Web-Based System Development for Usability Evaluation of Ubiquitous Computing Device

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Abstract. Recently, with the development of electronic technology, information technology (IT) devices that satisfy user requirements, such as PMP (Portable Multimedia Player), PDA (Personal Data Assistant), UMPC (Ultra Mobile Personal Computer) and mobile phones have been developed. These devices are making wireless communication and network communication more accessible, and by the ubiquitous paradigm, provide accessibility of information everywhere. The appearance of these devices and the development of the technology are integrating and converging in the IT devices. Therefore, there are significant changes in the purpose and environment of IT device applications. This is due to the modification of the environment in which the device is used (not only in a passive state but also in a motional state), which has a greater influence on usability. Therefore, a new methodology is required to evaluate the usability of the devices. In previous studies, by gathering and integrating the usability factors and ubiquitous characteristics, the Ubiquitous Evaluation Factor was obtained. For each factor of ubiquitous devices, deconstruction was accomplished for each usability evaluation. Through this process, components of ubiquitous devices could be extracted. Evaluation scores of ubiquitous device components and the score of the evaluation of each usability factor could be obtained from the usability evaluation. This evaluation framework was developed as a Web-based system to let the users perform the usability evaluation without having trouble with the location. This system was developed in Windows Server 2003 Enterprise Edition platform. Web Server IIS (Internet Information Server) 6.0 was used, and MS-SQL 2000 was used for the database server. For development of language, ASP (Active Server Page) was used, which is run in IIS. This study is meaningful in that through a Web-based system, various people could easily access the device, and in that evaluation of a portion of the device as well as the entire device is possible.

Keywords: Ubiquitous computing device, usability, web-based system, system development.

1 Introduction

The development and improvement of electronic and related technology, as well as diverse IT devices are being introduced. The appearance of Mobile devices such as PDA (Personal Digital Assistant), PMP (Portable Multimedia Player), UMPC (Ultra Mobile Personal Computer) and mobile phones is making wireless communication

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more accessible and providing the possibility of having access to information everywhere[1]. Therefore, the development of these IT devices and the improvement upon technology together requires integration and convergence [2].

The environments where the IT devices are being used and the purposes for their utilization are changing. For instance, IT devices are not only used in the passive state, but also in a state of motion, which influences the usability of the device. The distinguishing characteristic of ubiquitous computing is that it is a communication system [3] that allows the users to obtain the required information in any place. Therefore, previous usability evaluation tools need to be improved, taking into consideration new user environments and ubiquitous computing [1].

From previous studies, we selected and integrated the usability factors and ubiquitous characteristic factors, developing new Ubiquitous Evaluation Factors. Each part of the ubiquitous device usability evaluation was deconstructed so the separate components of the ubiquitous device could be obtained. Through the usability evaluation, the evaluation score and each usability factor evaluation score of a ubiquitous device component can be obtained. In this study, an evaluation framework was developed as a Web-based system, allowing users to perform a usability evaluation anywhere.

2 Background

2.1 Ubiquitous Computing Device

Ubiquitous computing technology development and mobile information device convergence development provide information to the user everywhere at every moment with any device. The basis of ubiquitous computing is to provide service at the request of a user and to grasp the intention of a user and situation. This results in one service system actively supporting another; that is to say the ubiquitous computing service. A ubiquitous computing device is a device for the ubiquitous service that allows a user to interact with the service anywhere at any time. Also, it grasps the intention of the user and situation to support the user. Ubiquitous devices function in a state where people do not realize that we acquire information about embedded, pervasive, portability and mobility functions; that is, to realize the ubiquitous environment [5].

Table 1. Characteristics of ubiquitous device

Researcher	Characteristics of ubiquitous device
M.Weiser	Pervasiveness
M.Weiser	Ubiquity
Burnet & Rainsford	Diversification
Kwon et al.	Poratbility
uKoreaForum, 2006	Interconnectivity

2.2 Previous Ubiquitous Computing Research

By understanding the ubiquitous computing user's intention and utilizing the user's envi ronmental characteristics, it was possible to reflect the interaction with the user [4]. Ther efore, it is possible to say that the Context-Aware Computing is similar to the condition

of the user; especially when it was focused on context-of-use of the mobile devices. Thu s, the Context-Aware Computing [6] model and the ubiquitous computing model are si milar in many ways, especially when focused on the context-of-use of mobile devices.

Consequently, it is possible to say that the Context-Aware Computing model and the ubiquitous computing model have many similar points [8,9].

J. Scholtz and S. Consolvo [10] have presented a framework (UEA, Ubiquitous computing Evaluation Area) to evaluate the ubiquitous computing application. The evaluation domains for the ubiquitous computing were: attention, conceptual model, appeal with each conceptual measure and metric.

