size.

<table>
<thead>
<tr>
<th>SCH-S310</th>
<th>SCH-V500</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Dimensional Movement Recognition Phone</td>
<td>Swiveling Landscape Display</td>
</tr>
<tr>
<td>-CDMA2000-1X (800 MHz)</td>
<td>-CDMA 2000-1X EV-DO (800 MHz)</td>
</tr>
<tr>
<td>-3D Movement Recognition Function</td>
<td>-1.3M Pixel Camera with Flash</td>
</tr>
<tr>
<td>-1.3M Pixel Camera with Flash</td>
<td>-VCD (Streaming/Download)/ MOD</td>
</tr>
<tr>
<td>-VCD</td>
<td>-Video Recorder &amp; Player (MPEG4)</td>
</tr>
<tr>
<td>-MP3 Player</td>
<td>-262K Color TPT Screen</td>
</tr>
<tr>
<td>-262K Color QVGA Screen</td>
<td>-4 Color OLED External Screen</td>
</tr>
<tr>
<td>-64 Polyphonic Ringtones</td>
<td>-64 Polyphonic Ringtones</td>
</tr>
<tr>
<td>-91 x 45.5 x 26 mm, 100g</td>
<td>-98.3 x 50 x 26 mm, 110g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SGH-E820T</th>
<th>SPH-A800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung’s Push-To-Talk Phone</td>
<td>Samsung’s Speech-To-Text Phone</td>
</tr>
<tr>
<td>-GPS (900/1800 MHz)</td>
<td>-CDMA 1X (1900MHz)</td>
</tr>
<tr>
<td>-VGA Camera with Flash</td>
<td>-SST Function</td>
</tr>
<tr>
<td>-PTT / Voice Clarify</td>
<td>-3M Pixel with Flash</td>
</tr>
<tr>
<td>-Loud Speaker (Sound Mate)</td>
<td>-Video Recorder &amp; Player (MPEG4)</td>
</tr>
<tr>
<td>-65K Color TPT Screen</td>
<td>-MP3 Player</td>
</tr>
<tr>
<td>-64 Polyphonic Ringtones</td>
<td>-Biz Card Reader</td>
</tr>
<tr>
<td>-MMS/JXW/WMF 2.0J Photo CLI</td>
<td>-262K Color TPT Screen</td>
</tr>
<tr>
<td>-87 x 43 x 23.5 mm, 85g</td>
<td>-65K Color OLED External Screen</td>
</tr>
<tr>
<td></td>
<td>-64 Polyphonic Ringtones</td>
</tr>
<tr>
<td></td>
<td>-99.3 x 49 x 28.8mm, 142g</td>
</tr>
</tbody>
</table>

Figure 2.7 Samsung Anicall cell phone design. (Source: Brochure ‘2005 Everyone’s invited’, Samsung Telecommunication Network)

The text layouts and graphics have been designed to help navigation and to make the menu structure easy to learn. One of challenge has been to design graphics that indicate the phone’s status in various situations. Because of the small display, the designed graphics have to be
clear and simple. Furthermore, because of the limited space on the display the graphical indicators cannot all be displayed at the same time. Therefore, they have been prioritized so that only the most important indicators for each situation and tasks are displayed at a time.

Designing navigation systems for cellular phone is made more difficult by several factors.

- Discrete selection actions in the form of button presses are usually needed to move from one menu item to any other, because most cellular phones lack more direct selection capability.
- Cellular phone displays are small, allowing only a few menu items to be displayed at a single time. Many cell phones lack functionality for paging up or down, making display limitations even more significant.
- There is less standardization in hardware supporting menu traversal for cell phones than for desktop machines. Some phones have two-way directional buttons, others four-way; some have a labeled “Menu” button, while others rely on a button with overloaded functionality. Button placement can vary significantly, with “Cancel” and “Ok” buttons reversed from one phone to another. (Amant, Horton, Ritter 2004, p.343)

The one possible for the small screen navigation design is the zoom in and out effect. Many of research papers have positive opinion of zoom in and out effect into small screen design.

As mentioned above, zoom systems are effective for navigating interface. (Cutwin, Fedak 2004, p.146; Kaptelinin 1995)

Zooming is that when documents are particularly large, scrolling alone becomes tedious. A number of systems have implemented the idea of zooming, both to speed navigation and also to provide multiple perspectives on the data. Zoom can either be dynamically controlled by the users. Systems where zooming is used to provide an overview of the space have been shown to perform better than basic scrolling systems.
Furthermore, according the book *The Human interface* suggested the zooming system for better solution.

The antithesis of a maze is a situation in which you can see your goal and the path to get there, one that preserves your sense of location while under way, making it equally easy to get back. An elegant solution is the zooming interface paradigm (ZIP), which in many situations solves the navigation problem and also provides a way around the problem of the limited screen real estate that any real display system must confront. (Raskin 2000, p.153)

For example, a large heading Personal Photos might, when you zoom in on there are sub menu pictures labeled Baby Pictures, Vacations Pets, etc. Furthermore, a zooming space gives a great deal of flexibility in layout. (Jef Raskin 2000, p155)

Lastly, the paper *Designing for small display screens* suggested several examples of guidelines that may help in designing small screen devices.

- Determine the purpose of the screen design
- Present the most important information first an the top of the hierarchy: Since small screen users do not tend to navigate deep into the site, it is important that they need not follow long link paths in order to reach the desired information.
- Re-think the navigation aids: Constantly visible navigation bars require too much display space. Consider using alternative ways to navigation
- Indicate the links clearly: Use text links with a clear indication.
- Optimize the reading process: Use at least 14pts font. Due to poor resolution of small screen a variable lightning conditions, a smaller font size may deteriorate the reading process.
- Use markers while scrolling or paging test: Scrolling interrupts a user’s activities. Moreover, because of the small display size, more scrolling and paging is required. Therefore, it is important to guide the user’s attention to the right place after a scrolling operation.
3. Examples of existing display design

As mentioned in Chapter 1, in the past, mobile phones were used primarily for voice conversations. Today, however, more and more people are using their mobile phones for voice mail, playing games, browsing the Web, and buy a product (E-commerce). This means there are a lot of functions in the small screen, and it should be well organized to transfer the information efficiently to user. From now on, author will show several existing display design examples in small screen. Following images are main menu display design from Samsung ‘Anicall’. Samsung which has become a global leader in mobile because of their focus on excellence in design, also recognized as one of the fastest growing global brands. (Stephen Elop, CEO, Macromedia; Macromedia electronic new 2005)

Figure 2.8 Samsung ‘Anicall’ cell phone display design.
(Source: www.cetizone.com)

These three images are menu display design of each cellular phone. First of all, these display designs make user attention and interest. Overall of designs feel bright and exciting colorful and the structure are not boring. The icons are more like 3dimensions. First display design in Figure 2.8 has three steps, when people choose an icon; the color become brighter
and pop up. Text that comes with icon makes clearer to navigate. Second design is more like user experience. This display design is like screen capture from your desk, so it makes more familiar, and fun to navigate. Beside, when mouse roll over, each icon has short animation, so it catches a user’s eye and clear to know the function of icons. Third display design is well organized, but somehow it is boring. However, using colorful and actual feature of icons, the problem is solved. Furthermore, when mouse roll over, circle shape appears and is animating, so that make user’s attention.

Figure2.9 Samsung ‘Anicall’ cell phone display design.  
(Source: www.cetizone.com)

These three display designs in Figure2.9 have side bar menus which are placed all the same location, so it keeps consistency of display designs. When mouse roll over, icons that people choose pop up with text, and background image is used similar image with icons. Therefore, using graphical elements, it is easy to understand each category’s function. These display designs used screen space very efficiently and clear look, so make users want to explore the navigation structure.
These display design in Figure 2.10 also suggest different kind of structures and appearances. These are simple and clear to see. The third display design has drop menu, and this is the one of way to use screen space effectively.

There are several display design examples to control the home appliances. To control the home appliances on small screen is not widespread yet, but it is been hot issued several years, soon the innovative new model will be launched onto the market. Now, however, there is not proper design to support this technology, so that this paper will be cover the area which is useful and efficient small screen design to control the home appliances. Author will show several existing screen designs to control the home appliances. These examples are designed on large screen, but it will be helpful to know what kind of methods people used to show the screen design which controls the home appliances.

The following images are from LG home network. (Figure2.11) This interface system is designed to control the several home appliances such as digital TV, Refrigerator, Microwave, and Washing machine. The example shows the process to control the refrigerator.
Figure 2.11 Dreams LG Home Network 'Internet Refrigerator' *Changed Korean to English (Source: http://www.dreamlg.com)
Images in Figure 2.11 show a merit of grid system. The menu is always placed right side, and images and icons that people choose are left side. Therefore users will not be confused to operate the design. Users already get used to the place of menu, images, and icons etc, so they can easily find what they want. Furthermore, color that designer used is a shared human experience. When users see the refrigerator, they feel like cool and fresh, so designer used blue color as representing this design feeling itself. Also users can recall the oven as hot and warm feeling, so the radish color to represent this feeling. These icon designs are also successful both look, and function. It is important to choose style that is simple and consistently reinforced throughout icon design. In here, designer brought each character of product, and simplified as icons well. Especially these icons that are with text make explicity meaning of icon functions.

Figure 2.12 and 2.13 are Samsung home network system. Clean layout makes consistency of structure, and proper colors that used in controller part, background part, and button part are well organized in clean structure. Especially actual photos are used as icons and the status of Air condition, Microwave, Curtain so that it is clear to see and easy to use. Thus users get familiar with actual photo of each home appliance; therefore, they don’t confuse to identify the icons.
Air condition

Microwave

Actual Photo

Curtain (open)

Curtain (Close)

Figure 2.12 Samsung BAHA Home Network (Source: http://www.samsungbaha.com/)

Figure 2.13 Samsung i-BAS Home Network
4. Existing control devices of small wireless application

Currently there is a growing trend in developing small devices like mobile phones, and PDA. A control device into mobile devices is an increasingly important fact. For desktop computers and laptops, keyboards are familiar and common controller with spatial controllers such as the mouse, stylus, or trackball. However, when the size of device is reduced to something that fits in your hand, the existing controllers are not feasible in these small appliances. Most of these devices are handheld and have some kind of primary controller, such as a small keyboard, trackball, touchpad with stylus, or a small joystick. Research about existing desktop or laptop methods with touchpad, mouse, trackball, joystick and keyboard is not on the purpose of this chapter. Author will focus on current small applications, and what kinds of controller are implemented into small applications.

MP3 Player

MP3 player is simplest small application with cellular phone, so that if people look at the MP3’s controller, they can get some ideas. First of all, Apple computer has announced that it plans to release its new 0.69cm thick ‘iPod nano’. The ultra light (42g) and portable device (8.9mm x 4mm x 0.69mm) comes up with its unique design, easy user interface.

