EUI (Environmental User Interface): The Initiative of Environmental Data Coupled Human Computer Interaction (HCI)

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Abstract. In this paper, we propose a novel interactivity design concept called environment user interface (EUI) and show a preliminary evidence of its efficacy. It is our conjecture that EUI, leveraging contextually appropriate environmental data, could enrich the interactivity between a user and technology. This enriched interaction concept could enhance human situational awareness and, thus, support decision making. To evaluate the potential efficacy of EUI, an auditory alert system delivering auditory cues based on the level of ambient noise was implemented and evaluated with and without a EUI component. Throughout a pilot study, preliminary evidence was obtained that incorporating environmental data into a human technology interaction in the area of auditory alert system provided better auditory cues and enhanced decision making.

Keywords: interface, environment, interaction, user-center, human factor, HCI

1 Introduction

Many research efforts have been conducted on the investigations of interaction issues between human and technology. A tangible user interface allowing physical computing by integrating physical and computational design was introduced [7]. The main advantage of tangible user interface is to utilize physical affordances [6]. To reduce mental workloads and to give better metaphors, human cognition based user interaction mechanisms and frameworks were introduced. An embodied user interface emerged to reflect both a physical presence in the real world and a social embedding in a web of practices and purposes [2], since interaction points are being moved from a computer space to the real world under the concept of invisible interfaces and pervasive computing. However, human's needs may not be solely fulfilled even though various interactive user interfaces are provided by technology. One of reasons is current human computer interaction is mostly focused on interactions between human and technology basically based on human behaviors and cognitions. For example, an auditory alert system rings with a fixed intensity of sound pressure and frequency. Generally, alert systems do not consider the level of ambient sound pressure level when it rings. This reflects the limitations and abilities of current user-centric machine or technology that could hinder human computer interactions and stifle human situation awareness [3]. Situation awareness is an important element of decision making in natural environments [8] and human's ability to be aware of situations in the environment is limited [1].

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In this paper, we propose a novel interactivity design concept called environment user interface (EUI) to leverage interactions between humans and technology by incorporating environmental data. We introduced the motivation of this research in section two. We have defined the term of environment and the concept of EUI as well as its components in section three. Preliminary evidences of EUI from a pilot study and its discussions are addressed in section four.

2 Motivation and Approach

The above recent interfaces and interaction paradigms imply that there remains an interaction gap between human and technology. It is our conjecture that EUI could enrich the interactivity between a user and technology by leveraging contextually appropriate environmental data. The gap could be bridged if environmental data are being considered in a technology domain. Environmental data also could supplement human and machine abilities. Furthermore, this enriched interaction could enhance human situational awareness and, thus, support decision making process. For example, a decision support system providing auditory cues in a medical environment or in an aviation area could not effectively interact with a human or cause a mistake under the circumstances of unexpected loud noise, if environmental data such as ambient noise is not being considered. In this example, since the level and type of a sound cue from a decision support system supporting a human decision making process is associated with ambient noise, the system should interacts with ambient noise using an appropriate technology to enhance human computer interaction.

From the basic problem from above, the EUI framework is being defined following an iterative user-centered design mode of four steps; modeling environmental data, designing sub EUIs, developing proof of concepts on each sub EUI and establishing the overall EUI framework.

3 The Features of EUI

Place is an instance of space [5], and an environment can be defined as an instance of the real world including place, space and objects, where all abstracts are realized with specific meanings. EUI is an interactivity framework leveraging contextually appropriate environmental data in environment and could enrich the interactivity between a user and technology.

Figure 1 illustrates the overall concept of EUI and its components. First, there are three types of environmental data such as static environmental data (SED), dynamic environmental data (DED) and hybrid environmental data (HED). For instance, an object's name is an example of SED and ambient noise is an example of DED. The location of an object having an object name (SED) and orientations (DED) is an example of HED. In addition, each environmental data has their states and contextual information. EUI is represented by a large circle and has three types of sub EUIs called a selected EUI for accessing particular pointed environmental data, a focused EUI focusing on the amount of environmental data and an ambient EUI for accessing wide range of environmental data. In the figure, a technology interacts with state and contextual information of SED through out the selected sub EUI.

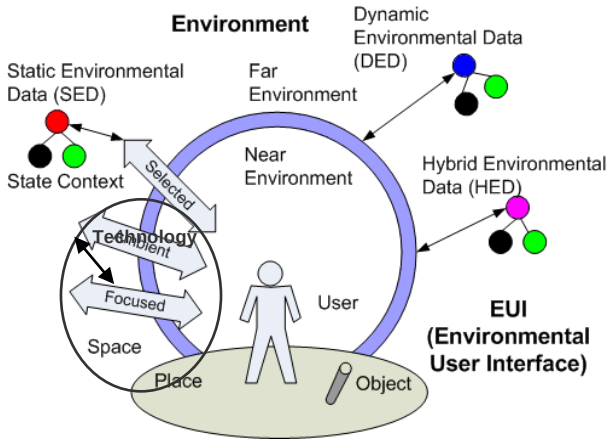

Fig. 1. The conceptual diagram of EUI and its components. Environment is an instance of real world consisting of three different types of environmental data (SED, DED and HED). EUI consists of three sub EUIs called selected, focused and ambient. In the diagram, a user receives static environmental data through the selected sub EUI.

