

Personal Context-aware Guidance System for Exhibition Tours

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Abstract

This paper presents our Context-aware Mobile Assistant Project (C-MAP). C-MAP is an attempt to build a personal mobile assistant that provides visitors touring exhibitions with information based on their locations and individual interests. We have prototyped the first version of the mobile assistant and used an open house exhibition held by our research laboratory as a testbed. The mobile assistant directs users with exhibition maps that are personalized based on the physical and mental contexts of the users. This paper also describes offsite services for overcoming temporal/spatial restrictions to facilitate communications and information sharing between exhibitors and visitors.

Introduction

Our long-term goal is to develop computer-augmented environments that enhance communications and information sharing between people and knowledgeable machines. Stefik (Stefik 1986) has proposed a notion of a new knowledge medium, which is a kind of information network with semiautomatic services for the generation, distribution, and consumption of knowledge in society. Such knowledge media include environments for the collaboration of humans and machines, where software acts not as a passive tool but as an autonomous and active machine agent.

In investigating how to create such a knowledge medium, we have chosen museums and open house exhibitions for research laboratories. These are places where knowledge is accumulated and/or conveyed, and where exhibitors as specialists provide knowledge to visitors with diverse interests and viewpoints. Actual exhibitions, however, have many restrictions. For example, exhibitors are unable to display all of their collected material due to temporal and spatial restrictions; not all visitors can receive individual explanations from exhibitors; all visitors are provided with the same information prepared beforehand; the one-way communication flow from the exhibitors to the visitor is often limiting. As a solution, recent computing technologies, such

as mobile computing, are expected to remove many of the restrictions that prevent natural two-way communications between exhibitors and visitors. At this time, we believe that the mediation of real objects in actual exhibitions is unavoidable for knowledge sharing, even in the coming digitized society.

This paper presents our Context-aware Mobile Assistant Project (C-MAP) (Fels *et al.* 1998; Sumi *et al.* 1998). The C-MAP is an attempt to build a tour guidance system that provides information to visitors at exhibitions based on their locations and individual interests.

This paper overviews the C-MAP system by the following classification of its services:

Onsite services¹ to provide visitors touring exhibitions with information based on the temporal and spatial conditions as well as individual interests; and

Offsite services to provide users with related information through the Internet, i.e., online viewing of exhibits and communications support between exhibitors and visitors before/after actual exhibition tours.

Successful development of the onsite services will involve a technique to facilitate communications mediated by real objects by augmenting real environments with computing technologies (Weiser 1993). The offsite services will aim to facilitate ongoing communications between exhibitors and visitors.

Both services are intended to enhance human communications distributed temporally and/or spatially. One characteristic of our approach is the mutual augmentation between two spaces, i.e., the information space and the real space. That is, the information space with guide services will reinforce tours in the exhibition (real space), and conversely, tours in the exhibition will provide users with motivation and focal points for communications with people who share interests in the exhibits.

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¹In this paper, we call services provided at exhibitions "onsite services", and services provided through a network before and/or after exhibition visits "offsite services."

Related Work

Recently, there has been much work on systems for supporting communications and information sharing in the real world, rather than in the virtual world created in the computers, by using mobile computing technologies. The following projects have great relevance to C-MAP: the Cyberguide (Abowd *et al.* 1997), which is another attempt to build a system providing information based on users' contexts such as their temporal/spatial situations; the Ubiquitous Talker (Nagao & Rekimoto 1995), which aims to demonstrate the augmentation of real space with information space by interactions with real objects; and the ICMAS'96 Mobile Assistant Project (Nishibe *et al.* 1997; Maeda *et al.* 1997; Nishimura *et al.* 1997), which was an attempt to support information sharing and meetings among conference attendees.

In contrast to the above efforts, we focus on the following issues:

- To provide exhibit-related information based on not only the user's physical (temporal and spatial) contexts but also his/her mental contexts, i.e., individual interests and knowledge;
- To facilitate person-to-person interaction as well as person-to-exhibit interaction; and
- To encourage communications between exhibitors and visitors beyond the temporal/spatial restrictions by providing offsite services.

Overview of the C-MAP system

We prototyped a mobile assistant for a public experiment at an annual two-day open house exhibition held at our research laboratory in November, 1997. The exhibition area for the experiment was on one floor and had 19 sites, including about 70 posters corresponding to research projects. We had about 170 visitors registered to use our mobile assistant during about 10 service hours over the two days.