Figure 2.14 iPod nano(Source http://aving.net/newproduct/, http://www.apple.com/ipodnano/)
One innovative thing is control device. According to Having news network the particular design of ‘click wheel’ functionality ensures a convenient use. (Kim 2005) iPod nano’s click wheel puts music under your thumb. Click to fast-forward, rewind, play, pause or access menus. Use the touch-sensitive surface to control volume or browse music. People can do it without looking. (i-Pod 2005)(Figure2.14)

There is one competitor with i-Pod nano which name is ‘U10’ that is innovative and new conceptualized user interface design. U10 is developed by Iriver which is the largest MP3 player company in Korea, and the product size is 69x47x16mm slim, and 2.2inch color TFT-LCD. When many of products are focusing on the click wheel system, while, Iriver suggests new interface style direction which calls ‘D-Click’. This is the function that is 1mm space between LCD and body, and put the top, bottom, right, and left switches into the space. When people press the one side, the whole LCF screen is like button function that was pushed itself and tilts over. So that reduce the general concern of touch screen, it is easy access with intuitive direct click interface. (Buyking 2005) Furthermore, the concept of this product is ‘It is thumbthing’, means only use a thumb to control whole directions. (Figure2.15)

Figure2.15 Iriver U10 (Source http://aving.net/newproduct/, www.buyking.com/news)
Figure 2.16 shows different kinds of controllers for small wireless application. First images has button on the side, and can be clickable. The way of holding the device is so natural, and where controller is placed meets with thumb. Second image choose the joystick type of controller which calls ‘Jog lever’. The ‘Jog lever’ is placed top of the device, and let finger placed comfortably. (Hantel 2005) Third and fourth images of controllers are circular shape which doesn’t mean wheel click system, this is just button controller. However the circular shape is one of fresh ideas that fit into small device, and use the space efficiently. The controller of fifth images is touch key. Four directions of keys are one of the device components. Up and down and back and forth buttons located in natural direction.

Figure 2.16 Different kinds of controller (Source http://aving.net/newproduct/)
Cellular phone and Etc

Nowadays, it will be becoming the popular product which can be possibly rotating. Cellular phone screen can be rotating, and the camera lens, and LCD screen can be turned 180 or 360 directions. Therefore, the product to use wheel system is getting really popular. (Buyking, 2005) The product which stands the wheel with feature Samsung Electronics (www.sec.co.kr) SCH-S380, and SKYTeletech (www.sky-teletech.com), IM-8000 are a wild possibility as examples.

SKYTeletech (www.sky-teletech.com) IM-8000 system was hot issued, when cellular phone came to market. The IM-8000 Cellular phone’s wheel navigation key was emphasized by T.V.advertisement that model does an aerial rotation. With this function of wheel navigation key, people can easily control a volume of music, a camera zoom, and navigate menus. Cellular phone and Mp3 player’s user interfaces were change the rotation way rather than just arranged menus to fit with wheel navigation key. (Buyking 2005)(Figure2.17)
SCH-S380 loads the wheel very in the center, and they called wheel as ‘Jog disc’. It can be rotated by thumb, and search music and the photograph. (Figure 2.18)

Figure 2.18 Samsung Electronics, SCH-S380 (Source: www.sec.co.kr)

Finger of the thumbs does a lot of works nowadays, so that, many of people are suggesting a user center interface which use wheel system to make finger comfortable. Wheel system is natural and intuitive way to control the device. (Buyking 2005) It is sure that wheel system was made considering user’s convenience, comfortable, and one of most innovative idea in these days. (Figure 2.17, 18)

One more example is Slingshot cellular phone which is not wheel navigation system. In facts, this is totally different idea that author researched, because what here focused in is playing a game. However, the cellular phone device requires using thumb to control the device. According the web news The future of mobile, the current game of cellular phone is still feature the absolutely archaic thumb pad as the main input for game control. As mobile game developers’ ambitions grow, the thumb pad becomes more and more antique. The slingshot features an analog nub to the left of the screen. When the screen is rotated horizontally on top of the base, the Slingshot can be held like a traditional games machine.
There are two shoulder buttons on the top of the unit, as well as four face buttons to the right of the screen. (Figure 2.19) Having a dedicated analog nub makes all the difference in the world, especially when playing a game. Control over the car is so much easier, so much smoother than when you try to use a basic four-direction pad. Especially when that thumb pad is coupled with a number pad that cannot accept one button input at a time. An analog nub bring mobile gaming up to speed with the rest of the industry, allowing the machine to suitable host 3dimention plat formers, racing fames. For mobile gaming to make that next big leap, analog control feels like a necessity. (IGN.com 2005)

![Different kinds of controller](http://aving.net/newproduct/)

5. New direction on cellular phone interface design

Flash, which is installed in 98% of consumers’ desktop computers is the powerful computer interface design software, and sophisticated mature design tool, easy to learn, and rich application development. Specially, flash is the hot issue and new direction on the cellular phone interface design in now days. Flash interface on cellular phones makes
possible to experience rich, interactive content and make their digital experiences more engaging and easy to use. (Macromedia 2005)
Figure 2.20, 21 are flash screen designs. As you can see, especially figure 2.21, it is valuable to compare between traditional design and flash design. More graphic elements such as colors, images, and texts are making easier to understand, and users keep interest.

Furthermore, many of companies the world’s leading wireless operates and manufactures: NTT DoCoMo, Sony Ericsson, Samsung Electronics, KDDI, and T-Mobile have licenses to use flash on the cellular phone. They stated about the situation on the macromedia website:

**NTT DoCoMo**
“NTT DoCoMo is pleased to be able to deliver Macromedia Flash technology as a key component of the i-mode service. Because content providers are already familiar with Macromedia’s widely-used internet technology for developing web content and applications, we expect dynamic new content to be created for the i-mode service, which will further enhance the mobile-internet user experience.” (Takeshi Natuno; Managing Director of i-mode services, planning department, NTT DoCoMo, 2005)

**Samsung Electronics**
“Macromedia Flash sets the standard for mobile rich interactive experiences. As a proven technology, it improves our user interface development, and improves the end user experience.” (Geehong Yoon; Executive Vice President of Design, Samsung Electronics, 2005)

**Sony Pictures**
“With Macromedia Flash, Developing Device content is made dramatically easier across a wide array of device operating systems, At Sony Pictures Digital, we are always looking for compelling ways to deliver our content to many devices.”(Tim Chambers; Senior Vice President, Advanced Platforms, Sony Pictures Digital Entertainment, 2005)

**Ynot Inc.**
“Macromedia Flash is a powerful tool for creating content for the mobile-internet. Enabling us to provide rich and interactive content with the innovation of Flash Lite” (Mie Kurosaka; President Ynot Inc. 2005)
Specially, Samsung “who has become a global leader in mobile because of their focus on excellence in design” (Stephen Elop, CEO, Macromedia 2005) was on the electronic news which calls Samsung electronics intergrades and shops macromedia Flash Lite 1.1 enabled handsets and stated Flash delivers graphical user interfaces and rich interactive experiences on new mobile handsets around the world. Flash Lite is a version of Macromedia Flash Player specifically developed for mobile phones so consumers can benefit from the power of rich interactive Flash experience, also looking forward to bring incredible new experiences to costumers around the world. So that, people can predict the “flash can be the standard for mobile rich interactive experience, as a proven technology, it improves our user interface development, and improves the end user experience.”(Geehong Yoon; executive vice president of design 2005)

Furthermore, T-Mobile launches first flash Lite and powered mobile service in Europe. “New express is the first European implementation of an offline news and infotainment service that is regularly updated without user interaction and incorporates a unique user experience powered by Macromedia Flash Lite technology” (David Mannl; T-Mobile international innovations team 2005) The main purpose of news express is to provide users with a truly superior, and unique, offline mobile multimedia new and entertainment service.
The total usable display size is 176x 208 pixels. The layout consists of four main areas. The four main areas are always visible to the user. Only the content of the application space is scrolled when the user navigates up or down with the 5-way joystick of the handset. News Express content by clicking an icon on the main menu of their mobile phones, clicking this icon launches the user with the most recent new edition. (Figure2.23)

The screen navigation is by scrolling left and right, user can move between the different channels. Before the next channel appears, user sees a small animation. This navigation concept enables the reader to get a quick overview of all articles in a pretty short timescale. It is easy, simple and transparent. (David Mannl; T-Mobile international innovations team 2005) (Figure2.24)
CHAPTER 3. METHODOLOGY

In the methodology section, this thesis will propose a suitable prototype of a cellular phone small-screen interface design. As an example of small-screen interface design, an interface that people can use to control home appliances with a cellular phone will be developed. This proposed cellular phone screen interface design and the cellular phone running the interface are both simulated on a computer using Macromedia Flash software. Because of the limitations of available technology, it was not possible to put the interface onto a real cellular phone. Using simulated prototype, usability test is conducted, in order to find out problems that users have while using the prototype.

A. Information electric home appliances kind and a function

Table 3.1 Information electric home appliances kind and function

<table>
<thead>
<tr>
<th>Home Appliance</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV/VTR</td>
<td>A broadcast channel pre-engagement, A VTR pre-engagement video recording, Power control</td>
</tr>
<tr>
<td>Air Condition/Heater</td>
<td>working / stop control, Direction of the wind / temperature setting, Power control</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>water temperature detergent, Wash course management, Power control</td>
</tr>
<tr>
<td>Electrical Light</td>
<td>Electric light state confirmation, turn off/on</td>
</tr>
<tr>
<td>Oven/Microwave</td>
<td>Cook food(Make heat), Power control</td>
</tr>
<tr>
<td>Gas</td>
<td>Gas information confirmation, A dangerous gas condition announcement, Power control</td>
</tr>
<tr>
<td>Alarm device</td>
<td>An intruder warning function, Power control</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>A food addition / offset, A food item and quantity of food confirmation, Power control</td>
</tr>
<tr>
<td>A gate lock control</td>
<td>Gate status confirmation, Locking/opening gate, Power control</td>
</tr>
</tbody>
</table>
The table provides information on the types of appliances that can be controlled with a cellular phone, PC, or remote control. Already, Samsung and LG provide a Home Network service that can control several home appliances. Among these home appliances, the most useful and popular functions (Air-conditioning, Lighting, and Microwave oven) were chosen for use in a cellular phone interface design. Air-conditioning and Lighting functions are very useful home appliances that can be controlled from outside the home. People expect their house to be warm when they return home. Also, people can make sure whether they turn off all lights or not, thus saving electricity. If people come back home late, they can turn on a lamppost or a front light from their phone. Controlling a microwave is still inconvenient in that you have to put in food before you leave, but it is likely that microwaves could be combined with refrigerators, so that it will be more convenient to remotely control microwaves in the future. Besides, users who participated in my usability test said that the microwave is the most useful home appliance to control from outside the home.

