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Design and Development of a Search Interface for an Information Gathering Tool

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Abstract

In order to design effective and usable search interfaces it is essential to fully understand the characteristics of the users and the tasks they perform. In this paper, we describe how to use a human-centered approach to design a usable search interface. We first conducted user and task analyses of the application domain -- Biomedical Engineers' log notes at NASA Johnson Space Center. From these analyses, we identified what functions the users want, the tasks they perform, and a coding system for the vocabulary used by the users to log entries in the log notes. We then implemented a prototype of a human-centered search interface by using the results of the user and task analyses and by applying other human-centered principles. Finally, we discussed the implications of human-centered design for general health information systems.

Keywords:

interface design, information retrieval, user analysis, task analysis

Introduction

Proper design of the user interface can substantially increase the efficiency of human-computer interaction in terms of increased task performance, user satisfaction, user's knowledge retention and decreased training time and error rate [1]. A good user interface design requires an understanding of the users and the tasks they perform. A user analysis provides information about user characteristics that should be considered in the design. A task analysis provides an understanding of the user's underlying tasks and helps the designer identify aspects of the interface that are most important to the user's task. [2,3,4] In this paper, we are using a task analysis to develop a user interface for the logger tool developed for the Biomedical Engineers (BME) who support the medical operations of the International Space Station (ISS). This new interface contains a menu selection designed to accommodate BMEs' tasks and work flow.

The focus for this project was to design a search menu as a part of a search interface that was both effective and usable for a specific group of end users. An inadequate search interface can adversely affect a user's search process by increasing their cognitive load and leading to a failed search. [5,6] Scaife [7] and Rogers [8] described how certain kinds of external information can reduce the mental effort involved in a task. Likewise, Zhang [9] argued that tasks involving perceptual judgements can be less demanding than those involving mental operations. Menus are effective because they allow users to recognize and select items rather than forcing them to recall information from memory. In a recognition task such as menu selection, users read the list of items, select the most appropriate item for their current task, verify that the selection is correct and observe the effect. [1] In order to make this happen easily, it is important to consider the structure and organizational sequence of items that make up the menu. Studies have shown that a meaningfully organized menu reduced the error rate and thinking time for user selection compared to a disorganized structure. [6] However, there is no guarantee that the interface will be effective unless the designer understands the cognitive and behavioral aspects of the end users. According to Norman [10], an effective interface for menu selection emerges only after studying and testing numerous design issues, such as task-related organization, phrasing of items, sequence of items, graphic layout and design, response time and shortcuts for more knowledgeable or frequent users.

Presenting selection items in a menu is, however, not sufficient for efficient task performance. The items in the menu have to match user's language so that the items in the menu are what the users want and what the users want is covered by the items in the menu. In order to make this happen, a structured controlled vocabulary is needed to serve as a foundation for a search interface. According to information storage and retrieval principles, controlled vocabulary has advantages over natural, uncontrolled vocabulary in terms of recall ratio and specificity of retrieval. Controlled vocabulary unifies the information at both input and output stage. It was found that there are two methods for constructing a controlled vocabulary: literary warrant (where terms are derived from the type of literature to be indexed) and user warrant (where terms come from the potential users of the information service). [11] Lancaster also pointed out that there were four possible approaches to handling the vocabulary used to represent documents and conduct searches in a retrieval system:

1. Control of vocabulary at input and output.
2. No control of any kind at input or output.
3. Control of vocabulary at input but no control at output.
4. No control at input but loose control at output.

In this article, we describe the design of an effective and usable search interface prototype for the ISS Log Notes used by the BMEs at the Mission Control Center at NASA Johnson Space Center. We start with a brief description of the user's domain and the current ISS Log Notes that is an information gathering tool the BMEs use throughout their shift. We will then describe a specific component of user/task analysis that was useful to the project. In addition, we will develop a taxonomy of information to be incorporated in a menu structure and present a prototype of such a taxonomy.

