Comprehension-Based Approach to HCI for Designing Interaction in Information Space

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Abstract

The traditional view of HCI has been based on a cognitive psychological analysis, in which people have to translate their intentions into the language of the computer and have to interpret the computer's response in terms of how successful they were in achieving their goals. However, with the ubiquity of information appliances, this view becomes inadequate. People are no longer simply interacting with a computer they are interacting with but they use various combinations of information appliances and media available for them to accomplish their tasks defined in information space. This opens up the possibility that any single task can be accomplished in various ways. This paper argues that such users' interaction processes can be better viewed as the processes consisting of comprehension of the current situation formed by integrating various sources of available information, followed by selection of an appropriate action based on the comprehension. A set of implications for interaction design for information space is derived based on this comprehension-based view of HCI.

1 Introduction

As the integration of communication and computer advances, our computerized tasks place more emphasis on interaction with information than interaction with computers. Interaction with devices based on familiar interface conventions becomes less focused but interaction with information becomes more important. There are devices that aim to support activities in information apace. These devices are called information appliances[1] or internet appliances[2], providing interface for accessing and manipulating information.

The purpose of this paper is to define an appropriate viewpoint to understand users' activities in information space, and then derive implications for designing interaction for information space. This paper starts by showing that *comprehension* should be one of the fundamental cognitive skills

[1] A device for accessing or manipulating information, special-purpose in contrast to a general-purpose computer. The idea is a machine with computing power but designed and used like other consumer electronics, such as stereos, TVs, and toasters. It serves a limited function, enabling it to have a simplified user interface and to fit its intended task more perfectly than a general-purpose machine. (Adapted from http://www.usabilityfirst.com/glossary/)

[2] A device designed to simplify use of the internet and simplify setup compared to a general-purpose computer. Buttons and other controls are minimized and built in to the hardware. The application may permit any kind of web browsing or may be limited to a very restricted functionality such as an email reader, a picture display, or a coffee pot that can be activated over the internet. (Adapted from http://www.usabilityfirst.com/glossary/)

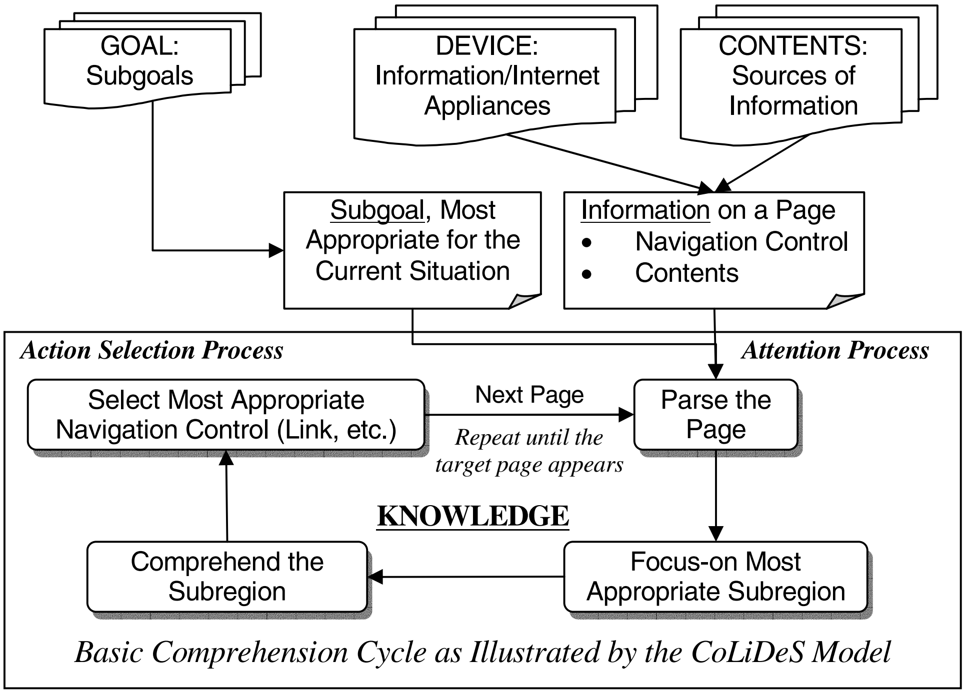

Figure 1: A comprehension-based view of HCI in information space.

that the users should apply in order to deal with interaction in information space, followed by brief description of comprehension-based cognitive models my colleagues and I have developed. It concludes with key design questions for designing interaction for information space.