B. Environment of using cellular phone

The cellular phone is an outdoor device, so sound cannot be used. Likewise, a considerable amount of information cannot be put on just one page. If sound is used as feedback for accomplishing a task, the user may not be able to hear the sound very well outside. It is likely the user would miss the sound and might wonder if the task was performed. Furthermore, because people cannot concentrate on detailed work when they are outside, they will not want to use the interface if a large amount of information is placed on one page. Therefore, the information should be divided into main points and spread across several pages.
C. Navigating device layout

1. Familiar experience with a PC on the cellular phone

The interface uses a cursor system, which is also used for navigating a PC environment, to navigate a cellular phone interface design. If the interface design of a cellular phone is consistent with the PC environment, users will need less time to learn how to use the cellular phone interface. To study this idea, the author of this thesis brought a paper called *The effects of experience with a PC on the usability of a mobile product*. This paper describes an experiment to determine if the desktop metaphor of the PC is more appropriate for a small device such as a PDA or cell-phone for users who are familiar with the PC than the dedicated new user interface design for PDAs. This paper was compared to different views which claim that the current interface design of PCs cannot be directly applied to mobile products because they have their own specific functions and requirements. Therefore, new design approaches are required to address the special design needs for these devices. It was found that using PC metaphors for mobile products could have advantages because users’ PC experiences can reduce the learning efforts and thus contribute to an intuitive understanding of the mobile product.

The author’s experimental results show that application of PC metaphors to mobile products can be advantageous because users’ PC experiences can reduce the learning efforts and thus contribute to an intuitive understanding of the mobile device (Sang-Hoon Jeong, Kun-Pyo Lee, p.2). Therefore, large numbers of people are familiar with using a cursor system because they already use similar systems on computers or MP3 players. Furthermore, the other benefit of using cursor system is saving time. In current cellular phone designs, navigating their information structure is a step-by-step process using the arrow key. For
instance, if users want to use menu 1 and menu 7, they use a menu 1 item and then they have to go through seven steps to use menu 7. This is unnecessary and wastes time. To solve this problem, a cursor system was brought to the small screen so that it will be convenient to navigate regardless of what the user wants to do.

2. Suitable three input devices in cellular phone

To control the cursor, people need a device such as mouse. However, it would be ridiculous to use a mouse with a cellular phone, particularly since a mouse is the similar size as a phone. Several input devices to control the cursor were researched; from the information gathered in the literature review, it was concluded there are three appropriate input devices. Five criteria were used to make this decision: how easy natural the device is to use, how easy it is to learn, how accurate the device is, how much time will the user spend on the system, and how much space is available (Stone, Jarrett, et al. 2005 p.234). The small amount of available space in a small cellular phone was a design limitation that had to be addressed. Design strategies such as a touch screen and pen system need larger screens, so that it is impossible to use touch screens and pens as an input system in cell-phone design.

Figure 3.1 Mouse ball and joystick in cellular phone and use mouse ball, and joystick

Joysticks and track balls are among the three input devices that the author concluded were appropriate input devices. In the case of a joystick, it will be placed on the side of a
cellular phone. In the case of a mouse ball, it will replace an ‘ok’ button. These two input devices are small and are pretty accurate. Also, when a user holds a cellular phone by one hand, it is easy and natural to manipulate the mouse ball with the thumb and manipulate a joystick with the middle of the fingers. (Figure3.1) However, these two input functions are not available on the market yet.

![Figure3.2 LG Telecom, IM-8000 (Source: www.sky-teletech.com)](image)

The last appropriate input device is the wheel key. This device is mainly used in MP3 players, as was mentioned in the literature review, and there is an existing cellular phone which has a wheel key. The wheel key is familiar and easy to use for controlling navigation. The size can be small, so that it easily fits in a cellular phone. Currently there is an existing example a cellular phone using a wheel key: the LG Telecom IM-8500L (Figure 3.2). The
size of the cellular phone is 97.4 x 44.2 x 23.7 mm, and the screen size is 1.8", and is a 260K color TFT LCD (176x220). It also has a 2 Mega Pixel camera with flash. Therefore, the author will use this cell-phone, which has a wheel key to control the cursor system, to demonstrate a screen interface design that simulates the control of home appliances.

D. Process of developing a prototype

1. Scenario-based design

   To develop a cellular phone design to control the home appliance, a scenario-based design was used to identify important characteristics of the user character, behavior and navigation map. According to a paper, Five Reasons for Scenario-Based Design, “Scenarios evoke reflection in the content of design work, helping developers coordinate design action and reflection.” Thus, “Scenarios can be abstracted and categorized, helping designers to recognize, capture, and reuse generalizations, and to address the challenge that technical knowledge often lags the needs of technical design.”(Carroll 1999, p.1) Therefore, a scenario was created that anticipates the user’s performance when he/she uses a cellular phone to control home appliances.

1-1. Story of Ms. Sunny Lee

   My name is Sunny Lee. I am 48 years old, and I am a college educated American. Currently, I don’t have a job. My computer experience is around 5 years, and I use the computer for one or two hours per day. Usually I am checking email, surfing and chatting with my family. Also, I have been using a cellular phone for 5 years. My main phone use is to call family and friends. I have two children, one son and daughter, and a husband. My
husband is a university professor in the computer science department. My son is a senior in the university, and my daughter is studying abroad. I am not familiar with new technology devices, but I keep abreast of technological development because of my husband and son who are often discussing computer and mobile device/software development. I spend most of my time for family, which includes cooking laundry and cleaning rooms. However, after they get busy, I have a lot of free time to spend for me, so that often I went out exercising, volunteering, and meeting with friends. One day for a birthday present, I got a new cellular phone that can take pictures and control home appliances from outside the home. I think this cellular phone fits my needs, because I would often worry about whether I turned off all of the lights and gas when I went out. Besides I think it will be good to control the heater from outside, so that I do not need to hurry back home to warm up the house before the rest of the family comes back. Therefore, I learned to take pictures of our home appliances and control them. This cellular phone uses the same kind of cursor system to control the interface that computers use, so I am already familiar with it. It is a pretty natural and intuitive way to control the system; therefore, it is fun to learn and makes the system easy to control.

1-2. Task procedure

Set up

First I took pictures of our living room, bathroom, kitchen, and the son’s and daughter’s rooms. Then I decided how many categories I will have (one living room, one bathroom, one kitchen, and two rooms), and save all of the pictures for each category. Therefore, I can see the living room picture that included several home appliances like lighting, air conditioner, TV, and a curtain. Now I finished all of the set up process.
Control

Today, I have an appointment with a friend. After I helped my husband and son to go to work and school, there was not much time left, so I was in a hurry to go out. I was in such a hurry, so I was not sure whether I turned off the living room light or not. I checked the cellular phone, and went to the page for controlling home appliances. After I enter my user name and pin number to log in for safety, I can see the home appliances menu that I set up earlier. I click a lighting button, and make sure it is off. Just to be sure I did not miss any other lights, I checked the Later, when I am having great time with my friend, my cellular phone rang, and I checked it. Somebody unexpectedly visited my home, and was ringing a bell. The gate ring was transferred to my cellular phone, and cellular phone screen shows somebody that looks like my sister. So I asked, “Who is it?” She responded, “I am your sister.” I clicked the icon for the door and clicked open. Then the pin number box appeared, and I entered the pin number. The lock was released, and my sister could enter. I ask my sister to put a chicken meal in the microwave, and then I set up a time to cook before my family comes back from work.
2. Navigating sequences

2-1. Navigation map

The Navigation Map is organized to help people to understand the overall sequence design. It is organized into two main categories; Set up and Control. The Set up category is divided into three submenus: Pin number, User name, and Set up picture. The control category is divided into three submenus: Microwave, Lighting, and Heater.

![Navigation Map Diagram]

Figure 3.3 Navigation Map
2-2. Story Board by flash card

Using flash cards to understand the navigation step is a useful method for developing a storyboard. Following the navigation map, the author sketched each step in the flash card and explored several possible screen designs.

Figure 3.4 Process of navigation sequence
3. Screen design using graphic design element

3-1. Screen layout

As mentioned in the literature review, layout is the most important graphic element that affects the overall design. A clean and consistent layout makes the layout easy for the user to understand and natural to navigate. For a screen design for controlling home appliances, four different kinds of layout systems were explored. The first and second layouts were designed as circular shapes because of the wheel key system. When using wheel key system, it is easier and more natural to navigate a circular layout (Figure3.5)

![Figure3.5 Circular shape of layout](image)

However, if pictures of home appliances were used as an icon, a square shape layout is a better solution because the square shape saves more space and shows pictures more clearly and precisely (Figure3.6). All contents can be designed into two different kinds of
square layouts in diverse, clean ways. This layout also fits the purpose of this navigation prototype that is more natural to understand and is easier to recognize contents. Even though people will use the circular shape of the wheel key in the screen, the wheel is controlling a cursor, so that it does not matter, even if the layout is used square shapes. Therefore, the author decided to design using a square layout for the final screen interface design.

3-2. Icon & image

According to Raskin (2000) from a literature review, “Icons are another visual cue that helps users locate and remember information. Furthermore icons can contribute to visual attractiveness of an interface and under the appropriate circumstances, can contribute to clarity.” Because of these benefits, the author tried to develop several icons for this interface
design. There are several icons that represent each room. The author used a TV as a living room icon, people who sleep as a bedroom icon, a shower as a bathroom icon, and a dish as a kitchen icon. Figure 3.7 shows comparisons between different sizes, with text and without text. These icons were put on a cellular phone screen to see the relationship between icon identification and the screen (Figure 3.8). The Set up and Control icons were clear to identify. However, problems were noted when developing the room icons. It was difficult to put text in the room icons, which had to be small to fit on cellular phone screen. Without text, there were some difficulties in identifying each icon. The TV icon seemed like the microwave icon, and the bedroom symbol could be seen as a hospital symbol. If icons are not clear enough, the benefit of the icons are lost and may even confuse the user’s understanding of the icons’ function.

Because of the difficulties with icon identification, the author tried to use image as a button. There are several types of images, but a picture can provide information that would be difficult to describe in words. A picture also contains a large amount of detail about the

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**Figure 3.7 Icons**

**Figure 3.8 Icons in screen**
size, shape, and relative position of the various rooms in a house (Stone, Jarrett, Woodroffe, Minochas 2005).

The author decided to use a picture to identify a button. If users see rooms and home appliance pictures for identification, they are easy to recognize (Figure 3.9). Since people can take their own room and home appliances’ pictures with their camera, they are already familiar with all images. Therefore, there is no time required to figure out icons, and buttons.

3-3. Color

According to the literature review, color is the most powerful element of visual communication. “Color evokes immediate and forceful responses both emotional and informational. Because color is a shared human experience, it is symbolic as well” (Watzmann 2003, p.277). The authors of User Interface Design and Evaluation show a variety of reasons for using color in a screen. (Stone, Jarrett, et al. 2005, p.250)

To draw attention: People will often find that important buttons or areas of the screen are a different color
To show status: As the status becomes more critical, the color might change. An example of this is a traffic light changing from yellow to red.
To make the information on the display clearer: Color can be used to organize the screen or to show perspective.  
To make the display more: Usability is more important than aesthetics, but it is important to ensure that the combination of color is visually appealing.