The Domain

The user's domain is the work practice of Biomedical Engineers in the Mission Control, Center at NASA Johnson Space Center. The BMEs work in a distributed information system. This complex environment contains disparate human agents and artifacts. BMEs are responsible for the technical and operational support in medically related tasks. Their responsibilities include acquiring and distributing information from disparate systems using timely, reliable, secure measures to different communities for the execution of various health related operations of space missions. Typically, one BME works at console for eight hours. There are three handover shifts scheduled during a 24-hour period. During the handover, two BMEs work together for about 1-2 hours. BMEs at console are equipped with a variety of facilities. A large collection of information propagates through disparate entities and different mediums, such as laptops, desktops, voice loops, telephones, TV monitor, printer, fax machine, video cassette recorder, and so on. The work environment is high in workload and sometimes stressful. But the role of the BME is essential in the safe operation of a space mission. Organizing and searching information in such a complex system is one of the major challenges for BMEs.

One major task for BMEs is gathering and logging records of significant events that occur throughout their shift. This is done by creating entries in the ISS Log Notes, which is currently a MS Word based document. One major function of the Log Notes is to reconstruct the events for the following shift so as to facilitate an efficient handover. It also functions as a reference tool for post flight/operations analysis [12] or contingency incidents during space missions. The log notes not only include records of events but also environmental variables, decisions, results of actions, actions to be carried out by the next or later shifts, and shift reports. [12]

User and Task Analysis

User and task analyses of Biomedical Engineers were initially conducted in August 2000. [13] Information specific to logging and relevant to the design of the search interface were obtained from this report. Information was also gathered through indirect methods such as the review of pictures and video of the BME console, related manuals and handbooks, a week of Log Notes, and an interview with a BME.

To limit the scope of the current study, we focus on the following aspects of the Log Notes: search limitations (relatively inaccessible data), uncontrolled input, and single user access at a time. From the user and task analyses, we found that data retrieval from the log notes is a frequent task for BMEs. However, the current ISS Log Notes did not appear to support a quick and feasible search process because it is basically a MS Word document with free text entries. Search can only take place through opening individual files and searching with the MS Word search feature.

From the observational analysis of a 2-hour video tape, we discovered that an adequate search function did not exist in the Log Notes. This became especially evident when BMEs needed to respond to an urgent query and the search process persisted for a long period of time. BMEs prefer browsing the Log Notes to using the MS Word's "Find" function, even if it is more efficient for BMEs to use the "Find" function than to scroll up and down through the document to search the content. The search function embedded in MS Word is primitive. For example, it does not support combined search.

Another issue with the current log notes is that the entries are uncontrolled input that limits the efficiency of search. Our analysis of the contents of the log notes revealed many inconsistencies which cause an incomplete and inefficient search. For example, BMEs used bolded font to represent different meanings, such as the beginning of an event or a change in personnel, or to emphasize an entry that requires follow-up action.

Another inconsistency found in the current log notes is that the same concepts are often recorded in different ways. This is one of the main reasons for the difficulty of retrieval. For example, BME logged as "05:15 'Person 1 *returned page* to Person 2, with the location . . .'" and in another place, BME described the communication using symbol, "07:03 'Person 1 > Person 2: We may reach alarm levels at . . .'".

The inconsistencies also exist in the amount of information in each single entry. Most of the entries contain only one single event. However, some entries include more than one event. This makes the information retrieval even more difficult.

These inconsistencies make the log notes document difficult to understand as well as inefficient for information retrieval. In order for a log notes tool to be efficient, it should provide BMEs sufficient capabilities to make the log entries rich and meaningful as well as retrievable.

Interface Design

The purpose of utilizing a controlled vocabulary is to achieve a better organized data file and to ultimately improve the retrieval result. Thus, implementing a controlled vocabulary through a menu selection would improve data retrieval and decrease the heavy workload of BMEs.

The user and task analyses described above provided basic information for the generation of a key word list. We also analyzed the ISS Medical Console Handbook from which routine events/activities were extracted with their frequencies. This list was also combined with another list that was generated by BMEs themselves. Some of the key words provided by the BMEs overlapped with the key words from the list. Therefore, the most frequently used key words were put together.

