Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

What does the Representation Talk Back to You?

Kumiyo Nakakoji[1,2,3] and Yasuhiro Yamamoto[1]

[1]Graduate School of Information Science
Nara Institute of Science and Technology
8916-5, Takayama-cho, Ikoma, Nara
630-0101, Japan

{kumiyo, yasuhi-y}@is.aist-nara.ac.jp
tel: +81-(743)72-5381, fax: +81-(743)72-5383

[2]Software Engineering Laboratory
SRA Inc.
3-12 Yotsuya, Shinjyuku-ku, Tokyo
160-0004, Japan

[3]Information and Human Activity Group, PRESTO
Japan Science and Technology Corporation (JST)
3-4-12 Mita, Minato-ku, Tokyo
108-0073, Japan

Abstract

Our research goal is to support designers with interactive systems by exploring the relationship among representations, their meanings, and their effects. This paper first outlines ART (Amplifying Representational Talkback), a prototype system which we have developed to instantiate our research framework. We then reinterpret the essence of the ART system by illustrating the ART approach with other people's work in Semiotic Approaches to User Interface Design presented at the ACM CHI 2000 workshop. We identify critical aspects of the system from four points: (1) interactions with representations *"I"* produced; (2) representations as indices for thoughts; (3) hands-on representations; and (4) limiting the automation. By having the ART system as an object-to-thing-with, we argue that communication with interactive computational tools had better been regarded as interaction with representations.

Keywords: two-dimensional spatial positioning as a representation, HCI for supporting early phases of design, human-representation interaction

1 INTRODUCTION

In the realm of computer support for design, the rationalistic tradition has slowly been challenged [Winograd, Flores 1986]. While D. A. Schoen [1983] has nicely illustrated the process of design as a cycle of reflection-in-action through a conversation with the material, little theoretical ground has been provided for what is really happening during the reflection-in-action process. Our research goal is to support designers with interactive systems by exploring the relationship among (1) a representation that a designer produces (such as sketches), (2) its meaning that the designer "sees" in the representation, and (3) its effects onto the designer's understanding of the design task. This nicely fits the framework of Semiotic Approaches to User Interface Design, where *Semiotics is devoted to studying communication: representations, their interpretation and usage* [in WS2000].

This paper consists of two parts. In the first part, we outline the ART (Amplifying Representational Talkback) system, a prototype system we have developed to support early phases of a design task, in this particular case, *writing* [Yamamoto et al. 2000a]. The design of ART is based on the notion called *Representational Talkback* [Nakakoji et al. 1998]. Representational talkback, based on Schoen's design theory [1983], is defined as a perceptual feedback from the externalized artifact (representations) to the designer; in other words, how the designer interprets what he/she has just represented. In the second part of this paper, we describe four characteristics of the ART system in terms of interaction

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

with representations and illustrate the ART approach with other people's work in Semiotic Approaches to User Interface Design presented at the ACM CHI 2000 workshop [in WS2000]. This helps us identify critical aspects of the ART system and semiotically reinterpret the essence of the system.

2 THE ART SYSTEM

ART is a system that supports early phases of a writing task as design. The system consists of four parts: ELEMENTEDITOR (lower-center in Figure 1), ELEMENTSMAP (upper-right), DOCUMENTVIEWER (upper-left), and LAYERMANAGER (lower-right). A user of ART can edit a "chunk" of text using ELEMENTEDITOR, and place the chunk in the ELEMENTSMAP as an element. The size, color, location of the element can be changed with the direct manipulation style in the ELEMENTSMAP. DOCUMENTVIEWER shows the entire document, which consists of the contents of each element in the ELEMENTSMAP, appended in the order from top to bottom. Thus, when a user changes the location of an element in the ELEMENTSMAP in terms of vertical locations of other elements, the position of its corresponding text in the whole text presented in DOCUMENTVIEWER also changes. LAYERMANAGER allows a user to create and manipulate multiple translucent layers in ELEMENTSMAP. Detailed descriptions of the system can be found in [Yamamoto et al. 2000a].