Figure 1 illustrates the hardware architecture of the system. The system principally consists of servers providing exhibit-related information and guide information, and portable PCs² connected to the servers by a wireless LAN.

For detecting users' locations, we used Olivetti's Active Badge Systems (ABS) (Want *et al.* 1992). ABS infrared sensors mounted on the wall of each exhibit site detect badges worn by users. The ABS server gathers the latest sensor data and updates the location data of all badges, i.e., users.

The agent server provides personalized guidance during the tours such as route planning and exhibit recommendations by monitoring the ABS information and each user's interaction with the system via the portable PC.

²We prepared portable Windows95 PCs, i.e., fifteen Mitsubishi AMiTYs with a pen-based interface and fifteen Toshiba Librettos.

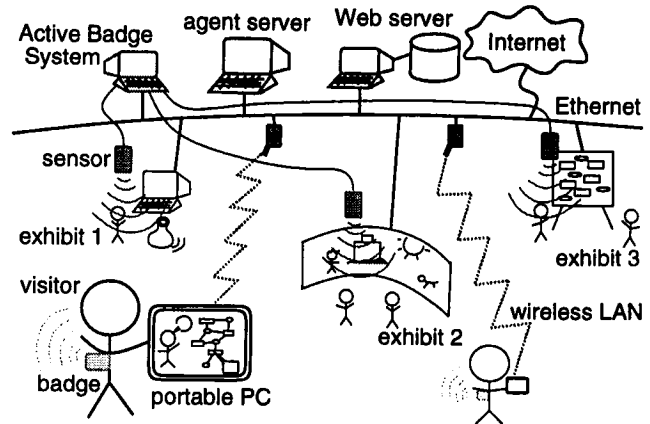


Figure 1: Schematic diagram of C-MAP system

The Web server is used as a server of Java applets for the mobile assistant, and as a server of exhibit-related information. This server is connected to the Internet, and is therefore open to users outside of the exhibition site. This facilitates the seamless provision of offsite services.

Figure 2 shows snapshots of the public experiment at our open house.

Onsite Services by the Mobile Assistant

Each portable PC runs the HotJava browser for the mobile assistant's Java applets to guide the tour, show exhibit-related information, interact with the user, and display animated characters of the guide agents.

Examples of a mobile assistant's display are shown in Figures 3 and 4. Both displays have a main window on the right and a frame on the left. The user obtains visual guidance of the exhibition space in the main window by alternatively viewing a physical map applet (Figure 3), which displays the geographical layout of the sites, and a semantic map applet (Figure 4), which visualizes the semantic relationships between the exhibits. The controlling frame displays links for viewing the two applets and the animated character and message box of the personal guide agent.

Visual Guidance of Exhibition Space

The principal function of the mobile assistant is guidance based on the visualized exhibition space. This provides the user with a comprehensive view of the exhibition space from two aspects, i.e., a geographical map of the exhibition sites and visualization of the semantic relationships between the exhibits.

The physical map shown in Figure 3 displays a two-dimensional view of an exhibition floor. This map provides the locations of exhibit sites (19 in our open house) and posters (about 70) at the sites. A user can view short explanations by moving the mouse pointer to site/poster marks on the map. The map also shows the



Figure 2: Snapshots of public experiment

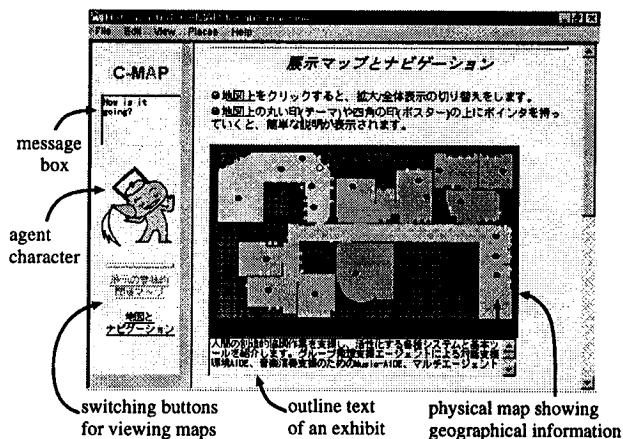


Figure 3: Screenshot of the mobile assistant's display showing a physical map

user his/her current location as another colored mark by using the ABS data.