Menus are an increasingly popular method of interacting with computers. [14] The key issue for designers is deciding how to organize the sequence of the menu items after an appropriate controlled vocabulary has been developed and embedded into a database. Typical choices of vocabulary organization usually include alphabetical, logical, categorical, or frequency of use. [14]

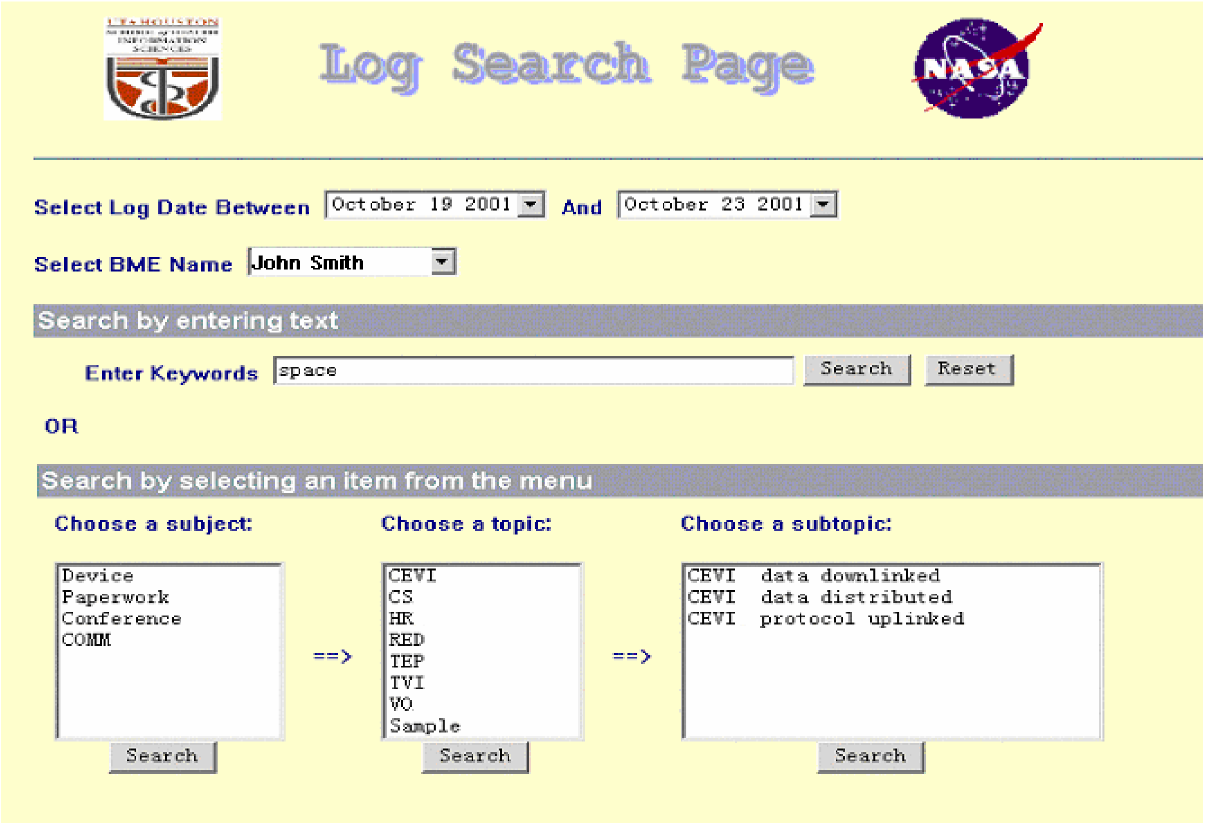


Figure 1 - Search Interface of Log Note

Alphabetical organizations order menu items alphabetically by names. Studies that investigated the effects of this type of menu organization indicate that it does not organize the items in a task oriented way. [14] Logical organizations order the menu items by the logical relationship between the items. Menu items grouped together according to common properties are known as categorical lists. This is usually implemented as a multi-level hierarchical structure in which the first level contains the category name and the second contains more detailed contents. Finally, the frequency based orderings refers to placing the items by the frequency of use starting with the most frequently used items at the top of the menu. Manipulating the way menu items are organized is crucial for the design of good user interfaces.

