3-2 Digital Content Embedded in Real World Environment and It's Utilization Technologies

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The Interactive Media and Contents Group focused on exploring fundamental technologies for fusion of contents in the WWW, broadcasting, and real world environment over the past five-years of this NICT project. Especially, in this research, the authors focused on the transition of the network environment from broadband to ubiquitous, and explored many related technologies. The research group mainly concentrated on the research of fundamental technologies, publishing of research papers, and any significant technical and sociological impacts worldwide. We have published 246 journals and refereed papers. Some of our papers were accepted, and appeared at key conferences such as the WWW Conference and ACM Multimedia.

Additionally, the outcomes were not only academic, but also practical, such as 51 patents and 2 technical transfers to private companies, which demonstrates that we have made an impact on the industry.

In this paper, we describe our research results on digital content merged into the real-world and its utilization technology, which are selected from research activities in the Interactive Media and Contents group.

Keywords
Web, Virtual 3D, Ubiquitous Computing, Ambient Knowledge, Peer-to-Peer communications, Information retrieval, User Interface, Interaction Media, Multimedia.

1 Introduction

During the five years from fiscal 2001 to fiscal 2005, the Interactive Communication Media and Contents Group of the Keihanna Human Info-Communication Research Center conducted a “content fusion” project. When the project began, broadband Internet was starting to extend into homes and the fusion of the communication and broadcasting infrastructures was beginning to attract attention. However, many of the technologies discussed at the time aimed at fusing content delivery methods based on infrastructural technologies, while methods of fusing communication and broadcasting content gained little attention. Although the current project began in fiscal 2001, in fiscal 2003 we took particular note of the importance of technologies for fusing communication content and broadcasting content, and it was at this point that we began to focus on research and development of content-related fusion technologies. In the succeeding years, the aims of network-related research overall began to move from implementing broadband networks to implementing the so-called “ubiquitous network”, which provides the basis for what have come to be known as ubiquitous computing technologies. At this point people began to see the advent of an era in which digital content would be embedded in the real world through devices placed ubiquitously throughout. At the same time, the public began to demand research and development of fusion technologies that would seamlessly connect the real-world environment and the digital information environment. In this project we noted the importance of these demands at the early stages, launching new research and development in fiscal 2004 aiming at fusing digital content and the real-world environment.

This paper describes the results of research concerning technologies aimed at making use of new digital content that fuses the information environment with the real world. Section **2** describes technologies for fusing real- and virtual-world spatial information using virtual 3D content. Section **3** describes technologies designed to make use of such information in the real world. Section **4** describes the relevant research, and Section **5** describes future research goals. Section **6** provides a summary of the paper.

2 Using virtual 3D space

Virtual 3D content is beginning to find practical use, particularly with the recent evolution of graphics processing units, or GPUs. Specifically, such content has found wide use in the world of computer games, leading to the establishment in computers of environments impossible to implement in the real world. Recently, a new communication environment referred to as “Second Life”[11] has emerged, where the user not only walks through a virtual 3D space but can also construct a building or make and sell accessories as virtual 3D objects. The technologies for constructing a virtual 3D world enable communication between people in an information space that models objects and spaces existing in the real world. For example, it has become possible to superimpose human knowledge on the virtual 3D world, knowledge that can be transferred from one user to another through virtual objects in the virtual space or through the virtual space itself. This section describes the technologies developed to facilitate the use of such virtual 3D content.

2.1 Comparative viewing of virtual 3D content and the real-world environment

Objects that have been lost and that are no longer observable in the real world can be modeled as virtual 3D objects and viewed from any desired angle. For example, many archeological sites are ruins consisting of only foundations or partial wall structures. However, experts can construct images based on their knowledge of the field. Through this knowledge, these lost images can be recreated as virtual 3D objects. If we can link virtual 3D objects with video content — scanning data relating to the ruins in the real world for comparative examination, for example — we can present information lost or otherwise hidden in the real world. To these ends, we have developed a browser that enables comparative examination of virtual 3D objects and real-world information. Figure 1 shows an example screen shot of the comparative browser. This system allows the user to browse past and present images in a superposed manner. This method has attracted significant attention as a new method of presentation for digital library content[1].

