Abstract

This paper describes a project based multi-disciplinary design course focusing on rapid prototyping of mobile computer systems. The class provides a unique experimental testbed, covering the full design process. We built a novel input device integrated with a wearable computer system for aircraft technicians that combines Training Material and Interactive Electronic Technical Manuals. Integration of the input device and wearable computer with the application is also described.

1. Introduction

With the advent of rapid design methodologies and rapid fabrication technologies, it is possible to construct fully customized systems in a matter of months. We have developed a User-Centered Interdisciplinary Concurrent System Design Methodology (UICSM) that takes teams of electrical engineers, mechanical engineers, computer scientists, industrial designers, and human-computer interaction (HCI) students who work with an end-user to generate a complete prototype system during a four-month long capstone design course run in conjunction with industry partners [1, 2].

The course has created a novel generation of wearable computer systems for an industry partner every semester. In the Spring 2006 Rapid Prototyping of Computer Systems (RPCS) class, students developed a Mobile Reference Environment (MoRE), a wearable computer system for aircraft technicians that combines Training Material and Interactive Electronic Technical Manuals (IETM) with a novel dial input device. Aircraft maintenance is complex and requires constant reference to technical manuals. IETMs allow technicians to follow complex procedures while on the flight line. The system was built using the training material and IETMs for an actual naval aircraft. The system is intended to support technicians repairing aircraft on the flight line accessing technical and training information.

2. System architecture

The MoRE system provides portable means of accessing reference material or any other dense, inter-related set of informational units. Harsh environmental and operating conditions associated with aircraft maintenance and operation (e.g. large temperature variations, ambient noise, heavy work gloves) eliminate most of the available input devices, such as keyboard, pen-based input, voice, etc. This motivated us to develop a dial as a novel input device for wearable computers. The dial’s components include a wheel, select button, pane switch button, two tabbing buttons, and pointer knob, as shown in Figure 1. The dominant feature of the dial is the wheel. By turning the wheel clockwise/counter-clockwise, the user can move the selection box to the next/previous link accordingly. The wheel scrolls up/down the page when the selection box reached the top/bottom of the displayed screen but not the actual top/bottom of the pane. When the box reaches the top/bottom link on the pane, continuously turning the wheel will move the selection box back to the bottom/top link of the pane. The inner area of the ring of the wheel acts as the select button. The center knob within the selection button has the capability to move the cursor on the screen in eight-direction movement. The large button placed on the upper section of the dial is the pane switch button. By pressing this button, the user can move the selection box to the next pane in the current tab. Pressing the left/right tab button will open the tab accordingly. The dial interacts with the user interface of the manual integration software. The software provides four panes in which contents of the manuals, options for the screen, results of user’s search queries, and annotation recording interface are presented. Each component of the user interface and the dial are functionally connected to support the application, as illustrated in Figure 2.

In addition to our custom-made dial input device, the wearable computing platform contains a portable computer, head-mounted display, and a headset and earphones. Functionality of the dial includes the ability to left click, scroll through menus and links on a page, navigate the screen with a joystick, move through tabs, create tabs, and switch page frames. We designed and fabricated the printed circuit board (PCB) for the dial, and its electronics design is based on a Freescale Semiconductor MC908JB16DWE microcontroller.

3. Experiments

The system provides easy reference to various forms of documentation of the complex aircraft system, a mapping between them and easy searching capabilities. An indexer, as part of the local web server, parses manuals and populates the database with relevant information about the keywords and pages. The data indicated that the distribution of words in the training manual was very exponential, with a few words appearing ubiquitously and the majority of words appearing on very few pages. Figure 3 shows this trend more specifically. The distribution of words helped in selecting thresholds for word importance, page importance, and how relevant certain words were in determining the content of the page. These concepts together form the basis of selecting keywords to create search links within each page.

4. Conclusions

We present a project based multi-disciplinary course on mobile computer systems. The newest prototype of a wearable computer with a dial input device is described. The integration of the dial and application software has also been presented. The system is applied for an actual navy aircraft and its training and maintenance manuals.

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References