The method used in our design of the search interface is a three-level hierarchical menu representing the relationship of the categories. This design allowed selection from one menu to control the contents of another (Figure 1). Therefore, the three menus on the interface are dynamically related to each other. Users can determine where they are in the interface (or what search methods are available or how they can perform a search task) by reading related menu items and can quickly change tasks by selecting the appropriate item in the related menu.

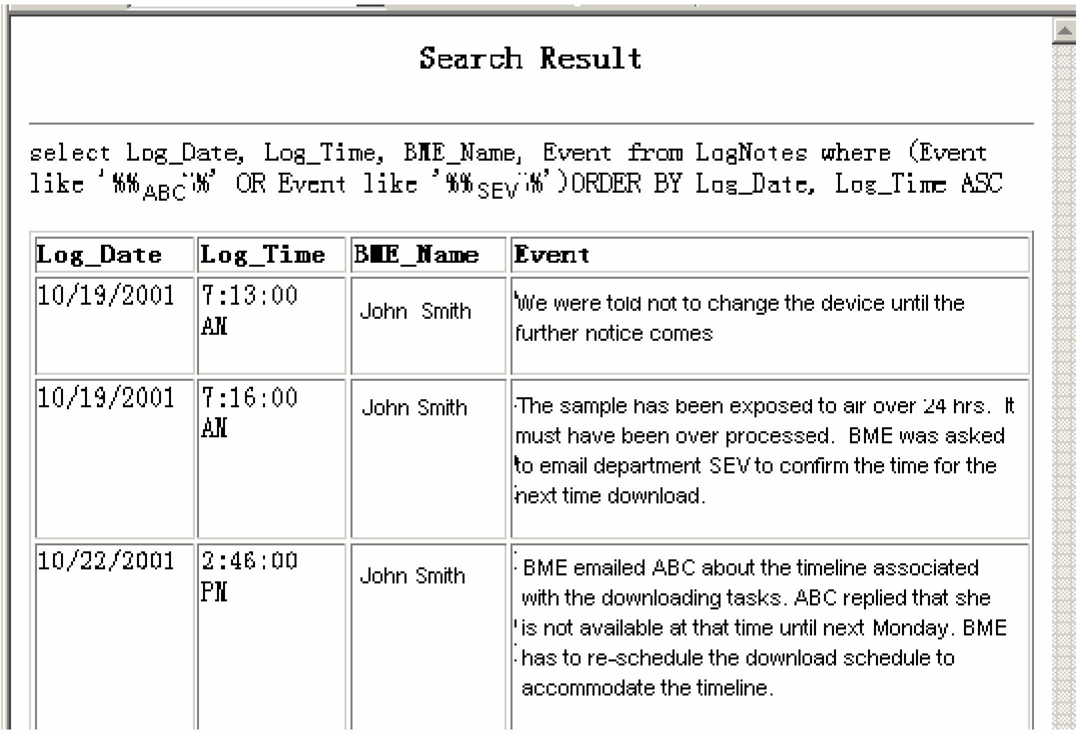
The items in our design are organized in hierarchical order of the BMEs frequently used terms. For example, when the conference item on the first level is chosen, all the categories under conference will appear in the second and third level menus accordingly. This menu might be helpful in developing a proper search strategy.

Search function design

The logging tool would support storing each entry as a record in a database. [15] Each log entry would be associated with meta-data to facilitate grouping, sorting, or filtering of log entries when the user wishes to view the logs, generate reports based on the logs, or search for specific logs. To support search, BMEs would select standard text to include in log entries from controlled vocabulary menus. These selections would have the side effect of attaching meta-data to the log entry. Coded data in the database is easier to organize than free text in MS Word documents. In addition, it allows synchronous multiple user access. On the basis of this condition, we designed a search interface associated with the database, using the same controlled vocabulary.

This will allow the BMEs to track all the entries associated with a specific topic. For example, BMEs can find out when a specific issue first appeared, how the issue progressed and track anything else related to that issue.