In relation to Context-Aware Computing, Nigel and Miles [11] had presented the idea that to confidentially calculate the usability, it is necessary to evaluate the representative environment, user and task. Thus, it is essential to have a deep understanding of the context of use of the product.

2.3 Limitation

J. Scholtz [10] defined things that are important to take into account in ubiquitous computing as "area," and then categorize them to experiment with a systematic analysis to present a conceptual measurement variable. However, this had a major focus on the ubiquitous service; it did not focus on the device usability evaluation, so there was insufficient consideration of the user's task. Taken from Nigel's study[12,13], in most of the context-aware computing studies, only information on the diverse types of context is presented, lacking a concrete connection with usability principles.

3 Framework

The Ubiquitous device's usability evaluation framework was established from previous studies [14].

New suggestions on usability evaluation were proposed after a modification on the context deconstruction. Figure 1 shows how the main user and main task were selected by having the user information of the device. In this way, a specification of the device context information was achieved, which later will be used in an evaluation checklist. Consideration of each device characteristic makes further ubiquitous device usability evaluations possible.

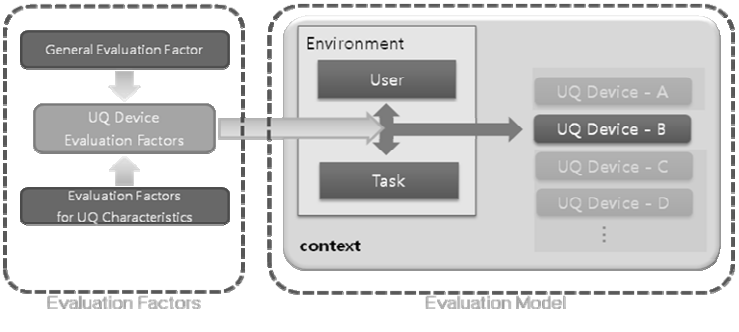

Fig. 1. Evaluation Framework

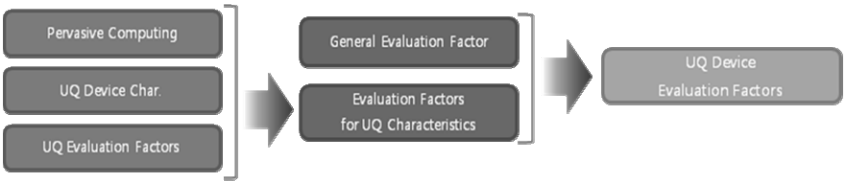

Fig. 2. Generating Evaluation Factors

3.1 Evaluation Factors

Figure 2 shows the extractions made in the usability factors for the evaluation framework of the ubiquitous computing environment property. In previous studies, the basic properties for usability evaluation were: efficiency, effectiveness and satisfaction – that is to say 'General Evaluation Factors.' The General Evaluation Factors are considered suitable for general device evaluation, but are not specified for ubiquitous computing devices. Proposing factors for a ubiquitous device demands creation of pervasive computing quality and ubiquitous computing quality tool.

Table 2. Ubiquitous Device Evaluation Factors

Factor	Description
Adaptability	Adaptable or easily adjusted to the changes in context
Controllability	Able to control device in any circumstances
Interconnectivity	Interconnected network among devices, allowing sharing of information
Mobility	The station of the device can be mobile as the user carries it with him
Predictability	From past experience, the result of the system execution can be predicted
Simplicity	User interface and instruction are simple
Transparency	Provides the current status of system as well as when it is running an execution

Table 2 shows some comparative computing of related studies that were used for ubiquitous service or ubiquitous software studies: Adaptability, Controllability, Interconnectivity, Mobility, Predictability, Simplicity and Transparency. This is an assortment and integration of ubiquitous device related factors.

Usability evaluation factors of devices are organized as: (visual) Clarity, Accessibility, Affect, Compatibility, Consistency, Effectiveness, Efficiency, Error prevention, Feedback, Forgiveness, Helpless, Learnability, Memorability, Multi-threading, Responsiveness, Safety and User tailorability.

3.2 Evaluation Area

Figure 3 shows an elementary device deconstruction for a device evaluation. It implements the usability evaluation on each device so as to obtain the degree of usability

(high or low) that each factor has. The developed factors can be applied to evaluate each device components: LUI (Logical User Interface), GUI (Graphical User Interface), and PUI (Physical User Interface), respectively. The device component can be individually evaluated by making a separation.