From this point of view, Author explored several colors and combine together. (Figure 3.10)

There is book calls Color Index by Jim Krause that helps author to combine proper color together. Author chose four colors enclosed in the red square as finalists from the several color combinations by criteria. These four color combinations had different colors for each button, so the buttons stand out more than any other color combinations, so these well organized colors make people get more attention and attractive. (Figure 3.10)
Ophthalmologist recommends gazing on sky when people get tired of their eye, because blue color is good for eye, and comfortable to see. There are many people who use blue as computer background or screen saver. Beside, blue is strongly associated with sky and water which has strong associations of permanence. These associations make blue feel reliable, trustworthy, and dependable (Eiseman 2000, p.39). This prototype also needs to convey feelings of safety and trust. Therefore, blue is a perfect color as a background for the prototype.

3-4. Typography

According to the information in the literature review, typography cannot be a dominant part of the interface design; it is more related with legibility and readability. The typographic choice affects legibility, and the choice of typeface immediately impacts whether a communication is read and how it is perceived. Typeface designed for screen use can increase legibility as well as providing perceptual cues about the approachability and quality of an interface (Watzmann 2003, p.268). From a research, most common typefaces for screens are Verdana, Helvetica, and Arial which are san-serif typeface. These typefaces are clean, easy to read, and optimize the reading process. Serif type face such as Georgia is too decorated typeface, and it is good for design. However it is not good for Legibility and Readability in screen. Author chose Arial typeface for a prototype, because it is most clear precise, and easiest to read from screen, also Arial is the basic and common typeface which is available most of devices such as Computer, PDA, Cellular phone etc.

According to a literature review, “Use at least 14 pts font for designing small screen devices. Due to poor resolution of small screen a variable lighting conditions, a smaller font
size may deteriorate the reading process” (Karkkainen, Laarni 2002, p.229) Author tried to use 14 point in the prototype screen, but it is too big to cover all contents. Therefore, author decided to use 14 point Aria as a keyword text and to use 13 point and 12 point Aria as a contents text.

3-5. Navigation cues

According to the literature review, navigation cues are related to an increase in the ease of use and focus on user needs. Designers have to consider how to enable people to navigate an interface design easily using menus, button design, and hierarchical structures. The author explored several ways to navigate more naturally and easily using menus, buttons, and hierarchical structures. The first thing that the author tried was 3D rotation menus showing living room, kitchen, bathroom, and bedroom pictures. A 3-dimentional picture rotated when the user’s mouse rolled over the picture. When a user’s mouse rolled over the picture and the user clicked the living room picture, it went to the living room section. Once users are in the living room, they can see different colored small squares, which represent controllable home appliances. When the user’s mouse does a roll over in the lighting purple square, the lighting menu appears which shows lighting that can be turned on and off (Figure 3.11). This navigation step is a pretty easy and natural way to navigate, but users have to go through too many steps. A 3D rotation menu cannot be shown at once on the screen; users have to move a mouse several times. Furthermore, there is no color relationship and consistency between each small square and each home appliance menu. It is randomly chosen and is confusing to the user.
The second method that the author focused on was a natural way to navigate (Figure 3.12). The navigation steps goes from outside to inside. The author assumes that users start at the front door: 1. Turn on a front light, 2. Open a door, 3. Choose kitchen picture, 4. Choose microwave, and 5. Control microwave menu. This navigation step progresses smoothly, naturally, and easily. Beside, users can see all rooms’ buttons at once from menu page, so they can click the desired rooms immediately. However, there are some unnecessary things that users always have to go through. For example, there is a first page where users have to open a door every time they want to enter inside. Therefore, it requires too many steps to navigate, and took more time to complete a task. The last method that the author tried is to organize the menu structure by home appliances instead of rooms (Figure 3.13).
With the previous ideas, users always needed two steps to approach each home appliance page because the contents were divided by rooms. However, if the contents are organized by home appliances, the user can directly choose each home appliance from a menu page. This is still a natural and easy way to navigate, and it takes fewer steps to go through.

### 3-6. Usability Test

Using the simulated prototype, usability tests were conducted to analyze the user’s experience with the prototype with respect to designing a user-friendly, small screen interface to control home appliances. There were 12 participants for the usability test. Their ages ranged from 25~45, and were equally divided by gender (six men, six women). Also, they were divided by region, six participants were from Korean and Taiwan, and six participants were from the USA. Different groups of people were tested, because there should be some different user’s perception of cellular phone use. This decision is based on the author’s assumptions that Asian cellular phone technology, especially Korea and Japan, is more advanced and is in broader use than American cellular phone technology. Also, the author wanted to research any differences between men and women with regard to the
interface prototype. Participants had various occupations such as campus minister, IT support, Academic advisor, Social worker, Computer programmer, Research associate, House wife, Pastor, Student and most of the jobs required them to use a computer. Seven of the participants used a computer for over six hours per day. The participant’s computer experience is over 5 years, and they use the computer for checking email, web searches, browsing the Internet, entertainment, work processes, research, and programming). Most participants’ cellular phone experience is over 6 years. Mainly the participants use the cellular phone for voice communication, to check time, and as an alarm clock (Table 3.2).

<table>
<thead>
<tr>
<th>Purpose of using cellular phone</th>
<th>Number</th>
<th>Purpose of using cellular phone</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice Communication</td>
<td>11</td>
<td>Schedule Planner</td>
<td>3</td>
</tr>
<tr>
<td>Take a picture-Camera</td>
<td>3</td>
<td>Alarm Clock</td>
<td>4</td>
</tr>
<tr>
<td>Text message</td>
<td>3</td>
<td>Calculator</td>
<td>3</td>
</tr>
<tr>
<td>Entertainment-Game, web surfing</td>
<td>3</td>
<td>Check Time</td>
<td>6</td>
</tr>
</tbody>
</table>

Before conducting the study, the author had to get permission to proceed with usability test from ISU Human Subject Research, and they reviewed the study under the Exempt category of the Federal Regulations. Permission was given for the usability research on December 8th 2005. Completing the usability test required approximately 30 minutes. First, participants were asked for demographic information such as age, occupation, and their use of computers and cellular phones. Second, participants were asked to perform five tasks in the computer, and they had to finish all tasks using the provided simulation. Each task was divided into three to four specific questions in order to find more accurate results (Table 3.3). The software ‘Camtasia’ was used to capture a screen and record a participant’s voice.
Table 3.3 User tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 1</strong></td>
<td>You are the first user, set up the user name as ‘poeat’ pin number as ’1459’ to make accessible to home application.</td>
</tr>
<tr>
<td>1-1</td>
<td>Find home appliances page</td>
</tr>
<tr>
<td>1-2</td>
<td>Find a ‘Set up’ button</td>
</tr>
<tr>
<td>1-3</td>
<td>Set up user and pin #</td>
</tr>
<tr>
<td>1-4</td>
<td>Find button ‘Next’</td>
</tr>
<tr>
<td><strong>Task 2</strong></td>
<td>Bring the picture of Lighting, Microwave, Oven and Air condition</td>
</tr>
<tr>
<td>2-1</td>
<td>Find Category of home appliances</td>
</tr>
<tr>
<td>2-2</td>
<td>Click each home appliance’s button</td>
</tr>
<tr>
<td>2-3</td>
<td>Bring pictures</td>
</tr>
<tr>
<td><strong>Task 3</strong></td>
<td>Change orders the kitchen home appliances to the top line, and placed the air condition on the left side.</td>
</tr>
<tr>
<td><strong>Task 4</strong></td>
<td>Control the microwave time to 15min, and make the heater temperature 80 degree on second floor.</td>
</tr>
<tr>
<td>4-1</td>
<td>Find a Microwave button</td>
</tr>
<tr>
<td>4-2</td>
<td>Set up a time of 15 minutes</td>
</tr>
<tr>
<td>4-3</td>
<td>Find a power button and makes work</td>
</tr>
<tr>
<td>4-4</td>
<td>Find to go back ’Menu’ button</td>
</tr>
<tr>
<td>4-5</td>
<td>Find an ‘Air condition’ button</td>
</tr>
<tr>
<td>4-6</td>
<td>Find the place to set up temperature 80 degree, and click ‘Heat’ button</td>
</tr>
<tr>
<td><strong>Task 5</strong></td>
<td>Turn off all lightings, and then turn on the lightings of kitchen, and living room</td>
</tr>
<tr>
<td>5-1</td>
<td>Find a Lighting button</td>
</tr>
<tr>
<td>5-2</td>
<td>Find ‘All off’ button</td>
</tr>
<tr>
<td>5-3</td>
<td>Turn on each room</td>
</tr>
</tbody>
</table>

Third, participants were asked for their perceptions on the prototype and preferences related to the task or pictures that the author showed to participants.
CHAPTER 4. PROTOTYPE OF NATURAL INTERFACE DESIGN TO CONTROL THE HOME APPLIANCES

In the methodology section, author explored several aspects of design: layout, icon & image, color, text, and navigation cues to create a final prototype of a Natural (Intuitive) Interface Design to Control Home Appliances. Author defines the phrase, “natural (intuitive) design,” as a design that allows users to manipulate the interface without needing to think about what they are doing. It builds on people’s prior experience. Therefore, author used a cursor system to navigate the interface design. According to the literature review and methodology section, a number of people are familiar with using a cursor system because they already use similar systems on computers or MP3 players. To control the cursor, author decided that a good solution would use a wheel key as the mouse.

A. Overall of design

In the methodology section, author decided to use a square format for the final design (Figure 4.1). This final layout design was determined under two criteria which are as follows, “Present the most important information first and at the top of the hierarchy, and indicate the links clearly” (Karkkainen, Laarni 2002, p.229). According to priority, the main layout is divided three parts: the Main title, the Content, and the Sub menus. The Main title and Sub menus always stay in the same place and create consistency for all of the screen pages. The most important Main title text, “Home Appliances,” is placed on the left side of the Main title. Sub title text, which tells users where they are located, is placed on right side of the Main title. The content area is changeable. The information it displays depends on the context or
location in the information hierarchy. The Sub menus are always placed at bottom of the screen. Therefore, wherever users are in a page, they can quit what they are doing and move to other pages.

Figure 4.1 Overall of design

For colors, author uses blue as a background color. As discussed in the methodology section, blue is a reasonable color for the background, and dark red is used in the Sub menu for contrast. For text, author decides to use 14 point Aria for keyword text and to use 13 point and 12 point Aria for contents text. For button identification, author use real pictures of home appliances. Because of cameras built into many cellular phones, people can take good quality pictures of their own appliances to use in the interface. Seeing pictures of their own appliances in a familiar setting will help people navigate this cellular phone screen design. For navigation structure part, author focus to organize contents in order to less click, and easy to navigate. All contents were categorized by home appliances, not by rooms. Previous category which divided by rooms requires more step to navigate to finish a task. Therefore, people can immediately click a home appliance which they want to control from a menu page, so they can navigate the cellular phone screen design easily and simply.
B. Final prototype on screen

From this point on, author will show all screen designs in a sequence, and will comment on each design.

