

COMPARISON OF DESIGN REQUIREMENTS METHODS FOR MONITORING EATING PATTERNS OF SENIORS IN A SMART HOUSE

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The Smart House technology introduced an intelligent home designed to monitor the health and well being of senior residents unobtrusively. As one of the most important components of the smart house technology, we are developing an online eating-pattern monitoring system to be incorporated into a Smart House. A combination of four needs assessment methods including focus groups, observation, questionnaire and document review was used to gather information from seniors to determine critical design requirements for the system. A framework of information and interface requirements was developed to compare the effectiveness of the four methods used in our needs assessment. All four methods provided useful design recommendations, but each method differed in terms of specification of information and interface requirements. Based on the classification and comparison of methods, other practitioners can determine tradeoffs and select relevant needs assessment methods for their particular application.

INTRODUCTION

The concept of a Smart House has been discussed for more than a decade. So far, controlling appliances, maintaining comfortable home environment, or intelligently reinforcing security have been the focus of efforts in this area. But the Smart House could be more beneficial to seniors or those with disabilities by facilitating independent living, promoting social integration, providing technical assistance, and increasing the availability and quality of healthcare.

Technology must play a fundamental role in developing Smart Houses. But it is important to address user needs and the delivery of services to support those needs. This paper focuses on both objectives. A Smart House is defined as a sensor-based intelligent home designed to monitor the health and well being of senior residents. This information can be made available to remote family members and healthcare providers by a variety of interfaces. One of the most important components of this Smart House concept is an online eating-pattern monitoring system since eating behavior is critical to many chronic health conditions.

To develop a successful health related application, the needs assessment process and subsequent needs analysis are substantial in the entire system development process. Examples of extensive needs analysis in the area of smart systems in health care are few in number. One example, however, is the research of Delano and Hartman (2001) who used a combination of focus group and survey methods to perform a needs assessment with design implications for a home health care system.

During the needs assessments process, various aspects of information and interface design requirements should be identified. To achieve this, we need a systematic framework for information and interface requirements for online monitoring systems. In this project, an overview of user-centered design context and a modified scheme of interface elements is introduced and used for information and interface requirements respectively as operational frameworks.

Since a variety of methods are available for user needs analysis, practitioners may need guidelines for choosing appropriate methods or combining different methods for a comprehensive assessment of user needs. User-centered self-report approaches such as focus groups and questionnaires were selected to perform the relevant needs assessment to elicit design requirements of the online eating-pattern monitoring system. Activity theory, proposed by several HCI researchers for application to innovative HCI approaches (Bødker, 1991; Nardi 1996), focuses on the human's use of objects within their social environment to achieve specific outcomes or objectives. Based on activity theory, activity analysis by observation was recommended as a needs assessment method. In addition to the three methods, document review was conducted.

THESIS

Methods to elicit specific categories of user requirements for any system differ in the quality or usefulness of the resulting information. We present a framework for classification of design requirements that extend from different needs analysis methods. Guidelines for selecting needs assessment methods are recommended to other practitioners based on the framework and the results.

SOURCES OF INFORMATION

This study compared four specific methods of determining design requirements based on user needs. All participants for focus groups, observation and questionnaire methods were recruited from the members of the Blacksburg Electronic Village Seniors and the Blacksburg Parks and Recreation Senior Center in Blacksburg, Virginia. In addition, a senior advisory board provided oversight and information.

Focus Group

The focus group meeting centered on identifying ideas related to the design of a Smart House and an eating-pattern monitoring system. The focus group was conducted as a brainstorming session. To provide a context for the focus group, some of the objectives of the Smart House and a scenario were given to the participants.

Observation

We used a participatory needs analysis based upon Activity Theory (Bødker, 1991; Nardi, 1996) to implement the observation method. First, a participant's kitchen activity was recorded on videotape. We then developed an observation template to guide observers to identify significant activities and interactions with objects, and asked them to provide design recommendations. Then senior advisory members reviewed the videotape and analyzed the user's activity by using the observation template.