The semantic map shown in Figure 4 displays the graphical relationships between exhibits. The rectangular icons in the graph signify exhibits and the oval icons signify keywords or researchers (exhibitors). The keywords are technical terms characterizing the contents of the exhibits and had been previously extracted from outline texts prepared by the researchers. The semantic map provides the user with graphs having links between exhibit icons and keyword/researcher icons. The user can select keyword/researcher icons according to his/her interests, causing the semantic map to display only the selected icons with exhibit icons. As a result, the graph of the semantic map can be structured based on the individual user's interests.

User selection of keywords affects the restructuring

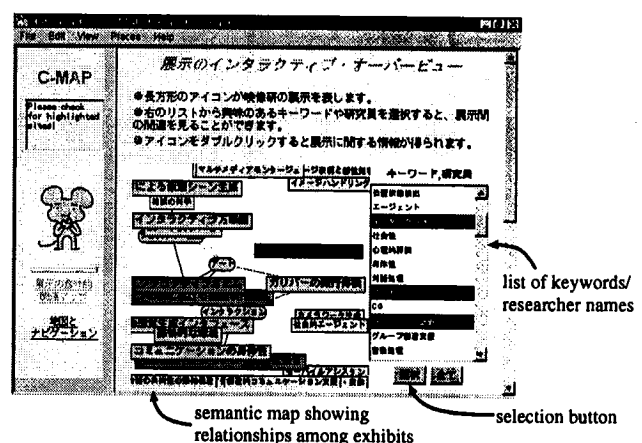


Figure 4: Screenshot showing a semantic map

of the semantic map and the guide agent's recommendations of exhibits as well. Whenever the user pushes the keyword selection button, an interest vector³ that quantifies the user's interests is sent to the agent server, and the personal guide agent calculates a new recommendation with the current interest vector of the user. In addition, this interest vector can be used to support meetings between visitors and exhibitors based on their current and previous interests.

According to the users' evaluations after using our mobile assistant at our open house, the visual guidance for the exhibition space with the semantic and physical maps was appreciated. The frequency of keyword selection on the semantic map, which can be regarded as an indication of user activity in our system, reached 3.7 times during the tour for an average of 84 users.

³ An interest vector is a multi-dimensional keyword vector, which is a sequence of 0 and 1.

More than 10% of the active users performed the keyword selection approximately ten times. Considering the inconvenience of the portable PC and the scale of the exhibition, this result seems to indicate user acceptance of the semantic map. We believe the semantic map is a simple and easy tool for all users, and visitors, in fact, are generally eager to receive background information about the exhibits they attend.

Recommending Exhibits

We have designed a personal guide agent that provides its user with personalized guidance in an exhibition. The guide agent calculates the user's mental context, processes the tour guidance by capturing his/her temporal and spatial context with the ABS information, and monitors the interaction between the user and the mobile assistant.

We prototyped a task of recommending exhibit based on various user contexts for spontaneous guidance by an agent. Several criteria were used for the recommendations, e.g., the similarity between the interest vector described in the previous section and each exhibit's keyword vector, the touring histories of users, the geographical distances between exhibit sites and user locations, the exhibit site attendance, and the exhibition's demonstration schedule. The calculation of a recommendation responds to changes in the contexts, e.g., a user's selection of keywords on the semantic map and the user's movement to different exhibit sites. Recommended exhibits are indicated to the user by highlighting three icons (with higher scores) on both the physical and semantic maps.

Most of the previous recommender systems provided users with little information on the relationships between recommended results and background knowledge since they only display a list of the results with a score order. In contrast, our guide agent's recommendations are provided with contexts embedded in the semantic/physical maps of the real exhibition space, and thus the user can exploit the recommended results in the real environment, i.e., visit the recommended exhibits, see demos, and speak with exhibitors.

Offsite Services via the Internet

Online Viewing of Exhibit information

Although we had prepared links to Web homepages related to the exhibits on the semantic and physical maps, Web-surfing by users was rarely observed during the open house exhibition. This is understandable because, in general, users are not expected to search the Internet with such inconvenient PCs when the actual exhibits are in front of them. However, when we consider the provision of these applets as an offsite service, the semantic map is useful for providing homepages of projects in our research laboratory according to the individual interests of users. Evaluating such an application by publicly providing offsite services is our present focus.