1. Main page & Set up page

When users click a home control button (see image number 1 in Figure 4.2), they will see a main page that requires them to type their “User name,” and “Pin number” (Figure 4.2, Image number 2). However, if people are first time users, they have to go a Set up page first to enter a user name, pin number, and home appliances picture (Figure 4.2, Image number 3).
2. Set up picture pages

The four images in Figure 4.3 show the process of setting up the home appliances pictures. Image 1 shows the home appliance set up screen where home appliance pictures are placed. The user needs to choose a home appliance category from the drop-down list, and then click a button for each home appliance (Image 2). For example, the user clicks the lighting button to put a picture in the space. A group of thumbnail pictures appears from which the user picks a lighting picture (Image 3). In the same way, the user can enter other appliance’s pictures such as a Microwave, Oven, and Air Conditioning/Heating. After the user finishes entering pictures of his or her home appliances, the completed screen looks like last image (Image 4).
3. Menu page & Microwave page

Once the user sets up the pictures in the Set up page, they can see their home appliances’ buttons from the Menu page. See image 1 in Figure 4.4. There are four clickable buttons: Lighting, Microwave, Oven, and Air condition/Heat. Users also can change this order using drag & drop actions. If users want to group kitchen appliances together, they can move the oven button to the top line. The color bar has a relationship with each home appliance. Red is used for the oven because red is used to depict heat, and blue is used for Air Conditioning because blue is used to depict cool temperatures. Image 2 of Figure 4.4 shows the microwave page. Once the user clicks the microwave button from the Menu page, Microwave page opens where there is a control box for the microwave. Red is used for the
microwave control panel because of microwave ovens' association with heat. In the control panel, there are six buttons called “One touch cook.” When users want to cook using these simple controls, they can set up a time in a box and click a power button to cook.

4. Air Condition/Heat page & Lighting page

Once users click on the Air-condition/Heat button from the Menu page, the Air-condition/Heat page appears. Author used a thermostat as the main image for this page. Yellow bold text indicates which location is being displayed, and the first box shows the current temperature for that location. If users want to increase the temperature to 80 degrees, they can enter the temperature in second box with the cellular phone keyboard and click the
red Heat button. Inversely, if users want to make the location cooler, they put a temperature in the second box and click the blue ‘Cool’ button. In the lighting page, author used yellow, which represents light, for the lighting menu bar. The light information is organized by rooms: the kitchen, the bedroom, the living room, and the study room. Users can turn on or off a light one by one or use the buttons ‘All off’ and ‘All on’ to turn off or on all of the lights.
The purpose of a usability test is to investigate whether a prototype meets its usability requirements and problem it is addressing. Evaluating the prototype interface design helps to find out how successfully the prototype works, and what kinds of problems users have while using the prototype. From the test, author will evaluate the prototype with regard to design and usability. The author will analyze the data between the gender groups and the ethnic groups. A limitation of this usability study relates to a limitation of technology. The cellular phone prototype, which is simulated in a computer, creates a level of inconvenience and difficulty for navigation because of the computer mouse. In contrast, people can directly manipulate the keypad of an actual cellular phone. Because using the computer mouse causes unexpected errors, these errors will not be considered a problem in the prototype. The Asian in this usability test indicate Korean and Taiwanese.
A. Analysis of tasks

1. Result and analysis of task 1

The goal of Task 1 is to investigate how participants find a screen of home appliances and recognize menu buttons. Overall, participants successfully performed four tasks that were subdivided from Task 1. Table 5.1 shows the data by gender and ethnic group.

Table 5.1 Percentage of completed tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>You are the first user, set up the user name as ‘poeat’ pin number as ‘1459’ to make accessible to home application.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td>1-1</td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td></td>
</tr>
</tbody>
</table>

From Table 5.1, participants successfully performed Task 1-1 and Task 1-2. However, one Asian woman failed to perform Task 1-3, because of some difficulties with controlling the cellular phone keyboard with the mouse. Both an American man and an Asian man failed to perform Task 1-4; they did not realize that they had to click the ‘Next’ button to go to the next step.

Table 5.2 Time to complete tasks

<table>
<thead>
<tr>
<th>Man</th>
<th>Time</th>
<th>Woman</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man 1</td>
<td>01:24</td>
<td>Woman 1</td>
<td>02:35</td>
</tr>
<tr>
<td>Man 2</td>
<td>02:28</td>
<td>Woman 2</td>
<td>02:54</td>
</tr>
<tr>
<td>Man 3</td>
<td>01:22</td>
<td>Woman 3</td>
<td>01:13</td>
</tr>
<tr>
<td>Man 4</td>
<td>01:44</td>
<td>Woman 4</td>
<td>03:21</td>
</tr>
<tr>
<td>Man 5</td>
<td>03:46</td>
<td>Woman 5</td>
<td>01:50</td>
</tr>
<tr>
<td>Man 6</td>
<td>02:09</td>
<td>Woman 6</td>
<td>02:03</td>
</tr>
</tbody>
</table>
The overall of time to completed Task 1 was between 1 minute 13 seconds and 3 minutes 46 seconds. Men took less time to complete Task 1 than women. However, there is no significant time difference. In the women’s case, they spent time browsing whole buttons carefully but did not really click each one, so that it took more time than men. In terms of ethnic differences, Asians finished Task 1 earlier than Americans. Specially, there were two people from the American group that took over 3 minutes (Table 5.2).

### Table 5.3 Number of errors

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1-4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 5.4 Frequency of assists

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>1-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1-4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

As can be seen in Table 5.3 and Table 5.4, Task 1-2 and Task 1-3 have many errors and required several assists to solve the problems compared to other tasks. Specially, women made many errors when trying to perform Task 1-3. As mentioned before, there were some difficulties with navigating a cellular phone keyboard using a computer mouse. According from the error lists (Table 5.5), when users were performing Task 1-2, they did not read
carefully and ignored an instruction that said ‘if you are first user, find set up part first’, so instead of finding a setup page, they just typed a user name and pin number directly into the menu page. Generally, both of American men and women had these problems. Asian men had fewer errors than American men. Inversely, Asian women had more errors than American women. Overall, women had more errors than men had.

Table 5.5 Error list of each sub task

<table>
<thead>
<tr>
<th>Task</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asian</td>
<td>American</td>
</tr>
<tr>
<td>1-1</td>
<td>0</td>
<td>•Try to find out button from keyboard not from screen</td>
</tr>
<tr>
<td>1-2</td>
<td>0</td>
<td>•Don’t find a button for set up, just directly to go menu page, ignored an instruction</td>
</tr>
</tbody>
</table>
| 1-3  | 0 | •Click ‘Next’ button first | 1 | •Try to click a ‘Quit’ button on the screen  
•Having a difficulty of add ‘user name’ and ‘pin number’  
•Try to click a ‘Log in’ button on the screen  
•Keep clicking a ‘OK’ button, so lost the way when she was | 1 | •Having a difficulty of add ‘user name’ and ‘pin number’  
•Try to click a ‘Log in’ button on the screen  
•Keep clicking a ‘OK’ button, so lost the way when she was  
•Click right side of mouse |
| 1-4  | •Didn’t realize that have to click ‘Next’ button | 1 | •Didn’t realize that have to click ‘Next’ button | 1 | 0 | 0 |
As can be seen in Table 5.5, the errors of Task 1-2 affected 50% of all participants. The right path that the author expected was for participants to find the Set up button from Step 2, in Figure 5.1, and type a user name and pin number in Set up page which is Step 3. However, most participants directly typed a user name and pin number in Step 2 page instead of finding the Step 3 (Set up) page. The participants suggested when they type in wrong page, there should be a pop up message that appears and instructs the user to go to the right page. As mentioned earlier, most errors of Task1-3 were navigation problems using the computer mouse. Lastly, some participants did not realize there is ‘Next’ button to go next page (Step3).

Recommendations

- Provide immediate feed back: For example, when the user types a user name and pin number in the wrong page, provide a pop-up message that instructs the user to go to the correct page
- Create a clear visual navigation hierarchy: For example, the ‘Next’ navigation button needs to be more noticeable, so the user will not miss it in the future.
2. Result and analysis of task 2

The goal of Task 2 was to investigate how participants place home appliance pictures into the right place using other navigation cues. Overall, participants performed successfully for the four tasks that were subdivided from Task 2. Table 5.6 shows the data by gender and ethnic group.

Table 5.6 Percentage of complete

| Task 2 | Bring the picture of Lighting, Microwave, Oven and Air condition | Man | | | Woman | | | Total |
|-------|---------------------------------------------------------------|-----|-----|-----|-----|-----|-----|
|       |                                                               | American | Asian | American | Asian | 100 | (12) |
| 2-1   | Find a picture category of home appliances                    | 100(3)   | 100(3) | 100(3)   | 100(3) | 100 | (12) |
| 2-2   | Click each home appliance’s button                           | 100(3)   | 100(3) | 100(3)   | 100(3) | 100 | (12) |
| 2-3   | Bring pictures in the place                                  | 100(3)   | 100(3) | 100(3)   | 67(3)  | 92  | (11) |
| 2-4   | Pictures recognition: Lighting 84(10), Microwave 100(12), Oven 100(12), Heater 60(7) | | | | | | |

Table 5.6 showed that participants successfully performed Task 2-1 and Task 2-2. However there was one Asian woman that failed to perform Task 2-3 because of navigation problems using the computer mouse. With Task 2-4, participants had hard time figuring out a thermostat picture for the Air-condition/Heater button. This was especially true for Asian people who had some difficulty with finding this picture because of differences in experience. In Asia, usually people buy an actual Air-conditioner to place in their house, so that they might expect to find a picture of an Air-conditioner instead of a picture of a thermostat.

Table 5.7 Time to complete

<table>
<thead>
<tr>
<th>Man</th>
<th>Time</th>
<th>Woman</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man 1 (Asian, 34-41)</td>
<td>01:30</td>
<td>Woman 1 (Asian, 26-33)</td>
<td>01:30</td>
</tr>
<tr>
<td>Man 2 (Asian, 42-49)</td>
<td>02:02</td>
<td>Woman 2 (Asian, 34-41)</td>
<td>01:02</td>
</tr>
<tr>
<td>Man 3 (Asian, 18-25)</td>
<td>01:03</td>
<td>Woman 3 (Asian, 26-33)</td>
<td>00:54</td>
</tr>
<tr>
<td>Man 4 (American, 42-49)</td>
<td>01:30</td>
<td>Woman 4 (American, 26-33)</td>
<td>01:44</td>
</tr>
<tr>
<td>Man 5 (American, 26-33)</td>
<td>01:36</td>
<td>Woman 5 (American, 34-41)</td>
<td>01:50</td>
</tr>
<tr>
<td>Man 6 (American, 26-33)</td>
<td>01:12</td>
<td>Woman 6 (American, 42-49)</td>
<td>01:14</td>
</tr>
</tbody>
</table>
The overall time required to complete Task 2 was between 54 seconds and 2 minutes 2 seconds. Men took more time to accomplish the tasks, and women took less time to finish the tasks because they are familiar with home appliances. When comparing between ethnic groups, there was no significant difference between American and Asian groups (Table 5.7).