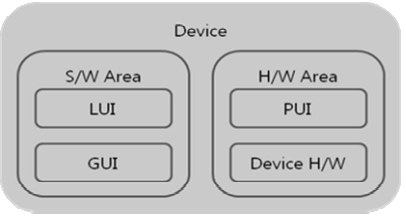

Fig. 3. Evaluation area

LUI is divided into: Application software, Menu structure and Contents, System Awareness and System Acceptance. GUI is divided into Indicator, Icon and Menu. In H/W Area, Device H/W is separated in Body and Screen while PUI is separated into Control key and Touch screen. In the case of Touch screen, it is necessary to separately subdivide by input methods, and when evaluating it is risky to use different factors and checklists as standard controllers. Consequently, when evaluating devices with a touch screen, PUI of the touch screen is performed. If there is no touch screen, that evaluation factor is not taken into account.

3.3 Context of Use

Figure1 shows the context of information that is solidified as: user type, device type, task type and use type. Use type is information about the environment and condition (situation) in which the user is using the device. Each context information framework has significance on the evaluation target, information access and entertainment systems. User type is divided into novice and expert, while device type is divided into PMP, Music Player, PDA, UMPC, Smartphone and Game Device. Through the expert evaluation, depending on different contexts, each evaluation factor and checklist was evaluated, giving the results of a usability evaluation with relative importance. Each evaluation factor has its own weight, which changes the importance of each checklist, depending on the device and context information.

4 System Development

4.1 System Structure

In this study, the system was developed as a Web-based system to let the users perform an evaluation without having trouble with location. This system is composed for a client and a Web server or database server.

The client indicates work to the Web server through browsers connected to the Internet after accessing the Web. The Web server then sends a Web page to the client

and provides data that the client requires of the database server. The database server is able to query the user regarding the data that the user wants from the Web server, and carries out the work, finally returning the results to the Web server.

In Figure 4, the system was developed using Windows Server 2003 Enterprise Edition, IIS (Internet Information Server 6.0) Web Server and MS-SQL 2000 Database Server. ASP (Active Server Page) was used for developing language.

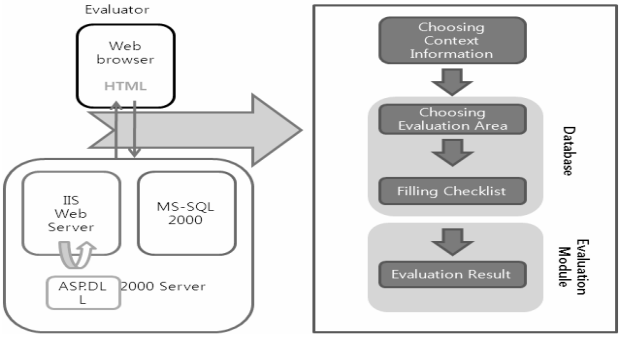

Fig. 4. System structure

4.2 Evaluation Procedure

The first step shows a Web page where information of each context type has to be inputted. The information about the context type that was saved in the database is recalled, then shown. In this step, the desired device to be evaluated is selected, and the user to be evaluated is identified as a novice or expert of the device in User Type. In Device Type, a selection is made between PMP Type, MP3 Type and PDA Type. Task type is divided into: video player, music player, information reading and game recognition. Use type depends on the wearable shape and portable form. After that, there is a step to input all the data in the form of a questionnaire. It gives a description of each context type so the user can understand easily, and it also gives an option of 'not considering' for the context types that the user does not wish to evaluate.

In the second step, after having selected the information for the context, the information about the user is inputted in the server session and a Web page appears showing the different evaluation areas that can be selected to continue. This action recalls the information that is saved in the database and displays it. To allow more than one selection of the area the user wisher to evaluate, the options are selected by checking a box. Moreover, to support the user's need of knowing more about the area to be evaluated, a description of each area is provided.

In the third step, the information about the area that is going to be evaluated is saved in the server session and is shown in the corresponding checklist of each area in the database. In the upper part of the page where the checklist was selected, information about the area that is being evaluated is displayed. Each area is displayed on a different page to reduce and avoid confusion and disorder.

In the last step, the user's selection of the checklist, the information of the context type that was saved in the sever session in previous steps, and the information of the

evaluation area are saved. From the data that was saved about a determined device, it is possible to obtain the average evaluation score. After being saved in the database, the visible result is shown in a page with an eight-column graph. The results from the evaluation of ubiquitous characteristics are shown in a graph that indicates the score of each ubiquitous factor. The results from the evaluation of general characteristics are also shown in a graph. Moreover, by providing a graph for each factor with a score over 100, we can see insufficient areas more clearly. Also, the result of the device evaluation area (LUI, GUI, PUI, Device H/W) of each of them is represented in a graph with a score over 100 so as to show the areas that have to be improved.