Document Review

Document review was conducted throughout the entire needs assessment period. The documents reviewed included research papers and software interface design guidelines. The research papers primarily focused on developing health monitoring systems and context-aware applications. Also existing software interface design guidelines were surveyed and reviewed to develop interface requirements.

Questionnaire

An online survey was developed from focus group results and our document review. The survey consisted of two parts - information requirements and interface requirements. The online survey was developed in HTML and launched on the Internet.

FINDINGS

In developing an information display system on the basis of a user-centered design approach, design requirements should be specified in two different aspects: information content and system interface features (Kwahk, Smith-Jackson, and Williges, 2001). Information content requirements deal with the content that can be presented to users in the context of a user, object, task, and environment. To elicit components of information requirements effectively, an overview of generally accepted user-centered design context is shown in Figure 1. Under each element of the design context including user, object, task and environment, several information requirement components are constructed (Table 1). System interface requirements cover interface design aspects through which users can interact with the system. These design aspects include the information metaphor, organization, interaction pattern, input/output devices, user assistance, protection, and the possibility of multiple users.

Information Requirements

As shown in Table 1, information requirements can be broken down into ten specific sub-categories. Each of the four needs assessment methods contributed differentially to these various information requirements categories.

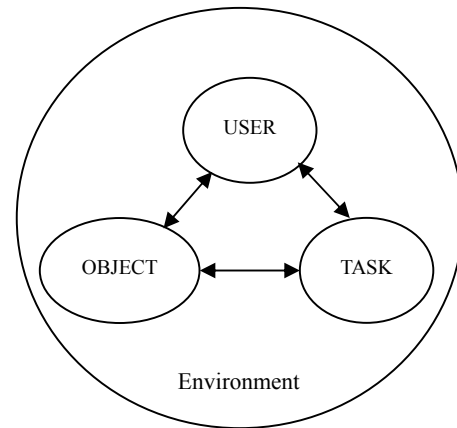


Figure 1. An overview of user-centered design context used for the classification of information requirements.

Information Requirements

As shown in Table 1, information requirements can be divided into ten specific sub-categories. Each of the four needs assessment methods contributed differentially to these various information requirements categories.

Table 1. Mapping between information type and needs assessment method

Information Requirement		Focus Group	Observation	Document Review	Questionnaire
User	Identification	X	X	X	
	Physiological Information	X		X	X
Task	Activity	X	X		X
	Inferential Information	X			X
Object	Availability of Resource	X	X		
	Emergency Signal	X		X	X
Environment	Temporal Environment			X	
	Spatial Environment		X	X	
	Social Environment		X		
	Physical Environment			X	

Identification. Information is required to distinguish those who use the system from those who are monitored by the system. For example, when there are multiple users involved, each user can be asked to wear a badge as an identifier that can be detected by a scanner to infer the identity of the current user. A user's identification can be determined by using a mat sensor that will be activated when a user steps on the mat. As shown in Table 1, the needs of user identification were

indicated through focus groups, observation of user activities, and document reviews.

Physiological information. Since most online health monitoring systems are designed to collect physiological signals to diagnose the health status of the patient, information in this category should be considered very important. To acquire physiological information in depth, a focus group or questionnaire method with health care professionals proved to be most useful, while some basic information was derived from literature.

Activity information. Focus groups and observational methods were used to gather possible activities that were related to meaningful information relevant to eating patterns. For example, opening a refrigerator, opening a microwave, and opening utensil cabinets were the possible activities related to eating patterns. A questionnaire method was used to determine the relative importance of the possible activities to represent user's eating patterns.

Inferential information. Inferential information is knowledge that can be inferred from the factual data representing the user's activity. A typical example of inferential information is diagnostic information about a user's eating pattern obtained through the statistical data representing user activity for a certain period of time. Overall needs for the information in this category can be identified during the focus group session, while the questionnaire can address more detailed requirements or the priority among the information items.

Availability of resource. Food inventory in a refrigerator or a cabinet can be resource information that is meaningful to residents. The needs for this type of information were made apparent from the focus groups. Through observation, analysts could identify relevant objects other than food resources such as the amount of utensils and dishes by reviewing the user's activity in a kitchen.