Table 5.8 Number of errors

<table>
<thead>
<tr>
<th>Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21</td>
</tr>
</tbody>
</table>

Asian Man | American Man | Asian Woman | American Woman

Table 5.9 Frequency of assists

<table>
<thead>
<tr>
<th>Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Asian Man | American Man | Asian Woman | American Woman

Tasks 2-1, 2-2, and 2-4 had almost the same number of errors. Most of the errors from Task 2-1 were that users clicked each home appliance button first instead of finding a picture category. The average of number of errors by both gender and ethnic groups were the same. Task 2-2’s errors occurred within the American group. Asian men had most errors in Task 2-4, because of recognition problems with the Air-condition/Heater picture, as mentioned before. Finally, the errors of Task 2-3 appeared only with Asian women. Again, their errors were the result of navigation problems using the computer mouse. Generally, the American
group had more errors and assists than the Asian group, and women had more errors and assists than men.

Table 5.10 Error list of each sub task

<table>
<thead>
<tr>
<th>Task</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.2 Right pass for Task 2
Table 5.10 shows that around 50% of participants made the same error with Task 2-1 in which they clicked each home appliance button first, (Step 2 of Figure 5.2) and then checked category next (Step 1 of Figure 5.2). Participants suggested that when they click each button first, the interface shows pop up message that says, “Check category list first.” Then users will know there is list menu bar that they have to choose the “home appliances” category first.

All of the American participants had errors with Task 2-2; they preferred to click the whole picture box instead of clicking a small text button (Step 2 of Figure 5.2). Therefore, the author can make whole box into a button that can be clickable, then users will not have confusion over which button they have to click. From the errors with Task 2-4, about 50% of participants mentioned that some photos are difficult to recognize. However, participants will take their own photos for this interface, so this will not be a problem for the actual product.

**Recommendations**

- Create a clear visual navigation hierarchy: For example, when the user starts to set up a picture, leave only the list bar menu visible in the start page and eliminate distracting elements. Once the user checks the ‘home appliance’ category from the list bar menu, the home appliance buttons will appear. Then the user will not select the home appliance buttons initially.

- Provide flexibility for the user in controlling buttons: Instead of only text, place text and a picture into each home appliance button that is clickable.
3. Result and analysis of task3

The goal of Task 3 was to investigate how participants learn how to change the order of each icon on the Menu page. To change the ordering of the icons, participants have to use a drag & drop method, and this task result will be affected by the drag & drop requirement whether they are familiar with computers or not. Overall, participants performed successfully for Task 3. Table 5.11 shows the data by gender and ethnic group.

Table 5.11 Percentage of Complete

<table>
<thead>
<tr>
<th>Task3</th>
<th>Man</th>
<th>Woman</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change orders the kitchen home appliances to the top line, and placed the air condition on the left side.</td>
<td>American</td>
<td>Asian</td>
<td>American</td>
</tr>
<tr>
<td></td>
<td>100(3)</td>
<td>100(3)</td>
<td>100(3)</td>
</tr>
</tbody>
</table>

As shown in table 5.11, participants successfully performed Task 3. However, in terms of the time required to complete Task 3, there were big differences (00:22-4:22). Men’s performances were completed successfully. Asian men in particular, took less than one minute to complete the task. In the women’s case, two people took a long time to finish a task, so the author checked their computer experience. The author found that the two women’s jobs were housewife and social worker, which means they use the computer less when compared to other participants. Probably this group of people had a difficult time with using the drag & drop method to change the order of icons (Table 5.12).

Table 5.12 Time to Complete

<table>
<thead>
<tr>
<th>Man</th>
<th>Time</th>
<th>Woman</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man1 (Asian, 34-41)</td>
<td>00:50</td>
<td>Woman1 (Asian, 26-33)</td>
<td>01:37</td>
</tr>
<tr>
<td>Man2 (Asian, 42-49)</td>
<td>00:55</td>
<td>Woman2 (Asian, 34-41)</td>
<td>03:31</td>
</tr>
<tr>
<td>Man3 (Asian, 18-25)</td>
<td>00:45</td>
<td>Woman3 (Asian, 26-33)</td>
<td>00:22</td>
</tr>
<tr>
<td>Man4 (American, 42-49)</td>
<td>01:36</td>
<td>Woman4 (American, 26-33)</td>
<td>04:22</td>
</tr>
<tr>
<td>Man5 (American, 26-33)</td>
<td>02:13</td>
<td>Woman5 (American, 34-41)</td>
<td>00:47</td>
</tr>
<tr>
<td>Man6 (American, 26-33)</td>
<td>01:10</td>
<td>Woman6 (American, 42-49)</td>
<td>00:48</td>
</tr>
</tbody>
</table>

As shown in table 5.11, participants successfully performed Task 3. However, in terms of the time required to complete Task 3, there were big differences (00:22-4:22). Men’s performances were completed successfully. Asian men in particular, took less than one minute to complete the task. In the women’s case, two people took a long time to finish a task, so the author checked their computer experience. The author found that the two women’s jobs were housewife and social worker, which means they use the computer less when compared to other participants. Probably this group of people had a difficult time with using the drag & drop method to change the order of icons (Table 5.12).
Table 5.13 Number of errors

<table>
<thead>
<tr>
<th>User</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Asian Man  American Man  Asian Woman  American Woman

Table 5.14 Frequency of assists

<table>
<thead>
<tr>
<th>User</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Asian Man  American Man  Asian Woman  American Woman

Task 3 had total 17 errors and 6 assists. Americans made 14 of the errors. Once I gave the American men a hint, they immediately figured out the task. On the other hand, American women still needed more time to figure out the task. Generally, American participants had more errors and assists than Asian participants, and Women had more errors and assists than men.

Table 5.15 Error list for each sub task

<table>
<thead>
<tr>
<th>Task</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>● Click each icon first</td>
<td>● Click each icon</td>
</tr>
<tr>
<td></td>
<td>● Click the keyboard arrow up and down</td>
<td>● Click the keyboard arrow up and down</td>
</tr>
<tr>
<td></td>
<td>● Click ‘Control’ text right side on screen</td>
<td>● Click ‘Control’ text right side on screen</td>
</tr>
<tr>
<td></td>
<td>● Click ‘Set up’ button left side on screen</td>
<td>● Click each icon</td>
</tr>
<tr>
<td></td>
<td>● Click ‘Set up’ button left side on screen</td>
<td>● Click each icon</td>
</tr>
<tr>
<td></td>
<td>● Click ‘End’ button right side on screen</td>
<td>● Click ‘Control’ text right side on screen</td>
</tr>
<tr>
<td></td>
<td>● Click ‘CLR’ button on a keyboard</td>
<td>● Click mouse right button</td>
</tr>
</tbody>
</table>

Man                                                                 | Woman                                                                 |
| 1                                                                 | 1                                                                 |
| 2                                                                 | 2                                                                 |
| 1                                                                 | 1                                                                 |

American #  Asian #  American #  Asian #
Among the 14 errors, American participants initially tried to click the up and down buttons from a cellular phone keyboard, to click the “Control” title text, to click the “Set up” button or to click icons to move them (Figure 5.4). However, once participants tried the drag & drop method, they liked it because they are already use to it from their computer experience. Participants asked that the author put drag & drop instructions into the interface, otherwise, it will not be obvious that drag & drop movements are possible.

**Recommendations**

- Keep the interaction metaphor consistent within the context of a current device: The user may be confused if confronted with a new navigation metaphor. Therefore, the drag & drop method for changing order of the icons need to be reconsidering as navigation method. It is better to maintain a consistent human interaction metaphor for changing the order of icon in the cellular phone.

- Provide clear instructions: To prevent the confusion problem with the drag and drop method, provide clear information indicating the availability of this method in the interface design.
4. Result and analysis of task 4

The goal of Task 4 was to investigate how navigation cues (buttons, icons, and colors etc) lead users to determine correct steps. Overall, participants performed successfully for six tasks that were subdivided from Task 4. This task in particular is important to process in the right sequence. Table 5.16 shows the data by gender and ethnic group.

Table 5.16 Percent of participants who complete the task

<table>
<thead>
<tr>
<th>Task 4</th>
<th>Control the microwave time to 15min, and make the heater temperature 80 degree on second floor.</th>
<th>Man American</th>
<th>Man Asian</th>
<th>Woman American</th>
<th>Woman Asian</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>Find a Microwave button</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100(12)</td>
</tr>
<tr>
<td>4-2</td>
<td>Set up a time of 15 minutes</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100 (3)</td>
<td>67(2)</td>
<td>92(11)</td>
</tr>
<tr>
<td>4-3</td>
<td>Find a power button and makes work</td>
<td>100 (3)</td>
<td>67(2)</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>92(11)</td>
</tr>
<tr>
<td>4-4</td>
<td>Find to go back ‘Menu’ button</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100(12)</td>
</tr>
<tr>
<td>4-5</td>
<td>Find an ‘Air condition’ button</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100(12)</td>
</tr>
<tr>
<td>4-6</td>
<td>Find the place to set up temperature 80 degree, and click ‘Heat’ button</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100 (3)</td>
<td>100(3)</td>
<td>100(12)</td>
</tr>
</tbody>
</table>

*Table 5.16 Percent of participants who complete the task*  

From Table 5.16, it can be seen that participants successfully performed most of Task 4 with the exceptions of Task 4-2, and Task 4-3. One Asian man and woman were failed each task, because they missed one step necessary to complete the tasks.

Table 5.17 Time to complete the task

<table>
<thead>
<tr>
<th>Men</th>
<th>Time</th>
<th>Women</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man1 (Asian, 34~41)</td>
<td>02:30</td>
<td>Woman1 (Asian, 26~33)</td>
<td>01:28</td>
</tr>
<tr>
<td>Man2 (Asian, 42~49)</td>
<td>02:30</td>
<td>Woman2 (Asian, 34~41)</td>
<td>02:08</td>
</tr>
<tr>
<td>Man3 (Asian, 18~25)</td>
<td>02:15</td>
<td>Woman3 (Asian, 26~33)</td>
<td>04:20</td>
</tr>
<tr>
<td>Man4 (American, 42~49)</td>
<td>01:36</td>
<td>Woman4 (American, 26~33)</td>
<td>03:37</td>
</tr>
<tr>
<td>Man5 (American, 26~33)</td>
<td>03:10</td>
<td>Woman5 (American, 34~41)</td>
<td>02:15</td>
</tr>
<tr>
<td>Man6 (American, 26~33)</td>
<td>02:31</td>
<td>Woman6 (American, 42~49)</td>
<td>01:35</td>
</tr>
</tbody>
</table>
The overall of time required to complete Task 4 was between 1 minute 28 seconds and 4 minutes 20 seconds. There are no distinguishable differences between men and women, and between American and Asian participants. One Asian woman took the longest time (4 minutes 20 seconds), because she randomly clicked several buttons: message, send, and to connect Internet, and lost where she was. The woman was curious about what other functions the cellular phone prototype had (Table 5.17).