4 Experiment and Evaluation

To explore EUI's functional validity, environmental data coupled with an auditory alert system called the EUI alert system has been implemented in the context of critical auditory signal delivering applications such as in health care and aviation. Basically, the EUI alert system was for delivering sound cues to notify critical signals, e.g., emergency warnings, medical alarms, system breakdown or health status monitoring.

The EUI alert system had two modes for an experiment as shown in figure 2, with and without considering environmental data. In the without environmental data mode, the EUI alert system acted like a conventional auditory alert system, which gave a sound cue with a unitary intensity of sound pressure. On the contrary, in the with environmental data mode, the EUI alert system interacted with ambient noise and adjusted the output intensity of sound pressure level according to the intensity of ambient noise. This was to provide a user with better affordances in interactions between an alert system and a human.

We conducted a pilot study with five participants to assess the efficacy of the EUI alert system. The participant's primary role during the experiment was writing the time whenever they heard an auditory alarms coming from the EUI alert system while watching a movie as a secondary task. Before any test or measurements were taken, all participants were asked about their seizure risks and a brief hearing test was conducted to screen out abnormal listeners. During the experiment, all participants were assumed to be organ recipients or have a critical disease such as cardiac arrest, in which they must not skip taking medicine at a specific time. The sound alert system provided six auditory cues within an hour of experiment session. The time slots for sound cues were set for three with EUI and for the others without EUI prior to take the experiment by experimentee. To elicit a user experience, a pre and a post questionnaire with an interview were used as a direct knowledge elicitation method. The primary evaluation rule was to figure it out whether a participant missed auditory cues under which modes, with and without EUI.

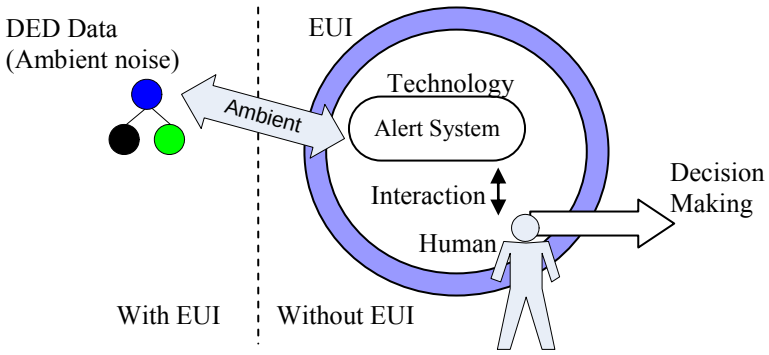

Fig. 2. The conceptual diagram of a EUI based auditory alert system which has ambient sub EUI channel. The system has two modes of sound alert system, with EUI and without EUI. The without EUI mode acts like a conventional sound alert system, and the with EUI mode interacts with ambient noise in order to adjust the output intensity of sound pressure level.

After finishing the experiment, the result showed preliminary evidence that participants better caught auditory alarms when the system interacted with ambient noise under with EUI mode, although the EUI based auditory alert system was quite simple. This was because the system using with EUI mode adjusted the intensity of output sound based on ambient noise level surrounding participants. We also discovered that secondary cues which have different modalities might be needed when the intensity of ambient noise is close to that of sound cues. Because there was a problem with a threshold level setting of sound intensity, since most alerts have high intensity and unique frequency range. Based on these findings, we realized that auditory alarm delivering technology interacting with ambient noise can enhance interactions between humans and systems. We postulate that human cognitions and behaviors are related to environmental situations and factors [10] and this can be leveraged as technology interacts with environmental situations and factors.

5 Conclusions and Future Works

In this paper, we proposed a novel interactivity design concept called environmental user interface (EUI) and its components. To prove the efficacy of EUI, we implemented the EUI auditory alert system which is an environmental data coupled human computer interaction system and evaluated it. Concerning overall interactivity of the EUI based auditory alert system, the alert system with EUI mode considering environmental data provided a better sound cue than that of the system without EUI mode which has not a EUI component. In the experiment, EUI played a leveraging role in enriching interactivity between human and technology.

As a future work, a formal user study will be made in terms of human behaviors. The specific outcomes of this research will be the refinement of the framework and conceptual architecture of EUI, with an emphasis on the contextual appropriateness of the healthcare and emergency signal delivering environment feasibility. We will try to embed the core algorithm of EUI into mobile devices to expand its possible applications.

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