2.2 Browsing of virtual 3D environment in the real word

Although many virtual 3D world navigation systems model the real world, most of

Fig. 1 Example screenshot of comparative browser

them require the user to sit in front of a computer and the user is able only to enter the world virtually. However, in car navigation systems, the user's position in the real world and his or her position in the virtual 3D world are matched, and information in the real world is represented in the virtual 3D environment. The presentation of real-world information by matching positional data from the real and virtual worlds offers the potential to form new means of information presentation in the near future, when presentation systems such as ambient displays begin to find applications in the real world. In the virtual 3D world, it is also possible to create digital content to be presented by virtual 3D characters. The user can browse the information from any desired angle, in the same manner as watching stereoscopic video content.

It is easy to install and connect displays in the real world to share a virtual 3D environment using ubiquitous network technology. If we can create content in which a virtual 3D character moves from one display to another in such an environment, this new means of content use will be able to guide the user, presenting real-world information through interaction with content in the real world. We have in fact developed such a technology, in collaboration with a research group lead by Dr. Alan Kay (known as the father of the personal computer) and the NHK Science and Technical Research Laboratory. Specifically, we selected the virtual 3D desktop, Croquet, currently under development by Dr. Kay's group, as the platform for sharing a virtual space on two or more computers. We then embedded TVML, a script developed by NHK for controlling virtual 3D characters, in Croquet. As a result, we were able to implement a virtual 3D digital content browser that controls characters using a simple script language, allowing them to move across two or more PCs[3]. This platform makes it possible to construct a virtual space using a simple language similar to HTML and makes it easy to create content in which characters can move across two or more computers. We were thus able to implement a completely new environment for the use of digital content. Using this platform, we developed an event site navigation system intended for children and performed a demonstration experiment on the NICT Open Day on July 31, 2005. With this system, when the user selects a menu on the screen, a small robot moves across adjacent displays to guide the user within the area. The system is designed for the user to follow the character through a series of enjoyable on-screen interactions until he or she arrives at the desired destination. The experiment demonstrated that such a character can successfully guide a user to a given destination; not only children but adult visitors as well were greatly interested in the system. Figure 2 shows scenes from the experiment.

2.3 User interaction via virtual 3D content

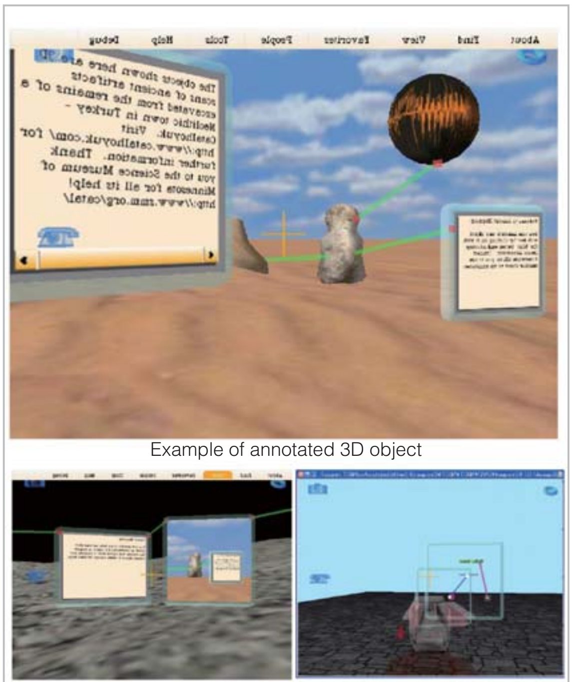
By sharing a virtual 3D world over a network, users visiting the virtual world can interact. In an ordinary network game, the users hold conversations through tools such as instant-message functions. Coordinated annotation of objects placed in the virtual 3D world

Fig.2 *Example of real-space navigation experiment, based on Croquet with embedded TVML*

makes it possible for all users to share knowledge — a virtual 3D object to be discussed is placed in the virtual 3D world and interactively annotated with diverse items of information. In this manner, users can easily share knowledge regardless of limitations of time and space. In addition, the knowledge provided by a user in annotation form can be converted into a blog or similar document, allowing for linkage to existing information-sharing structures. In collaboration with a University of Wisconsin group led by Dr. Alan Kay, this project developed an annotation system within a virtual 3D world, as well as a system for two-way conversion of input information into annotations or blog entries[2]. Figure 3 shows example screenshots of the developed system.