2 Comprehension as a Key Cognitive Skill

Interacting with information space is different from interacting with a computer for performing traditional computerized tasks in two important ways. First, there are multiple ways to interact with information space. A task in information space can be accomplished by using different information appliances or internet appliances, which would have different physical interfaces. And thus actual physical action sequences would differ device by device. Second, comprehension of a situation in which a task is carried out can vary according to the recruited knowledge by the individual performing the task. Because people have diverse background knowledge, the same physical data provided by the devices can be comprehended various ways. These would result in the observation of multiple paths for accomplishing the task. They are different from each other not only at the level of physical actions but also at the level of mental operations.

Actual physical action sequences observed in users' interaction in information space can be changeable, and thus they cannot be considered as good indexes for understanding people's activities in information space. They cannot be used for evaluating usability as is done, e.g., by the GOMS modeling techniques (Card, Moran, & Newell, 1983). Then what can be qualified as the fundamental cognitive processes that organize people's activities in information space, which should provide useful insights for designing interaction in information space?

I suggest that interaction in information space should be viewed as *goal directed activities driven by comprehension process* in which information on the interface is comprehended by the user with his/her background knowledge in the context of the intention of accomplishing the current goal. Many of our activities are purposeful because we interact with our environment to achieve specific goals. This is true too when we are in information space. What we actually do at a given moment, however, is determined not only by the goals and the environment – contents in the information space – but also by the knowledge utilized to comprehend the situation. In order to select what to do next, we integrate these sources of information: goals, information from the environment, and knowledge relevant to the current situation – the underlined elements in Figure 1.

The process of comprehension, typically observed in text comprehension, is a highly automated collection of cognitive processes that make use of massive amounts of knowledge stored in long-term memory. In text comprehension, for example, readers activate knowledge from long-term memory relevant to the current reading goal and integrate this knowledge with the current goal and representation of text. Conflict among activated knowledge elements may exist which necessitates an integration process to arbitrate this conflict within an appropriate time frame. I suggest this same skill is important in interacting with information abundant environment, where people have to derive appropriate meaning of the situation by recruiting appropriate knowledge for the particular situation. This skill is different from the skill required for performing routine tasks where people just execute precompiled methods for accomplishing tasks, as seen in the typical view of HCI which has been based on a cognitive psychological analysis; people have to translate their intentions into the language of the computer and have to interpret the computer's response in terms of how successful they were in achieving their goals (Norman, 1986).

3 Comprehension-Based Models

3.1 The LICAI Model – a Cognitive Model of Performing by Exploration

The author and his colleagues have developed a series of comprehension-based computational models that deal with cognitive processes of how computer-literate users perform various office automation tasks by using graphical user interfaces, such as word processing, spreadsheet, and graphing (Kitajima and Polson, 1995, 1997). These models are based on the construction-integration architecture, originated from the cognitive models of text comprehension (Kintsch, 1997). Kitajima and Polson (1995) proposes a model of action planning and error by experienced users, and Kitajima and Polson (1997) has extended it to a situation where novice users discover correct actions by exploration. The latter model is called LICAI, which stands for LInked model of Comprehension-based Action planning and Instruction taking.