Emergency signal. Information requirements for emergency signals (e.g., a signal noting that power to a kitchen range has been on after use) can be defined by focus groups, questionnaires, and literature reviews. The focus group was very helpful in addressing the importance of providing various emergency signals by asking the seniors to discuss dangerous experiences or near misses. The questionnaire was useful in identifying possible objects related to emergency situations and identifying the relative importance of those objects. Also Kidd et al. (1999) indicated a need for information to identify potential crisis situations for developing their Smart House applications for seniors.

Temporal information. Information such as dates, season of the year, or time of the day can be provided. Because temporal information is presented in a well-defined format in a variety of application systems, reviewing documents provided the relevant information.

Spatial information. Information requirements on the location of seniors in a Smart House can be found in the literature related to context-aware applications. Furthermore, based on the activity analysis of the observation method, there were further implications for having spatial information in more detail. For example, other than the locations of appliances such as microwaves or other objects in a kitchen, the directions that each object faces or the height where the object stands can be meaningful to users. Unlike temporal information, a user-centered approach, especially the observation method, is needed for gathering requirements of spatial information in addition to document review.

Social environment. Information about whom the resident is with, the identity of people in the neighborhood, or how many people are in the house could represent some aspects of the senior's social environment. Activity theory emphasizes the social environment as an important factor for understanding the users' activity and this information was collected through observations.

Physical environment. Temperature, air quality, light level, and noise level are examples of information requirements of the physical environment that can relate to a senior's health status. However, none of the other needs-assessment methods except document review identified this information as relevant in this research effort.

System Interface Requirement

Because there were several proposed classification schemes for software interface design (ECMA, 1992; Williges et al., 1987), existing classifications were reviewed and modified. Based on the classification scheme for software interface design (Williges et al., 1987) and the user interface taxonomy (ECMA, 1992), the classification of system interface requirements was developed and the seven categories of system interface requirements are shown in Table 2. Again, various needs assessment methods were differentially effective in providing system interface requirements in these seven sub-categories.

Table 2. Mapping between interface elements and needs assessment method

System Interface Requirement	Focus Group	Observation	Document Review	Questionnaire
Metaphor			X	X
Information Organization			X	X
Interaction Pattern			X	X
Input/Output Devices	X	X	X	X
User Assistance	X		X	
User Protection	X			
Multiple Users				X

Metaphor. Metaphor allows the user to gain a sense of how the system operates. For example, the most famous metaphor being used for computer interfaces is the desktop

metaphor. The research team suggested a calendar metaphor as a proper metaphor for the online eating pattern monitoring system. Then, the questionnaire method was used to verify the relevance of the suggested metaphor from the users' point of view.

Information organization. Information organization includes screen layout, data format, information coding, and data labeling. A specific level of decision-making is needed to obtain design requirements. For example, preference of table, chart, or text format to convey the same information should be decided by the user. Because there are numerous design guidelines in this category, a review of relevant design guidelines was first performed, and then aspects not covered in the existing guidelines were acquired by questionnaire.

Interaction pattern. Since there are many existing guidelines related to interaction patterns, the document review was performed first to develop design specifications. For example, organizing menus hierarchically and alphabetically is one guideline identified from the documents reviewed. The questionnaire method was used to make decisions about additional design specifications that were not addressed by existing guidelines.

Input/output devices. As computer technology quickly advances, the range of available input and output devices increases. As an example of recent research for selecting input/output devices for older people, Ziegler and Machate (1997) selected a touch screen for their home assistant system. Users are very interested in the selection of devices. Many concerns were provided about input and output devices during focus group sessions, observations, and from questionnaire data.

User Assistance. Providing proper technical supports, system feedback or error recovery procedure is an especially important issue for people who are less familiar with computer systems such as older users. Participants of the focus group sessions discussed some desirable forms of user assistance. Many software design guidelines emphasize the consideration of feedback and error recovery procedures and specific guidelines are presented such as offering advice when errors occur or providing error messages in consistent locations.

User protection. During the focus group, participants expressed concerns regarding privacy. Because the online eating-pattern monitoring system is conveying a user's private information through the system, the user should have control over the external recipient's information access (e.g., a remote family member or health care provider) as well as the type of information provided.