After the development of the search menu, we implemented its functions. The Web-based search interface and its functions were implemented by using HTML/ JAVAScript/VBScript as the front end, and SQL Server database as the back end. We used Active Server Pages (ASP) to connect the front-end interface to the backend database. The reason for choosing SQL Server rath



Search Result

select Log_Date, Log_Time, BME_Name, Event from LogNotes where (Event like '%%ABC%' OR Event like '%%SEV%')ORDER BY Log_Date, Log_Time ASC

Log_Date	Log_Time	BME_Name	Event
10/19/2001	7:13:00 AM	John Smith	We were told not to change the device until the further notice comes
10/19/2001	7:16:00 AM	John Smith	The sample has been exposed to air over 24 hrs. It must have been over processed. BME was asked to email department SEV to confirm the time for the next time download.
10/22/2001	2:46:00 PM	John Smith	BME emailed ABC about the timeline associated with the downloading tasks. ABC replied that she is not available at that time until next Monday. BME has to re-schedule the download schedule to accommodate the timeline.

Figure 2 - Search Result Page

er than MS Access to setup the database was due to the fact that the former allowed more than 255 characters in one text field. The web interface is an HTML document containing embedded forms. At the client side, we used JavaScript to implement the dynamic relations between the menu boxes and text fields. At the server side, we used VBScript to implement the connection to the log database and retrieve information from the database.

The structure of the log notes database table contains five fields, date of log event ID, log note, time of log entry, logger's name, and content of log note (or logged event). Log notes was first decomposed into several segments and appended into the database table.

Full-text search is allowed in the design. For example, if the user enters "TEP data" in the keyword input box, the default Boolean logic between the two words is "AND". Therefore, the search string that the program generates is "TEP" .and. "data". All the corresponding items in the table will be retrieved and displayed.

Search results (Figure 2) are displayed in the table in a chronological sequence. The data from real log notes adapted for the publication purpose is displayed on that screen. The search strategy is shown on the top of the table that contains log date, log time, BME name and log events. The functions of "enter text" and "select from menu" are not combined. For example, users can only use either the "search by entering text" or "search by selecting an item from the menu", but not both at the same time. This means that and accurate search with a controlled term is not combined with the free text search.

Conclusion

The real world information intensive domain of BMEs supporting the International Space Station provides an interesting area to explore ideas about how to best capture and organize data for later retrieval. Several issues were observed related to the free text nature of the data currently being captured and the difficulty in searching through multiple files for answers to questions.

Documented in a MS Word format with a free text, the current log notes have a primitive search function, which cannot meet the search needs of users who work in an information-rich environment with a heavy workload. The analysis of the log notes revealed that a couple of inconsistencies existed in the original document due to the free text entries could be solved through a user warranted and literature warranted taxonomy.

This taxonomy then was represented in the search interface in the form of a three-level hierarchical menu that represents the relationship of the categories. This menu provides a transparent view to users who may quickly change tasks by selecting the appropriate item in the related menu. Further, the design was implemented in a relational database with a web-based interface which allows combined search through manual entry for free text search or menu selections controlled vocabulary.

The solution to many of these issues involves creating more codified data. However, this must be done in a way that causes no more time than the old method, preferably less. A menu system for creating coded entries was devised using a hierarchical method. This appeared to give the best results for creating entries quickly and easily as well as for getting proper data into the system for better searching. Sample search results indicated that the coded entries in a database did indeed facilitate the types of searches that are frequently done by the BMEs. It should be noted that the same techniques that were used here also apply to various healthcare situations such as a hospital Electronic Medical Record (EMR). The key points being that having an electronic database facilitates retrieval across multiple units of time (such as days in ICU) and that a properly designed menu system can both speed entry of coded data as well as providing the scaffolding for efficient search.

In a nutshell, an effective and usable search interface prototype for a specific group of users should have a detailed user analysis and task analysis. With a taxonomy represented in a transparent interface, users might have an efficient mapping between the display and tasks. Therefore, a proper representation of the search function should fully consider the user's specification.

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