The essential part of the system is the use of the ELEMENTSMAP (the top-right window in Figure 1). Our previous case studies of ART [Yamamoto et al. 1998, Nakakoji et al. 2000] illustrate how two-dimensional positioning as an action helps designers be engaged in reflection-in-action, and how the resulting two-dimensional positioning of objects allows designers to perform reflection-on-action. We found that subjects used a variety of visual properties of two-dimensional positioning as a representation (Figure 2). Some put elements that need further attention in the bottom right corner of the ELEMENTSMAP. Some subjects made a set of completed elements be the same size and carefully aligned them. One user had two elements overlapping each other with a verbal protocol saying that she felt that they should be related to each other but could not describe how they are related (therefore they were overlapped and not aligned). Another user made some elements much larger than others so that it would "call for attention" later in the task. Subjects used different distances between two vertically positioned elements to represent different types of relations of the two elements. Some subjects placed two elements that were almost completely horizontally aligned but with a slight height difference so that they "looked" horizontally aligned but are not from the system's point of view.

Positioning objects in a two-dimensional space allows designers to be engaged in reflection in and on action. During the process of positioning, continuously changing and emerging representations "talk back" to designers allowing them to participate in reflection-in-action. Once objects are positioned, then designers can read the two-dimensional spatial representation for understanding the current state and design rationale behind the design allowing them to perform the more detached reflection-on-action.

We have applied the same interaction style for other domains. Figure 3 shows a screen image of Time-ART, which supports empirical video analysis tasks using two-dimensional spatial positioning [Yamamoto et al. 2000b]. Applications of the approach to other domains demonstrate that the interaction style of the ART system can be a rather generic framework for supporting a wide range of design tasks.

3 INTERPRETING THE ART SYSTEM FROM THE SEMIOTIC VIEWS

We view a two-dimensional spatial positioning interface as a simple and yet powerful representational means for designers. The critical aspect of a two-dimensional spatial positioning interface, such as one provided by the ART system, is best understood by making an analogy with a sketching interface for architectural designers [Do, Gross 1997].

Like sketching, the ART system allows a writer to represent various types of intermediate situations without requiring too much preciseness nor commitment. The ART system allows a designer to communicate with him/herself through interactions with a representation that he/she creates. Particularly in early phases of a design task, designers make sketches, position objects, and externalize rough ideas without having explicit goals or mental models for the task. The designers themselves interpret what has been represented (e.g., sketches or positioning) and discover or become aware of emerging meanings out of the representations.

We have a number of users who have downloaded the system from our Web site and regularly use the system. *What makes the ART system unique and appealing comparing to other text editors, word processors, and outline processing tools?*

While designing interactive systems using two-dimensional positioning for early stages of design tasks in various domains, we identify critical aspects of the system from four points:

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

(1) interactions with representations "I" produced;

(2) representations as indices for thoughts;

(3) hands-on representations for a user as a compulsive representer; and

(4) limiting the automation – the role division between humans and computers.

In this section, we discuss each of the four points by reinterpret them in the context of Semiotics applied to HCI and user interface design.

3.1. Interaction with Representations "I" Produced

Many researchers and practitioners being engaged in HCI and user interface design view computer systems as communication media. Most of communications they focus, however, is communication either between a designer and a user, or between a user and a system. While our approach has also been to view interactive systems as communication media, the ART system focuses on communication between a user and the representation produced by the user him/herself.

There are many situations when we represent something without really knowing what we mean. Early stages of a design task characterized with the action-reflection cycle are a series of this type of processes. To support this type of process, interactions need to be carefully designed so that it does not disturb a designer's cognitive processes. What is important is to give designers representational media that allow them to externalize what they want to express in ways they like – to *amplify representational talkback*. While doing so, the computational media need to stay as invisible as possible to designers requiring minimum commitment.

Interacting with representations "I" produced can be rephrased as communicating with myself. Semiotic views help us clarify what critical issues and challenges exist in designing computer systems as communication media. Benyon [in WS2000] claims that *information artifacts are not determined by the designer but they are produced by the users*. De Souza et al. [in WS2000] claim in the framework of Semiotic Engineering, that challenges in HCI is how designers can make communicative choices as a good interaction scheme and how they can bring the choice to users so that users would not be disturbed by them.

