COGNITIVE ENGINEERING COMPUTER INTERFACES: PART I - KNOWLEDGE ACQUISITION IN THE DESIGN PROCESS

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Abstract

Much is being written about "cognitive engineering" or the process of applying psychology and human factors engineering data to human interface design. Most of this literature is strong on theoretic advocacy of such a process but weak on implementation details. The present paper describes in detail the first part of one suggested methods for cognitive engineering of computer interfaces. This crucial first phase is the acquisition of knowledge from potential users and subject matter experts about what the computer system will do and how it should do it. Most contemporary application development processes rely heavily on user inputs, using these inputs to deliver what the user "wants." Unfortunately what the user "wants" often differs from what the user "needs." The present cognitive engineering method uses objective processes called concept mapping to process user inputs into system requirements based on needs rather than wants. New software under development to create and analyze concept maps will be described and sample output will be presented. An application based on efforts to assist development of the Open Command Tactical Information System (CTIS) command and control system of the Air Force's Alaskan Air Command will serve as an example of the process.

Knowledge acquisition is the first phase of the design process that includes combining domain expert knowledge, human engineering data, user interface guidelines, and aesthetics. It is one of the most difficult phases of cognitive engineering yet, it is also one of the most important. Extracting knowledge from potential users and domain experts about a system is the foundation for the design process. It is crucial that individuals involved in the design of systems obtain a good understanding of what the system constraints and capabilities are. Too often, designers begin projects without understanding what tasks are required to achieve the objective. This can lead to a less than adequate system. In addition, the users often have become accustomed to the existing system and "the way things have always been done". This way of thinking should not overcome design. It is imperative that the information and experience domain experts possess be utilized as a foundation for design in conjunction with empirical data and the experience of human factors engineers to create the best system possible.

Previous knowledge acquisition methods have not always been successful in tapping the vast amount of information available in the domain expert's brain. Often, information is excluded or biased simply because of the question being asked or how it is asked. This problem is found most often with the traditional structured interview technique. Questions are focused on a specific area of the domain and are phrased in a certain way by the knowledge engineer which creates a bottleneck that only allows a limited amount of information.
A technique known as concept mapping has the ability to alleviate this bottleneck. Concept mapping is a graphical interactive interview technique that provides a shared medium of communication. A concept map consists of nodes that contain concepts such as objects, actions, or events, and links that show the relationship between the concepts. A concept mapping session begins with a broad question such as "How do you do your job?" or "How does the system work?" Then, the domain expert is allowed to talk freely about the subject with few interruptions. The only other probes during the session are for clarification of a concept. The map is produced on a white board while the domain expert talks. The expert can see the map as it is created and correct any misinterpretations immediately. Often, the domain expert will actually create the map by telling the knowledge engineer where to place the nodes. The flexibility of the method allows any topic to be mapped.

Once the information has been mapped, the knowledge engineer must manipulate it. This can sometimes be overwhelming when there is a large amount of data. To assist the knowledge engineer in this endeavor, a Tools for Automated Knowledge Engineering (TAKE) software program has been developed. TAKE has three major functions including a drawing function, an outline function, and a categories function. The best way to explain the utility of the TAKE software is by describing its application in an effort to assist in the development of the Command Tactical Information System (CTIS) command and control system of the Air Force's Alaskan Air Command.

This example will focus on TAKE's use for the redesign of the computer system for the Rescue Coordination Center (RCC). First, concept maps were created through interviews with several officers that worked in the RCC. They were asked to explain what tasks they performed during a mission. In addition to details about how they performed their job, they also made comments on how they would like to see the system improved to better support their needs. These comments were recorded to see if they best met the actual requirements of the job.

Once the concept maps had been created, they were input into the TAKE program. The drawing function allows map input in the same form they are created, i.e. as a series of nodes and links. A sample of one of the maps created can be seen in Figure 1.

![Figure 1. Sample RCC Concept Map](image)

The map then acts as the database for the other functions to manipulate. The outline function can create a hierarchical form of the data by creating indentations based on parent and children nodes. This function makes task analysis a much smoother process. So, an outline was created for each concept map.

The most powerful portion of the program is the categories function. This was used to group the data into user-defined categories. For example, a "Requirements" category was created to group all data concerning task requirements to complete a mission. A category is created by providing the computer with keywords to search the database for. Any information that matches the keywords is grouped and saved in a file under the category name. For the "Requirements" category keywords such as require, must, need, and necessary. The computer searches for those words and any derivation of those words. Any concept or relational link that contains one or more of those words is included in the category. The categories created for the RCC example included "Requirements," "Tasks," and "Desired Enhancements." The "Requirements" category can...
be seen in Table 1. By grouping the data, we were able to easily connect possible design solutions to task and system requirements. The design solutions may be recommendations made by users or human factors specialists or computer programmers.

Requirements

Table 1. REQUIREMENTS CATEGORY
Keyword search by the computer found these data in the concept maps.

This is the area where cognitive engineering plays a vital role. What the user wants and what the user needs are not always the same thing. It is the job of the human factors engineer to employ sound design principles to meet the users' needs. By learning, in detail, how the user performs the job, the Human Factors Engineer can discern what information, tasks, and output is required. Also, knowledge should be gained from the engineers, in this case computer programmers, about constraints and options. Using all of this information, a design can be created that makes information easy to receive and understand, makes tasks easy to perform, and output of performance fit the requirements of the system. This is accomplished by drawing on design experience and guidelines from research and fits within the constraints of the system.

For CTIS, requirements for the tasks helped determine what types of screens are necessary. The information requirements, such as aircraft information the user needs and incident information the user must input to the system, helped define the design of a particular screen. The method by which information is retrieved from or supplied to the system should be designed based on research and system constraints and capabilities.

The design as a whole is based upon knowledge gained from users, system engineers, and human factors engineers. This multidisciplinary approach to design is only as good as the knowledge acquisition methodology. The TAKE method described here which incorporates concept mapping provides a means whereby as much unbiased information as possible is extracted from domain experts. An in-depth explanation of how this information is applied to the design is provided in Cognitive Engineering Computer Interfaces: Part II - An Objective Design Process.

Glossary of Terms:

CTIS - Command Tactical Information System
FAA - Federal Aviation Administration
RCC - Rescue Coordination Center
TAKE - Tools for Automated Knowledge Engineering

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