3 Content use in real-world environment

In the previous section we introduced real-world presentation and application technologies using virtual 3D methods. The development of ubiquitous computing technology is expected to establish an infrastructure that will enable anyone to obtain needed information anywhere and anytime, from any source or person. When such an environment is established, it will be as easy to acquire digital content from devices embedded in the real world as it is to take a picture. It will also be possible to use the acquired information as the basis of an inquiry and to retrieve related information from diverse databases, or to edit the acquired information and re-submit it as new information. These examples describe environments based on technologies that seamlessly connect the real and the virtual worlds. However, when implementing these technologies, the retrieval and presentation technologies must be tailored to a particular time and place in the real world, conveying to the user the impression that the digital content is customized to that moment, place, and user. This section describes research and development aimed at addressing these challenges.



Example of annotated 3D object

Example of transparent annotation-indicating anchor

Display of information relating to user's viewpoint

Fig.3 *Annotation system based on Croquet*

3.1 Context information management

To provide a large amount of information as needed to the user through access in the real world, the system requires information on the user's location in time and space and the history of the user's behavior. We have defined such information — concerning the user's interests and behavior and details on the time and space of his or her environment — as "context information". This context information is used as the basis of personalizing content to suit the user or to conform the content to suit a particular device used. In the past, this information was defined separately for each application. We have proposed a standard Context Markup Language to describe this context, in addition to the supporting Context Query Markup Language[4][5].

3.2 Presenting information in the real world

In a ubiquitous computing environment, diverse devices will be embedded in the real world. Numerous public information displays are already widely seen, and we can expect to see more of these devices in the future, incorporated with wireless network technology and linked with various other devices. In such an environment, each device will have the role of a content browser. In other words, we will browse for our information using diverse content browsers, both in and out of the home. Ideally these browsers will blend in the real world in a manner similar to existing posters, photos, and paintings, and information will be presented without discomforting users. In short, it is important to develop a technology that adjusts content before presentation to the user, based on user behavior and using a combination of user and real-world context information. If the above functions are to be realized, retrieval and presentation methods will be required that are based on environment context information provided by various sensors and personal context information provided by the user. More specifically, a technology is required that incorporates context information (on user behavior, for example, or on real-world brightness or temperature provided by sensors) to acquire information regarding the user's location and activity. In addition, methods of retrieving the desired content and rendering it according to the user's behavior will form the basic means of presenting such content in the real world. Accordingly, we have developed the Energy Browser[6], which progressively renders web content based on user behavior, and the Ambient Browser[7], which presents the web content according to the user's behavior in the real world. Energy Browser presents information easily and appropriately to the user in the real world by coordinating data on his or her behavior (acquired, for example, by a wearable acceleration sensor) with the rendering of web content. Ambient Browser presents information that the user is interested in by coordinating the presentation with the user's behavior such that the user automatically notices the information. Figure 4 shows scenes of Energy Browser experimentation and Figure 5 shows scenes of an Ambient Browser experiment.

3.3 Information presentation based on existing media metaphor

As ubiquitous computing technology brings a large number of digital devices into the real world, many such computing devices will no longer be found on a desk. We can expect that our use of digital content will therefore differ significantly from present practice. Digital content presented by ubiquitous devices will, ideally, be treated in a manner similar to that of existing media. Energy Browser and Ambient Browser, for example, are passive browsers that present content based on context information. However, browsers and content presentation technologies that the user can operate more actively will also play important roles.