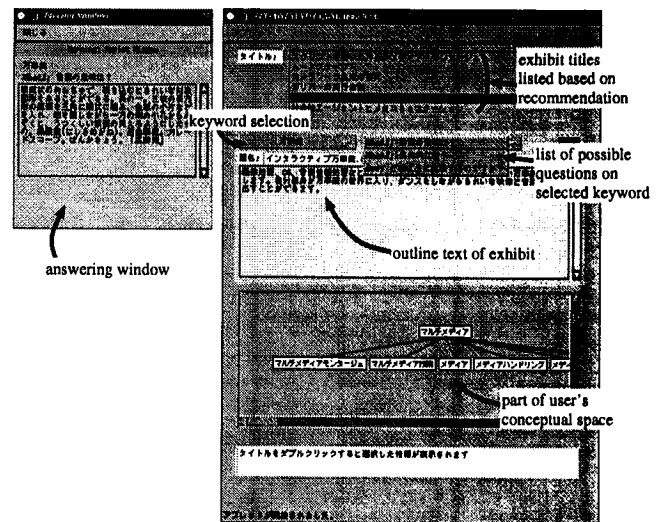


Figure 5: User interface of online viewing system based on question-and-answer interaction

Our mobile assistant can be used on Web browsers in remote sites because its user interface is built with Java applets. For example, although its development was not completed in time for the experiment, if we had released the semantic map before the open house it could have allowed potential visitors a preview of our research exhibition. This would have helped in the advance preparation of the personalized guide agents and in improving the exhibit.

Since the user data that can be obtained by the mobile assistant during a tour is limited, obtaining detailed user data such as user interests and areas of expertise by online services would be very beneficial. Currently, we have started the development of such an offsite service, i.e., an online viewing system based on question-and-answer interaction, which personally directs a user in exploring the information space of exhibitions (Kobayashi, Sumi, & Mase 1998). The user can select some interesting keywords from an outline text of an exhibit and ask questions about the keywords for getting detailed information from the system⁴. This helps the user to access deeper knowledge based on his/her interests (Figure 5). According to the user's interests and knowledge, the system recommends other exhibit information and predictively presents the answering windows of potentially attracting keywords when the user encounters related exhibit information. To do this, the system gradually improves the user's interest model (called "personal conceptual space" in this paper) by monitoring the user's selection of keywords and their related questions and his/her evaluation to given answers ("interesting" or "uninteresting");

⁴The outline text, keywords, and their possible questions and answers for every exhibit are prepared by exhibitors beforehand.

the system then uses that information for the recommendation and the predictive presentation of answering windows. The user's conceptual space, a by-product of system usage, can be exploited to prepare his/her guide agent and to model the user for the community-supporting systems described in the next sub-section.

Community Support

We are also planning to structure records of users of our mobile assistant to provide users with social networks (Kautz, Selman, & Shah 1997) that can be accessed by the Web. The social network's structure will be a graph whose nodes represent visitors, exhibitors, and exhibits and have connections between people having shared interests in the exhibition. It is hoped that these social networks can be used to encourage further communications between people by providing services such as proposing possible new communities and offering a virtual space for information exchange between individual exhibitors and visitors (Sumi, Nishimoto, & Mase 1996).

Concluding Remarks

We have prototyped a mobile assistant that can personally guide visitors touring exhibitions based on their locations and individual interests. This mobile assistant was used as a test at our two-day open house. The usability of visual guidance and exhibit recommendation in an exhibition space that is geographically/semantically visualized was experimentally demonstrated. In addition, we proposed offsite services, e.g., an online viewing system and community support systems.

Considering our C-MAP system as a recommender system, an interesting point is that actual exhibits in real space can provide users with motivation to explore information space and can provide focal points for people having shared interests and for their guide agents as well. Moreover, offsite services facilitate ongoing communications between exhibitors and visitors, thus extending the possibilities of existing museums and exhibitions.

Our system consists of many distributed sub-systems and users who work together cooperatively. In this system, communications and information sharing between people and knowledge-bases are mediated by machine agents that facilitate knowledge conveyance and future association. This approach shows one possible direction for future HCI. Although the current version of the C-MAP system uses only a guide agent as a machine agent, we plan to design an agent that acts as an exhibitor, one that acts as an interface secretary for visitors, and one that acts as a mediating agent for all participants including these machine agents.

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