Multiple users. To support multiple users, interface issues such as adaptive interfaces to support individual preference for specific interface elements need to be specified. For example, some users prefer Monday to start a week and some other

users prefer to start a week with Sunday when a weekly calendar is displayed. Various ways to support different users were addressed in the questionnaire.

DISCUSSION

Based on the results summarized in Tables 1 and 2, it is clear that each of the four different methods for collecting needs assessments were useful. The unique characteristic of each method must be considered when choosing a data collection method, and suggested guidelines for using these methods can be inferred from these considerations.

Focus Group

The focus group method allowed information to be gathered in close relation to the task or objects, and several interface aspects were identified through this method. Focus group settings proved to be most helpful in collecting new ideas related to the design of a system especially when it targets a special population of users. In addition, the results from the focus group session provided a good basis for developing questions for the online questionnaire.

Observation

Observations did not contribute directly to identifying system interface requirements. However, the observation method was useful in identifying relevant information requirements such as the spatial environment and social environment that were not addressed by the focus group and questionnaire methods. Observation also served an additional purpose of confirming other information requirements identified by focus group and questionnaire responses.

Document Review

The document review was performed during the entire needs assessment period. As a result, the document review roughly complemented the questionnaire method. Document review is an easy and cost-effective needs assessment method by reviewing relevant research papers, and many design requirements can be acquired for both information and system interfaces by this method.

Questionnaire

The questionnaire was developed based on the results of focus group sessions where information requirements were identified. In regard to system interface requirements, questionnaire items were included to cover interface elements that were not discovered by the document review. Therefore, the questionnaire method roughly complemented the document review in terms of both information and system interface requirements.

CONCLUSION

All four methods for collecting needs assessments were effective, but they were not equally useful in providing information and system interface requirements. The differential outcomes summarized in Tables 1 and 2 should be helpful to practitioners who are choosing needs assessment methods for a variety of design applications. For example, a practitioner who has a limited time and budget and wishes to select only 2 needs analysis methods can select focus group and document review methods because the combination of the two methods covers the most design requirements than any combination of others. Also according to the characteristic of an application and the knowledge type required by the application, different combinations of the methods can be recommended by consulting the fit tables.

Information requirement and interface specification obtained from this needs assessment were subsequently used in our project to develop an inferential system based on neural network modeling (Kwahk et al., 2002) to provide information concerning eating patterns of seniors. In addition, an information display was developed to represent eating patterns and nutritional information. Figure 2 shows a screen-shot of part of the information display system depicting the daily eating pattern of a senior.

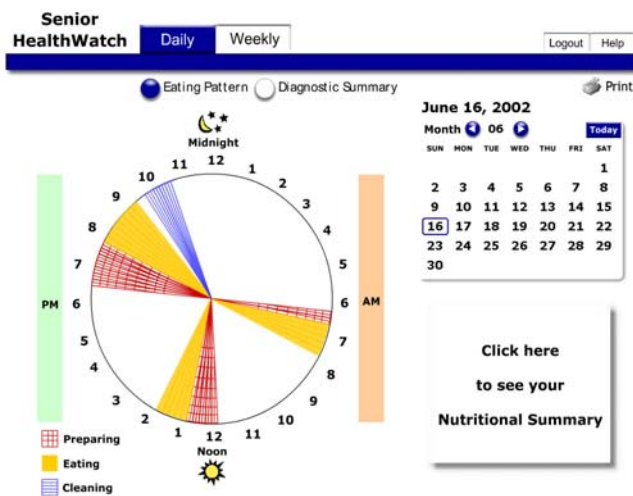


Figure 2. Example screen shot of online eating pattern monitoring system

Future Implication

We presented Figure 1 as an overview of user-centered design context for the classification of information requirements. Future efforts are required to expand and validate this overview into a 'framework' that provides practitioners with more helpful, detailed and structured guidance for selecting appropriate design requirements methods. The expanded framework could include other design requirements methods that were not compared in this study such as assessments through contextual inquiry or logging actual use. This framework can be extended further to include other stages of user-centered design process as well (i.e.,

prototype-based iterative design and usability evaluation stages).

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