Our approach is a step forward to let designers deal with tacit knowledge on a computer system. Meanings can be extracted from a representation only by the user; the system remains as a medium – but a useful one.

3.2. Representations as Indices for Thoughts

Two-dimensional spatial positioning of the ART system does not have any specific meaning, except that top-bottom ordering matters in appending each element to produce the whole document. Through our user observations [Yamamoto et al. 1998, Nakakoji et al. 2000], we have found not only that users assign variety of meanings to two-dimensional positioning of elements but also that they use two-dimensional positioning as *reminders*. In the latter case, it is not that a certain representation (i.e., positioning) has a specific meaning; rather, the representation reminds the user of a particular situation and thought processes that the user was engaged in when created the representation. Two-dimensional positioning served as indices for thoughts.

This aspect has not been well supported by existing outline processing tools. One frequent critique on the ART system is that the system's functionality seems to have already been provided in the outline mode of popular word processing software, such as Microsoft Word. We argue that those outlines represented with numbers, such as level-1, level-2, and level-3, impose users to inappropriately make explicit commitment on deciding how to structure portions of text by textual representations. With some interfaces, a user can shift a portion of text to left or right by a grid-based visual representations to represent structural outlines instead of specifying the level numbers. Even with such interfaces, however, representations are too "rigid" in a sense that they have more or less pre-assigned meanings, and therefore, it is difficult for users to use such representations as indices for thoughts.

The classification of signs that Peirce provides, Symbolic, Iconic, and Indexical, is useful for us to argue for the aspect of two-dimensional positioning serving as indices for thoughts. We view two-dimensional spatial positioning the ART provides is a type of Indexical interface. While describing current user interface approaches using the Peirce classification of symbols, Brown [in WS2000] claims that keyboard and command languages were concerned with symbolic communications and WIMPs with Iconic ones, and that Indexical interface needs to be explored in the coming age of HCI. We argue that two-dimensional positioning of ART is one type of such Indexical interfaces.

In writing, we sometimes do not know whether this particular text chunk is level-2 or level-3 but definitely not levevl-1. We need to represent that the chunk is not at level-1, without explicitly specifying other level numbers or counting how many grids to shift it to the right. Two-dimensional positioning as a representation allows this type of externalization. A user can position an element

slightly to the right, whether it is 7mm or 29mm away from the left edge, to represent that the chunk of text is not the level-1. This representation helps the writer to remind him/her that the chunk is not at the level-1, serving as an Indexical representation.

3.3. Hands on Representations for A User as a Compulsive Representer

Designers are good at producing representations. They cannot think clearly without representations. In observing architectural designers, Lawson [1994] identified that sketching is a ubiquitous activity among designers, and that designers continually create representations throughout the design process to test their ideas, to remember what came to their minds, or to simply draw to see what is going to happen. Using paper and pencil, one can sketch at infinite levels of abstraction or specificity and in a matter of mere seconds draw doodles without being forced to make explicit what exactly they represent. *Directness* is a key for successful representational media that serves for this purpose.

We argue that positioning of objects in a two-dimensional space serves as a hands-on representation for a designer that allows them to represent in order to think. It also allows them to test their ideas and to remember what came to their minds. In our user studies of ART, we have observed that subjects positioned objects in a very natural manner without being told to position them. People need to represent in order to think in nebulous states of mind – we are *compulsive representers*.

Existing design support tools do not adequately support the aspect of designers as compulsive representers. Working with an existing computer-based tool is analogous to using a translator to communicate. One must go through the tedious steps of choosing brush stroke, color, width, and so on all before being allowed to interact with the sketching surface, which itself is an arbitrarily small size on a screen. One cannot simply act directly requiring an effort to represent something – it is always indirectly through palettes or menus imposing cognitive overloads.

The aspect of humans as compulsive representers have been underemphasized in user interface design. In the context of semiotics, Andersen [in WS2000] argues that two human characteristics, (1) humans are compulsive interpreters, and (2) humans are compulsive talkers, can be used as informative guidance for HCI designers. Humans would try to interpret whatever representations presented in front of them, and they would try to verbally explain how they have interpreted them. These characteristics are critical especially when systems have something to communicate with users. On the other hand, in early phases of a design task when humans do not know what to do and communicating with self is critical, they first need to externalize representations to listen to *backtalk of the situation* [Schoen 1983]. Once they represent something, then humans would interpret them and talk about them.