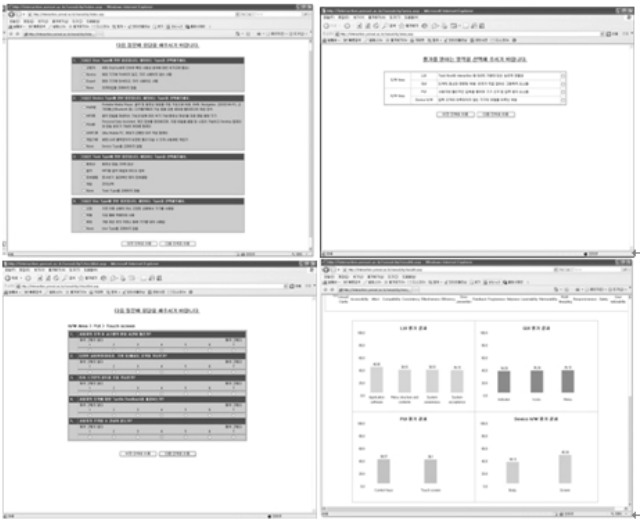

Fig. 5. Evaluation system

5 Conclusion and Further Study

This study developed a Web-based system of a framework to evaluate the usability of ubiquitous computing devices. There are three important aspects.

First, through the development of a Web-based system, the user can evaluate everywhere where the Internet is accessible. Also, it is more comfortable, as it allows the user to see the results in a moment.

Secondly, the user is able to select the area that he desires to evaluate. A complete or part evaluation of the selected areas is possible.

Thirdly, as this system uses a database, the evaluated data can be saved. Through this saved data, it is possible to see an average of all the other data of previous and other evaluations.

However, this system has only been implemented for a small number of devices, and not in every type of device. Therefore, in further studies it is necessary to increase the validity of the system by performing an evaluation of a more diverse range of devices. Then, after obtaining the validity of the system, it will be possible to make updates.

References

1. Zhang, D., Adipat, B.: Challenges, Methodologies, and Issues in the Usability testing of Mobile Applications. International Journal of Human-Computer Interaction 18(3), 293–308 (2005)
2. Rondeau, D.B.: Branding is Experience. Communication of the ACM 48(7), 61–66 (2005)
3. Park, I.C., Kim, S.C., Choi, M.S.: A Study on the Development Methods of gesture-oriented Natural Interface for the Control of Ubiquitous Device. Koeran Society of Basic Design & Art 6(3), 265–274 (2005)
4. Scholtz, J., Richter, H.: Report from ubicomp 2001 workshop: Evaluation methodologies for ubiquitous computing, SIGCHI Bulletin (January/February 2002)
5. Kim, J.Y.: Ubiquitous Computing: Business model and prospects, Samsung Economic Research Institute (2003)
6. Schilit, B.N., Adams, N., Want, R.: Context-Aware Computing Applications. In: IEEE Workshop on Mobile Computing Systems and Applications (1994)
7. Betiol, A.H., de Abreu Cybis, W.: Usability Testing of Mobile Devices: A Comparison of Three Approaches. In: Costabile, M.F., Paternó, F. (eds.) INTERACT 2005. LNCS, vol. 3585, pp. 470–481. Springer, Heidelberg (2005)
8. Kwon, O.B., Kim, J.H.: A Multi-Layered Approach to Assessing Level of Ubiquitous Computing Services. Information System Review 8(1), 43–61 (2006)
9. Nam, J.H., Choi, M.S.: A Study on the Multi Interface Factor Base the Service Evolution on Ubiquitous Computing Environment. Korea Digital Design Council 11, 357–366 (2006)
10. Scholtz, J., Consolvo, S.: Toward a framework for evaluating ubiquitous computing applications. IEEE 3(2), 82–88 (2004)
11. Bevan, N., Macleod, M.: Usability measurement in context. Behavioral and Information Technology 13, 132–145 (1994)
12. Lee, I.S., et al.: Use Contexts for the Mobile Internet: A Longitudinal Study Monitoring Actual Use of Mobile Internet Services. International Journal of Human-Computer Interaction 18(3), 269–292 (2005)
13. Barnard, L., Yi, J.S., Jacko, J.A., Sears, A.: Capturing the effects of context on human performance in mobile computing systems. Personal and Ubiquitous Computing 11, 81–96 (2007)
14. Kim, H.J., Choi, J.K., Ji, Y.: Usability Evaluation Framework for Ubiquitous Computing Device. In: International Conference on Convergence and Hybrid Information Technology (2008)