Table 5.18 Number of errors

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4-2</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4-3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>4-4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>4-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>4-6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 5.19 Frequency of assists

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4-3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4-4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>4-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4-6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

As can be seen from table 5.18 and 5.19, Tasks 4-4 and 4-6 had more errors compared to other tasks, and Tasks 4-2 and 4-5 had less errors compared to other tasks. Most errors that occurred from Task 4-4 involved returning to the Menu page when participants were in the
Microwave page. Sixty-eight percent of participants received 10 assists to complete the Task 4-4. Fourteen errors that participants made from Task 4-6 involved misunderstanding sequences. The errors of Task 4-1 only occurred with American participants. The errors of Task 4-3 are about recognizing the power button. Generally, American participants had more errors and assists than Asian participants, and women had more errors and assists than men.

Table 5.20 Error list of each sub task

<table>
<thead>
<tr>
<th>Task</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asian</td>
<td>American</td>
</tr>
<tr>
<td>4-1</td>
<td>1 ▪Click ‘Control’ text that placed right top on the screen after mouse over on the microwave button</td>
<td>3 ▪Click ‘Control’ text that placed right top on the screen after mouse over on the microwave button</td>
</tr>
<tr>
<td>4-2</td>
<td>0 ▪Missed to click ‘ok’ button first</td>
<td>1 ▪Missed to click ‘ok’ button first</td>
</tr>
<tr>
<td>4-3</td>
<td>2 ▪Missed to click ‘power’ button</td>
<td>2 ▪Missed to click ‘power’ button</td>
</tr>
<tr>
<td>4-4</td>
<td>3 ▪Click a title text ‘home appliance’ that placed top of screen ▪Keep clicking ‘Oven’ button, and click ‘Control’ text that placed right top on the screen</td>
<td>2 ▪Click a title text ‘home appliance’ that placed top of screen ▪Click the ‘Send’ button on keyboard ▪Click the ‘On’ button on keyboard</td>
</tr>
<tr>
<td>4-5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4-6</td>
<td>2 ▪Click ‘heat’ button first to increase temperature.</td>
<td>3 ▪Click ‘heat’ button first to increase temperature. ▪Keep clicking heat button</td>
</tr>
</tbody>
</table>


Table 5.20 shows that only American participants had errors for Task 4-1. They found a microwave button from the Menu page, but clicked the “Control” title text instead of the “Ok” button on the cellular phone keyboard. (Step 1 of Figure 5.5) The error from Task 4-3 is not recognizing the Power button. The right pass of Step 2 is that participants have to enter 15 minutes in the box, click the “Power button” and then click the “Ok” button. However, most participants missed the “Power button,” and just directly clicked the “Ok” button. One way to avoid this error is to display a pop up message that tells participants to click the power button first when they click the wrong button. Participants who had errors in Task 4-4 had problems finding the button that goes from Step 2 to Step 3. The right action was for participants to click the “CLR” button from a cellular phone keyboard, which are number 4
in Step 2. However, 68% of users tried to click “home appliances” or “Set up” text in Step 2. The problem in here is that participants thought it is too far to navigate from cellular phone screen to cellular phone keyboard using the computer mouse. Using a computer mouse, there is big distance to move from cellular phone screen to cellular phone keyboard. However, in the actual model, people will hold the phone and manipulate the keyboard with their hand. Therefore, this problem will not happen in an actual model. Fourteen errors that participants made in Task 4-6 were about misunderstanding sequences. The correct pass for Task 4-6 is Step 4; set the temperature to 80 degrees in the second box (number1) and click the “Heat button” (number 2). However, 84% of participants clicked the “Heat button” to increase temperature in the first box instead of entering 80 degrees in the second box. Participants preferred to use the “Heat button” to increase temperature. People find clicking the button to make the temperature go up and down more intuitive than typing 80 degrees into the box and clicking the “Heat” button.

**Recommendations**

- Provide immediate feedback: For example, when the user misses the ‘Power Button’, provide an error feedback message.
- Provide flexibility for the user in controlling buttons: For example, provide a ‘Home Appliance’ button which provides the additional option of returning to the menu page.
- Provide simple and natural navigation cues which follow common user conventions: For example, use a default temperature of 70 degrees, and provide arrow buttons instead of “Heat” and “Cool” buttons for increasing or decreasing the temperature.
5. Result and analysis of task 5

The goal of Task 5 is to investigate how participants use buttons to turn lights off and on. Overall, participants performed successfully for three tasks that were subdivided from Task 5. Table 5.21 shows the data by gender and ethnic group.

<table>
<thead>
<tr>
<th>Task5</th>
<th>Turn off all lightings, and then turn on the lightings of kitchen, and living room</th>
<th>Man</th>
<th>Woman</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>American</td>
<td>Asian</td>
<td>American</td>
</tr>
<tr>
<td>5-1</td>
<td>Find a Lighting button</td>
<td>100(3)</td>
<td>100(3)</td>
<td>100(3)</td>
</tr>
<tr>
<td>5-2</td>
<td>Find 'All off' button</td>
<td>100(3)</td>
<td>100(3)</td>
<td>100(3)</td>
</tr>
<tr>
<td>5-3</td>
<td>Turn on each room</td>
<td>100(3)</td>
<td>100(3)</td>
<td>100(3)</td>
</tr>
</tbody>
</table>

Table 5.21 showed that participants successfully performed Task 5. Also, participants completed the task in a short time. Seventy six percent of participants took less than 1 minute and twenty-four percent of participants took less than 1 minute 30 seconds. From an ethnic point of view, all members of the Asian group took less than 1 minute, and finished earlier than the American group (Table 5.22).

<table>
<thead>
<tr>
<th>Task5</th>
<th>Turn off all lightings, and then turn on the lightings of kitchen, and living room</th>
<th>Man</th>
<th>Woman</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1</td>
<td>Find a Lighting button</td>
<td>100(3)</td>
<td>100(3)</td>
<td>00:40</td>
</tr>
<tr>
<td>5-2</td>
<td>Find 'All off' button</td>
<td>100(3)</td>
<td>100(3)</td>
<td>00:25</td>
</tr>
<tr>
<td>5-3</td>
<td>Turn on each room</td>
<td>100(3)</td>
<td>100(3)</td>
<td>00:38</td>
</tr>
</tbody>
</table>

Table 5.22 Time to complete a task

<table>
<thead>
<tr>
<th>Man</th>
<th>Time</th>
<th>Woman</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man1</td>
<td>00:40</td>
<td>Woman1</td>
<td>00:57</td>
</tr>
<tr>
<td>Man2</td>
<td>00:25</td>
<td>Woman2</td>
<td>00:32</td>
</tr>
<tr>
<td>Man3</td>
<td>00:38</td>
<td>Woman3</td>
<td>00:59</td>
</tr>
<tr>
<td>Man4</td>
<td>01:03</td>
<td>Woman4</td>
<td>01:20</td>
</tr>
<tr>
<td>Man5</td>
<td>01:13</td>
<td>Woman5</td>
<td>00:34</td>
</tr>
<tr>
<td>Man6</td>
<td>00:35</td>
<td>Woman6</td>
<td>00:32</td>
</tr>
</tbody>
</table>
Table 5.23 Number of errors

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5.24 Frequency of assists

<table>
<thead>
<tr>
<th>User Task</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5.23 and 5.24 showed that participants had many errors and needed two assists in Task 5-2. Comparing between ethnic groups, there was no significant difference between American and Asian participants. Generally, women had more errors and assists than men.

Table 5.25 Error list of each sub task

<table>
<thead>
<tr>
<th></th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asian #</td>
<td>American</td>
</tr>
<tr>
<td>5-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-3</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Fifty percent of participants prefer to click each button to turn off the lights one by one (Figure 5.6--Number 2 in Step 2) instead of using the “All off” button (Figure 5.6--Number 1 in Step 2). Most of the women clicked each button (Figure 5.6--Number 2) several times to turn all off. Half of the participants did not realize that there is button for “All off.” Therefore, the “All off” button needs stand out more for the future users.

Recommendations

- Provide immediate feedback: For example, when the user turns the lights on and off, show some animation feedback that confirms the light is turned on and off.
- Create a clear visual navigation hierarchy: For example, make the ‘All off’ button more prominent than any other buttons.
B. User preference

Participants were asked their perception of the prototype and their preferences related to the tasks. There were nine questions that were answered on a scale between 1 and 5 where a 5 means strong agreement (the best) and a one means strong disagreement (the worst).

Table 5.26 Questions of preference for the prototype

<table>
<thead>
<tr>
<th>Questions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. This prototype, which controls the home appliances using cellular phone, is useful to use in future.</td>
<td>7</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>2. This prototype is easy to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. It is simple to navigate this interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. No problem recognizing the picture as icon.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Using home appliances pictures as icons is more natural and simple to understand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Color for screen design is appropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. The type size is legible or use to read</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. The font for screen design is appropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Do you think that you will use this prototype in the future?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.27 Results of preference questions

<table>
<thead>
<tr>
<th>Point</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>12</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Strongly agree</td>
<td>7</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td></td>
<td>Yes:</td>
<td></td>
</tr>
<tr>
<td>4 Agree</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td></td>
<td>No:</td>
<td></td>
</tr>
<tr>
<td>3 Neutral</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Disagree</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most of the participants responded with a higher rating. However, three of the participants responded with a lower rating than average for Question 2. As mentioned before, these participants’ occupations are social worker and housewife who are not expert in computers. Also, they had many difficulties while using the prototype. All these participants mentioned that knowing “how to access” initially was difficult. After receiving directions, they could
use the prototype with minimal difficulty. Three people disagree with Question 4. Participants thought the provided pictures were not clear enough to recognize, but the author explained that people would take their own home appliance pictures using the camera in the actual cellular phone. Therefore, all participants agreed with Question 5 in relation to Question 4. Lastly, three participants disagreed with Question 7, which states the type size is proper for read. The participants whose ages are 42~49 said that the type size is pretty small for reading from a screen. Therefore, they suggested making the type a little bit bigger.

The overall average of participants’ response was high; which means that most of the participants were satisfied using the prototype, and they were willing to use it in the future.

Figure 5.7 Average of participant’s preference

- 5 = Strongly agree
- 4 = Agree
- 3 = Neutral
- 2 = Disagree
- 1 = Strongly disagree
C. User survey

Author conducted a survey that provided three examples of color, font size, and font type that were showed from the screen. From these examples, participants could respond with the most proper color, typeface, and type size for a cellular phone screen.