Web content is replacing content provided through more conventional media such as books and newspapers. Nevertheless, the user will often print out web content that he or she has found as a final means of providing such information to another user. In other words, even information provided digitally is presented and distributed on paper. If the user wants to find related information, he or she will often identify keywords in the printed document and search for the keywords on the web. Although even now it is possible to exchange and distribute web content digitally via computers and

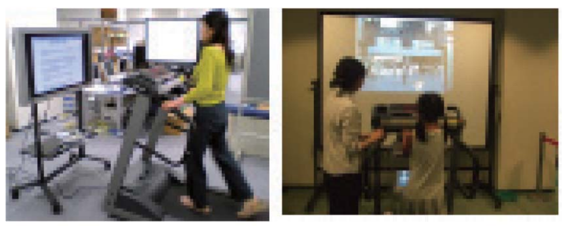


Fig.4 Experiment on web browsing with a walking user using Energy Browser

Fig.5 Example of Ambient Browser in the home

PDAs, this form of use is far from the mainstream form of media use, and it would be a stretch to say that the digital form of use has been fully adopted by users. If we can paste important web content directly — on a digital bulletin board, for example — and if we can also directly copy, hold, and present the content by pasting it on another bulletin board, we will in effect maintain the advantages of conventional distribution while preserving the beneficial features of digital content. In addition, if we can compare acquired items of web content by arranging these items on a computer desktop to enable operations on the content (for example, cutting and newly pasting excerpts on a bulletin board) we will be able to retrieve or edit information with all of the advantages of digital content. Further, if we can present information in a familiar layout — as with online newspapers and portal web sites — we will be able to present even large amounts of information in a manner that is understandable at a glance.

In the current project we developed the WebBoard system[8], which makes it possible to present, obtain, move, and edit information in the real world using existing media metaphors. We also developed the related MPV (My Portal Viewer)[9]. WebBoard enables new use of web content by allowing the user to present such content as if directly posting it on a bulletin board, to copy the selected web content together with related information to a PDA, to carry it to another location, and to post it on another WebBoard. MPV automatically retrieves the information that the user is interested in from the Internet and allows the user to browse for it through the design of a familiar portal site. Figure 6 shows an experimental example of use of the WebBoard as a bulletin board and an example MPV screenshot.

3.4 Utilization technology for content embedded in real world environment

Not only do we expect to see commonly discussed information presentation devices (such as displays) as ubiquitous devices, we also anticipate the widespread embedding of data storage devices that can hold, present, and manage information in the real world. Storage devices embedded in the real world will, of course, provide digital content in the real world. For example, the user will be able to acquire digital content by taking a picture with a camera mobile phone; he or she will then be able to retrieve or browse this content interactively from a variety of places. With WebBoard, we developed an environment in which the user can intuitively operate such digital web content. In addition, to handle content embedded in the real world environment, we developed the Portable Private Area Network Management Device, which controls the distribution of information among the devices around the user. This device enables the user to acquire content by constructing a dynamic network among devices providing content and devices acquiring content, based on content identifiers provided by RFID and QR codes. The device also dynamically combines functions provided by two or more devices, including retrieval functions, database operations, and application functions, enabling interactive operation of each. Through the foregoing process of development, we devised a system that first acquires content embedded in the real world and then uses two or more WebBoards to retrieve or browse for related information. In addition, we also developed a function for automatic generation of integrated content using the MPV function, after digital content has been retrieved based on user context infor-

Fig.6 Example of WebBoard experiment, posting web content as on a bulletin board (left) and example MPV experiment using CNN portal design (right)

mation[10]. Based on these elemental technologies, we developed a digital insect collection and survey application targeted at children and performed experiments on the Open Days in 2004 and 2005. These experiments verified the potential of content utilization technologies in the ubiquitous society. Figure 7 shows scenes from the experiment.