Thus, three characteristics of humans, that they are compulsive interpreters, talkers, and representers, need to be the center of the focus in designing human-computer interaction.

3.4. Limiting the Automation – The Role Division between Humans and Computers

Various studies on using spaces for representation have been done. The role of computers in many of those systems is either to automatically position objects [Sugimoto et al. 1998], to automatically infer or compute the meanings of positioning produced by a user [Shipman et al. 1995], or to pre-determine the meaning of positioning [Tsutsumi, Shinohara 1998].

The ART system takes none of these approaches. Our approach focuses on the use of a representation produced by a user using space. The representation is simply considered as an intermediate status of some task, which helps the user in their task, and is not interpreted by the system except that the system appends the contents of each element in the space in the order from top to bottom.

The ART system has occasionally been criticized of its lack of automation. The system is too simple and some users want to have functions such as automatic rephrasing of text according to the position of the element. Our position is that unless we see "*fixed determination*" in interpreting representations, we would not automate the process. Appending text in the order from top to bottom for us is a fixed determination because reading documents from top-to-bottom is a very natural activity for humans. We interpret most of things flowing from top to bottom, left to right (at least in most of Western countries and in Japan). These natural mapping is almost inherent in the human body and mind as a metaphor [Johnson 1987]. In contrast, other representational properties, such as automatic arrangements, rephrasing, positioning, or sizing, have not been reached to the point of fixed interpretation, thereby we provide no automation for dealing with those properties.

We argue that the criticality of the role division between humans and computers has been underestimated. There are many systems that automate some aspects of a task only because they can automate. This point is clearly articulated by Nake [in WS2000]. He states that HCI is related to two independent, yet related, processes, *a full-fledged sign process in the human*, and *a restricted signal process in the computer*. He continues that "*Cultural and*

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

interpersonal aspects influence the sign process which is a process of open interpretation. Technical and algorithmic aspects influence the signal process which is a process of fixed determination."

Historically, software systems have evolved by adding more and more functionality. We have reached to the point where it is not "the more, the better" anymore. We need to think how to take out irrelevant funcionality while leaving the essential functionality in the "right" representation to make the system truly useful and usable. Not human-computer interaction, but human-representation interaction, is critical. Semiotic frameworks are useful to address those issues.

4 CONCLUSION

By having the ART system as an object-to-think-with, we argue that communication with interactive computational tools had better been regarded as interaction with representations. HCI design has focused on identifying what functions are necessary for an interactive system and how to communicate them through an interface. As de Souza et al. states [in WS2000], the human-centered view that guided this approach has blurred the critical aspect of communication; how individual users interpret and use representations shown on a computer display is not fixed. We claim that HCI design needs to start with thinking about what representations are necessary for what purposes in what tasks – what we call the representation-centered design approach. Semiotics plays an important role in framing the human-representation interaction approach.

ACKNOWLEDGMENTS

We would like to thank Shingo Takada, Mark D. Gross, and Brent N. Reeves for valuable discussions, and Clarisse S. de Souza for constructive comments on earlier versions of this paper. We appreciate the organizers of the CHI 2000 workshop and the Editor of this Special issue for giving us the opportunity to rethink our work in the context of Semiotics and HCI.

REFERENCES

Do, E. Y.-L. & Gross, M. D. (1997) "Inferring Design Intentions from Sketches: An Investigation of Freehand Drawing Conventions in Design." Proc. of the 2nd Conf. on Computer Aided Architectural Design Research in Asia (CAADRIA '97), Taipei, Taiwan.

Lawson, B. (1994) Design in Mind, Reed Educational and Professional Publishing Ltd.

Johnson, M. (1987) The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason, University of Chicago Press.

Nakakoji, K., Yamamoto, Y., Suzuki, T., Takada, S., & Gross, M. (1998) "Beyond Critiquing: Using Representational Talkback to Elicit Design Intention." Knowledge-Based Systems Journal, 11(7-8), 457-468.