Nine participants (76%) chose third one from three color combinations enclosed in the red square. Actually, the second and third color combinations had different colors for each button, so the buttons stand out more than the first color combination. However, participants prefer a bluish color for the background color, because a blue screen is comfortable for viewing. (Figure5.7)

Color

Eight participants (68%) chose the third typeface, Helvetica, because it is the most clear and easiest to read from screen. The Verdana typeface is also clear, but Helvetica is more precise. Nobody chose the second typeface, Georgia, because the shape is not appropriate for use on a screen. Serif is a decorated typeface, and it is good for design. However, it is not good for legibility and readability on a screen. (Figure5.8)
Half of the participants (6 participants) whose age group is 26~40 chose the second type size, Arial 12, because it would be the best trade off in terms of size and the amount of contents. It is not too big and not too small on a screen. The other half of the participants whose age group is over 50 chose the third type size, Arial 13, because it is bigger and easier to see from a cellular phone screen. (Figure 5.9)

Half of the participants (6 participants) whose age group is 26~40 chose the second type size, Arial 12, because it would be the best trade off in terms of size and the amount of contents. It is not too big and not too small on a screen. The other half of the participants whose age group is over 50 chose the third type size, Arial 13, because it is bigger and easier to see from a cellular phone screen. (Figure 5.9)
D. Conclusion

Generally, participants were satisfied the prototype interface to control home appliances using a cellular phone. All participants mentioned it is hard to navigate at first without assistance. However, once participants spent five minutes with the interface, they got used to it.

As mentioned before, the author had a foundation assumption that there are some differences in users’ ability to use a cellular phone between Asian (Korean and Taiwanese) and American participants. This assumption is based on the knowledge that Korean and Japanese cellular phone technology is more advanced and used more broadly than American phone technology. The usability test indicated that Asian participants are less error prone than American participants overall. Specially, Asian men had been conceptually more advanced than their American counterparts because the Asian men kept asking about “Shortcut” buttons to finish the tasks quickly. However, this assumption can not be a significant and generalized the final result, because it is small sample group. There was no significant difference between men and women. From the usability test results, women had more errors than men, but it is not because of gender difference. This result had more to do with how computer intensive the participants’ jobs and their educations were than with gender and ethnic differences.

From a graphical point of view, participants were satisfied with the icons, colors, and text. Most of the participants responded with a high rating in the questionnaire of colors, icons, typeface, and type size from the result of participants’ preferences (Question 5, 6, 7, 8). However, the 42-49 age groups still mentioned that the text size is small to read. Author conducted a survey that provided three examples of color, font size, and font type that were
showed from the screen. The 42-49 age groups like to see largest font (Arial 13) Most of participants chose ‘Blue background color’ same as the prototype color, and chose font type ‘Helvetica’ that is precise and easiest to read from screen.
CHAPTER 6. CONCLUSION

With advances in technology, the design of the human computer interface has become a contemporary issue. Human interface design has attracted much attention, and numerous design research studies have attempted to determine what makes a good interface. The role of interface design is to create a method of communication between people and the technical product. The ability of users to finish their task successfully is the goal of good interface design. Most of these studies had a general perspective and were not very specific. Furthermore, the focus was mainly on technology, not on the people using the technology. Technology is advancing more quickly than people’s ability to adapt. Human interface design is intended to make people satisfied by creating an interface that is easy, natural, and pleasant to use. This involves not only designing the interface to make it eye-catching, but also designing the interface to work with people’s natural inclinations in terms of their experience.

Therefore, the intent of this thesis is to approach, from a more practical point of view, interface design based on people’s experience. Interface design uses graphic elements in order to make a user-friendly design that people really need and find comfortable using. This thesis proposes a prototype for a cellular phone interface that people can use to control home appliances.

The author explored several aspects of design such as layout, icon & image, color, text, and navigation cues to create the final prototype for a Natural (Intuitive) Interface Design for Controlling Home Appliances. The author defines the phrase, “Natural (intuitive) Interface Design,” as a design that allows users to manipulate the interface without needing to think about what they are doing, and it builds on people’s prior experience. Therefore, all
graphical elements such as layout, icon & image, color, and text help the user to remember the interface and navigate.

A usability test was conducted to find out how well this prototype works and what kinds of problems users have while using the prototype. A usability test is one of the most important methods for finding problems in an interface design and soliciting users’ practical suggestions. The results indicated that the usability test was successful, and all participants responded with a high rating for both the design and its usability. Participants mentioned that they would be willing to buy the prototype as a production product if it is not too expensive.

Therefore, the author made these conclusions from the prototyping and usability testing results. The first conclusion is that using pictures of home appliances as icons is a natural and simple way to navigate the interface because users are already familiar with seeing their own home appliances. The second conclusion is that using a cursor system is an excellent method for navigating the cellular phone screen because users are already used to it, and it does not create limitations in navigating the screen. The third conclusion is that users prefer type that is clear and precise. Therefore, a bigger type size is better (13 or 14 point fonts) and a clearer typeface is better (Arial or Helvetica). The fourth conclusion is that users like to see a strong color contrast between the background and buttons because it is easier to distinguish between the two. The fifth and final conclusion is that people do not want to go through too many steps; they prefer to click less and use shortcuts to complete the tasks quickly.

Although people were satisfied with the prototype, there are still details that will need to be implemented in order to improve both the design and usability of the interface. For example, proper responses need to be provided when users perform an action. If they are not
provided, users wonder if the action was completed. Thus, a prototype that requires users to go through too many steps leaves them confused. For example, the correct path in the Air-condition page is as follows: (1) check the current temperature from the first box, (2) enter the temperature in the second box, and (3) click the heat button. However, participants tried to immediately click the heat button when they wanted to increase the temperature, which would require only one step. Therefore, the author identified several kinds of problems with the interface design; then based on these problems, made the following recommendations to improve user success with the interface. The recommendations are as follows: provide immediate feedback, create a clear visual navigation hierarchy, provide flexibility for the user in controlling buttons, keep the interaction metaphor consistent within the context of a current device, provide clear instructions, and provide simple and natural navigation cues which use common user conventions.

Due to technology and time limitations, the prototype was simulated on a computer screen. Perhaps, in a future study, it will be possible to simulate the prototype in an actual cellular phone. The biggest limitation of this study is the small sample size. Therefore, the author cannot generalize beyond the sample. For future usability tests, the author wants to include more participants, so the results can be generalized across a broader population. Even with the limited sample size, the author hopes this thesis makes the following contributions: wireless content will be easier to use due to a simplified and comfortable interface, wireless products can be developed more quickly due to the simplified interface, and human interface technology associated with cell phones will be diversify more rapidly.
APPENDIX: SURVEY QUESTIONNAIRE
INFORMED CONSENT DOCUMENT

Title of Study: Human interface design for controlling home appliances with cellular phone
Investigators: Haeinn Lee, Graduate Student.

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION

The purpose of this research is to determine a prototype in designing the small screen interface for home appliances using a cellular phone. The idea is to able to use cellular phone to control your home appliances and design a friendly-user small screen interface. Font size, types and color, lay-out, etc. will be explored in this research.

DESCRIPTION OF PROCEDURES

This whole research survey will last for approximately 30 minutes. First, you will be asked some demographic information such as age, occupation, and your use of computers and cellular phones. Secondly, you will be asked to perform five tasks in the computer (i.e. login to the system, setting password, pin numbers, bring pictures of the home appliance chosen, and controlling buttons). Thirdly, I will be asking your perception on the prototype and preferences related to the task or pictures that I showed you.

RISKS

There are no foreseeable risks at this time from participating in this study.

BENEFITS

There is no direct benefit to you but the information gained in this study will benefit the future cellular phone users and developers in developing the interface design.

COSTS AND COMPENSATION

There is no compensation involved in this survey.

PARTICIPANT RIGHTS

Your participation is completely voluntary and you don’t have to answer nor perform any task that you are not comfortable with. You can stop the survey anytime without any penalty.
CONFIDENTIALITY

There are no personal information solicited in the survey except for age and occupation. The data will be entered in a password-protected computer that will be kept in the researcher’s house. The data will be analyzed and reported in aggregate. No individual information will be reported in the thesis. Only the investigator and the major professor, Sunghyun Kang will get access to the data collected.

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study. For further information about the study contact Haeinn Lee, 515-450-4041, haeinn78@iastate.edu and/or Sunghyun Kang, shrkang@iastate.edu. If you have any questions about the rights of research subjects or research-related injury, please contact Ginny Austin Eason, IRB Administrator, (515) 294-4566, austingr@iastate.edu, or Diane Ament, Research Compliance Officer (515) 294-3115, dament@iastate.edu.

Thank you for your interest in this survey
Questionnaire 1

User Profile

Gender: □ Man □ Female

Age: □ 18 – 25 □ 26 – 33 □ 34 – 41 □ 42 – 49 □ 50 - 58

What is your occupation? ____________________________

Is English your first language?
□ Yes □ No
If no, what is your first language? ____________________

Computer use:
How many years you used computer?
□ Less than 1 year ( month) □ 2~3 years □ 3~4 years □ 4~5 years □ Over 5 years

How many times do you use a computer per a day?
□ Never □ 1~3 hours □ 3~6 hours □ Over 6 hours

What is your main purpose of using computer?
________________________________________________

Cellular phone use:
How many years you used cellular phone? _____________

What is your main purpose of using cellular phone? (Check all that apply)
( ) Voice Communication ( ) Schedule Planner
( ) Take a picture-Camera ( ) Alarm Clock
( ) Text message ( ) Calculator
( ) Entertainment-Game, web surfing ( ) Check Time
Etc________________________
Questionnaire 2

User Task

1. You are the first user, set up the user name as ‘poeat’ and pin number as ‘1459’ to make accessible to home appliances.

2. Bring the picture of Lighting, Microwave, Oven and Air condition.

3. Change orders the kitchen home appliances to the top line, and placed the air condition on the left side.

4. Control the microwave time to 15min, and make the heater temperature 80 degree on second floor

5. Turn off all lightings, and then turn on the lightings of kitchen, and living room.
### Questionnaire 3

**User Survey**

Please indicate whether you agree/disagree to the following statements.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. This prototype which controls the home appliances using cellular phone is useful to use in future.</td>
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<td>2. This prototype is easy to use.</td>
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<td>3. It is simple to navigate this interface</td>
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<td>4. No problem recognizing the picture as icon.</td>
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<td>5. Using home appliances pictures as icons is more natural and simple to understand</td>
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<td>6. Color for screen design is appropriate</td>
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<td>7. The type size is legible or use to read</td>
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<td>8. The font for screen design is appropriate</td>
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<td>9. Do you think that you will use this prototype in the future?</td>
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<td>___ Yes ___ No</td>
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<tr>
<td>10. Do you have any suggestion to improve the design?</td>
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</table>
Questionnaire 4

User Survey

1. Color combination

You can see three different types of color combination from the screen; choose the best color for the screen.

1(  )  2(  )  3(  )

Why? ________________________________________________________________

2. Type size

You can see three different type sizes from the screen; choose the best type size for the screen.

1(  )  2(  )  3(  )

Why? ________________________________________________________________

3. Typeface

You can see three different typefaces from the screen; choose the one best typeface for the screen.

1(  )  2(  )  3(  )

Why? ________________________________________________________________
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