4 Developing technology for the use of ambient knowledge

The digital content integrated and embedded in the real world can provide knowledge to users in all situations in the real world: on business production sites, on the street, in shopping centers, and at theme parks. Computer networks feature hyperlinks that connect documents stored on different computers — the web, in essence. However, the benefits of these links are limited to sites at which computers and networks are found. Ubiquitous computing technology will soon lead to an overall environment that can provide information to the user (or anyone) at any time and in any place. In such an environment, information links will be formed through contact among people and contact between a person and his or her real-world environment. The key here will lie in the extraction and distribution of information once these links are formed.

Ubiquitous computing is generating a string of new technologies, including fast wireless networks and diverse devices from new information displays to information management devices. It is thus fair to say that the time is indeed ripe for the coming ubiquitous society. However, this nascent environment is still limited to conventional multimedia and web content; indeed one may regard the technology discussed herein simply as marginally advanced mobile computing. To make effective use of the new environment in the future, we will need content that is distinctively characteristic to the ubiquitous computing environment that the public is anxiously awaiting.

Browse and acquisition of embedded digital content in real-world

Information retrieval and editing using WebBoard

Fig.7 *Browsing and acquisition of content embedded in the real world; content use and editing using WebBoard*

In this project we conducted research and development of technologies for fusing content to the real world and corresponding methods of use, in order to provide information in the real world — a function that will only increase in importance in a future ubiquitous information society. The comparative browser provides content that presents information on unseen elements of the real world using a virtual space. Virtual 3D content in the real world and content used in current media metaphors will differ from conventional monitor-browsed content in that the newer types of content make effective use of devices embedded in the real world. In addition, our research and development to date have enabled means of browsing, presentation, and other operations involving these types of content. Nevertheless, an overall scheme to capitalize on user knowledge resources in the new environment remains insufficiently drawn. The knowledge present around the user in his or her environment is beginning to be referred to as "ambient knowledge"; that is, knowledge that is blended into the environment. Research and development of knowledge mining and processing technologies in the real world aimed at tapping into this "ambient knowledge" thus stands as a principle future challenge.

5 Conclusions

In this project we conducted research and development concerning two important themes: technologies for fusing broadcast content and communications content and technologies for seamlessly fusing the information environment and the real-world environment. This research and development have led to academically interesting outcomes as well as actual technologies that can lead to practical applications.

We conducted research and development of content processing technologies aimed at providing information in the real world, a function that will prove of increasing importance in the coming ubiquitous information society. Information presented in a virtual 3D space and current media metaphor content differ from conventional content browsed for in front of a computer monitor; nevertheless, these newer forms will come to comprise the major content provided to displays embedded in the real world. Moreover, the technologies aimed at using digital content embedded in the real world will find useful application in countless situations, from business production sites to the street, in shopping centers, and at theme parks.

Computer networks offer hyperlinks that connect documents; this is the basis of the web. However, the benefit of the web is limited to locations in which conventional computers and networks are found. Ubiquitous computing technology will soon provide an environment that can provide information to any user at any time and any place. In such an environment, a person's knowledge can be tapped into and conveyed to another, both directly by contact between individuals or through the interaction between the individuals and the real world. Our research and development to date have established techniques for browsing, presenting, and operating upon such information. However, research and development into knowledge mining technology and associated information processing technology in such a new environment remains insufficient. It is important that we develop technologies specifically targeting ambient knowledge — knowledge processing technologies applicable to the real-world environment. This research topic will undoubtedly form a significant future focus.

This paper introduces the development of technologies for fusing digital content with the real world and corresponding technologies of use. This topic grew as a sub-theme of a content fusion project conducted in the former Media Interaction Group. This paper also discusses a number of future challenges. The project progressed through collaboration among industry, academia, and government, through international research exchanges with established enterprises, universities, and research institutions. As a result, we obtained research results that were extremely unique, effective, and generally applicable, and evaluated extremely highly both within and outside of Japan. Not only did we generate interesting academic results, but we also established numerous technologies that can lead to practical applications. Due to limitations of space in this paper, we can only introduce outlines of each of these research results. Please refer to the references for more detailed information.

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