Nakakoji, K., Yamamoto, Y., Takada, S., & Reeves, B.N. (2000) Two-Dimensional Positioning as a Means for Reflection in Design, Proc. of Design of Interactive Systems (DIS2000), ACM Press, August, 145-154.

Schoen, D. A. (1983) The Reflective Practitioner: How Professionals Think in Action. Basic Books, NY.

Shipman, F. M., Marshall, C. C., & Moran, T. P. (1995) "Finding and Using Implicit Structure in Human-Organized Spatial Layouts of Information. Proc. of Conf. on Human Factors in Computing Systems (CHI '95) Denver, CO. 346-353.

Sugimoto, M., Hori, K., & Ohsuga, S. (1998) "A System for Visualizing Viewpoints and its Application to Intelligent Activity Support." IEEE Trans. on Systems, Man, and Cybernetics, 28C(1), 124-136.

Tsutsumi, F. & Shinohara, Y. (1998) "Search Space: Document Retrieval by 2-D Positioning Keyword Query." Computer Software, 15(4), 2-15 (in Japanese).

Winograd, T. & F. Flores (1986). Understanding Computers and Cognition: A New Foundation for Design. Norwood, NJ, Ablex Publishing Corporation.

WS2000 (2000) CHI 2000 Workshop on Semiotic Approaches to User Interface Design, http://peirce.inf.puc-rio.br/chi2000ws6/.

Yamamoto, Y., Takada, S., & Nakakoji, K. (1998) "Representational Talkback: An Approach to Support Writing as Design." Proc. of 3rd Asia Pacific Computer Human Interaction Conf., 125-131, Kanagawa, Japan. IEEE Computer Society.

Yamamoto, Y., Nakakoji, K., & Takada, S. (2000a) Hands-on Representations in a Two-Dimensional Space for Early Stages of Design, Knowledge-Based Systems Journal, Elsevier Science, 2000 (to appear).

Yamamoto, Y., Nakakoji, K., & Aoki, A. (2000b) An Interaction Model for Experimental Data Analysis Using Spatial Positioning, Proc. of the International Symposium on Future Software Technology (ISFST-00), Guiyang, China, Software Engineers Associates, August, 111-116.

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

Figure Captions

Figure 1: The ART System

Figure 2: A Variety of Two-dimensional Positioning of Objects Emerged During a Writing Task

Figure 3: The Time-ART System

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

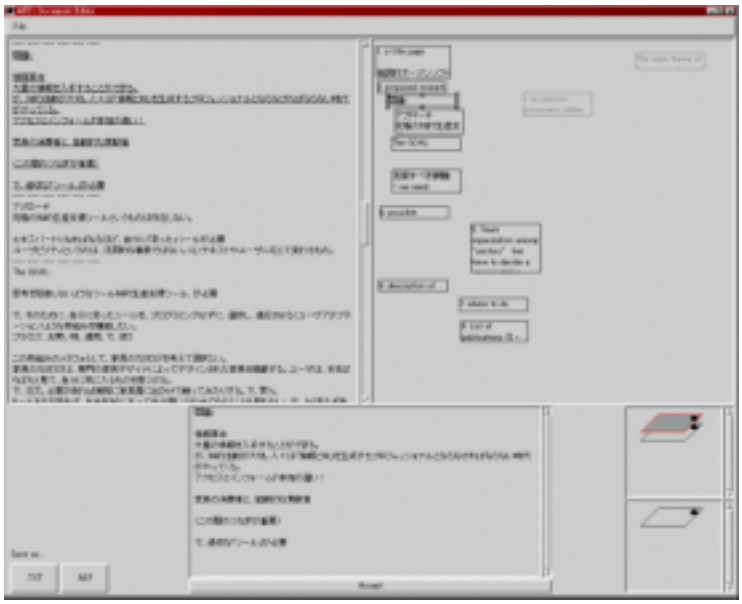

Figure 1, The ART System

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

Figure 2, A Variety of Two-dimensional Positioning of Objects Emerged During a Writing Task

Appeared in Knowledge-Based Systems Journal, Special Issue on Semiotic Approaches to Human-Computer Interaction, Elsevior Science, Vol.14., No.8, pp.449-453, 2001.

Figure 3: The Time-ART System