LICAI models novice users' activities by the following processes, each places emphasis on comprehension process that utilizes knowledge in LTM and creates a coherent understanding of the situation:

1) *Goal Formation Process* – comprehends the task for the purpose of transforming it into workable subtasks, for example, the goal of purchasing an item at an online store is decomposed into a set of subgoals, including browsing a catalogue, selecting an item to purchase, paying for the selected item, and so on.
2) *Goal Selection Process* – comprehends the interface to sequence the subtasks properly.
3) *Action Selection Process* – selects an object-action pair to execute, consisting of the following sub-processes;

a) *Object Selection Process* – comprehends the interface to select the right object.
b) *Action Selection Process* – comprehends the interface to select the right action, for example, click, drag, and type.

3.2 The CoLiDeS Model – a Cognitive Model of Web Navigation

Web navigation can be considered as a typical example of activities in information space; it consists of a series of link selection, each selection leads to a new web page, where next selection is carried out. In each selection, the user compares the representation of the current page with the representation of the task goal by using general knowledge about the page and the goal, and selects a link that would contribute most to accomplishing the goal.

Kitajima, Blackmon, and Polson (2000) have developed a comprehension-based model of web navigation by extending the LICAI model. The model is named CoLiDeS, standing for Comprehension-based Linked model of Deliberate Search. Figure 1 illustrates CoLiDeS schematically. CoLiDeS adds the attention process to the LICAI model in order to model interactions with web which is richer in information and less formatted than those with office applications. The CoLiDeS model is used to develop CWW – the Cognitive Walkthrough for the Web – a usability inspection method for detecting and repairing usability problems, mostly in navigational problems in informational sites (Blackmon, Polson, Kitajima, and Lewis, 2002; Blackmon, Kitajima, and Polson, 2003).

The processes in the CoLiDeS model are defined as follows:

1) *Forming goal and selecting a subgoal*: These processes correspond to the instruction taking process and the goal selection process of the LICAI model, respectively.

2) *Parse the page and focus-on one sub-region:* On encountering a new web page, the user first parses the page into meaningful units. The user then selects one of the units, schematic object, by comprehending the parsed page. This process is called the attention process. This process results in making available the contents in the schematic object to the user.

3) *Comprehend the selected sub-region and select link:* Finally, the user comprehends the contents and selects one link. This process corresponds to the action selection process of the LICAI model.

Parse and focus-on are important addition to the LICAI model and play crucial role in attention management for processing new contents on the pages.

4 Implications for Designing Interactions for Information Space

By looking at the processes defined in the CoLiDeS model from the viewpoint of knowledge use, we could derive key questions at each stage of interaction to be answered affirmatively when designing interfaces for tasks performed in information space. Table 1 summarizes the features of knowledge use at each stage of interaction process as defined by the CoLiDeS model and the third column holds key issues for designing *usable* interface for information space.

One of the serious problems in the information abundant environment is that people cannot reach the desired information that *does exist* in the environment by successively following links. This

Table 1: Cognitive processes necessary to perform tasks in information space and their implications for designing usable user interfaces.

Stage	Feature of the Cognitive Processes	Key Issues for Designing Usable Interface for Tasks in Information Space
Goal Formation	Comprehend the task in order to transform it into workable subtasks	Is the task representation appropriate for activating critical knowledge, such as schema, script, etc.?
Goal Selection	Comprehend the interface to sequence the subtasks properly	Is the interface representation appropriate for activating the right subgoal?
Action Selection	Comprehend the interface to attend to appropriate portion of the interface	Is the interface representation appropriate for activating critical knowledge for parsing the interface?
	Comprehend the interface to select the right object	Is the representation of the interface object appropriate for activating knowledge necessary to relate it with the current subgoal?
	Comprehend the interface to select the right action	Is the representation of the interface object appropriate for activating eligible action for the current subgoal?

problem would be resolved, not fully but partially though, by considering the key issues listed in Table 1. Think first how people comprehend the environment. This is the key to designing usable, if not effective and efficient, interface for supporting activities in information space.

5 References

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