Harmonized Inter-Personal Display Project

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ABSTRACT

The project aims to pioneer a new field of information media technology for providing intuitive understanding and promoting face-to-face communication in everyday living environments and public spaces. Moreover, the project will explore some methodologies for producing emergent effects such as spurring intellectual curiosity and creative drive. Current information media technology is located in the confined situation in physical displays. As a result, our daily activities are divided into two categories: using digital equipment or not. It is time to explore a new technological field to pull down the barrier separating real and information worlds. For this purpose, the project develops methods that extend our real world by information technology. Especially, the project will focus on the nature of “spatial interaction,” “compatibility,” and “openness” in order to eliminate the physical constraints of display devices, enhance the compatibility between daily commodities and information devices, and activate the face-to-face communication by giving high priority concern to privacy issues.

Keywords: Information Media Technology, Real-world Oriented Interface, Augmented Reality, Face-to-Face Communication, CSCW, Interaction Design, User Study, Outreach Activity.

Index Terms: H5.1 [INFORMATION INTERFACES AND PRESENTATION]: Multimedia Information Systems — Artificial, augmented, and virtual realities.

1 INTRODUCTION

In accordance with the upgrading of network infrastructure, information reaches our everyday living environments. Current methods of accessing the information are, however, still limited to conventional display technology. Superimposing the information onto the real world is one of the ways to provide more intuitive understanding; this is called as Augmented Reality (AR). But, even the AR technology depends on the existing display hardware to show synthetic images. Thus, the display technology has been captured in the physical constraints that screen. Especially, in the case of multiplayer, people cut off face-to-face communication to look at each display. It is hard to say that the existing display technology is in harmony with multi user.

It is getting easier for people to receive information or obtain automatic services from the latest information technology. However, too much services might allow people to stop thinking, and take away the opportunity to demonstrate their abilities. The research field of Computer Supported Cooperative Work (CSCW) has been trying to take advantage of the power of people to support the cooperation among them. However, there still exists the barrier separating real and information worlds, because of the limitation of existing hardware.

Thus, the physical constraints of display devices separate the information world from the real world. The problems of compelling people to attach something special or incompatibilities between daily commodities and information devices have led to the same situation.

Our objective is not simply to make information environments more convenient, but also to spur intellectual curiosity, creative drive, and thereby contribute to spiritual richness and better quality of life. It will thus be apparent, that as information environments have become mature and sophisticated, more and more people are calling for new more people-oriented designs.

The project declares the following three concepts for creating new value and experience to produce the emergent effects:

A) Spatial Interaction,
B) Compatibility, and
C) Openness.

The objective of the concept of "Spatial Interaction" is to eliminate the physical constraints of display devices by controlling the position and direction of information in the real world. Users can interact with spatially arranged information with direction-dependency.

The objective of the concept of "Compatibility" is to enhance the compatibility between daily commodities and information devices and to remove the barrier separating real and information worlds. It is very important to avoid schemes that compel users to wear specialized glasses or sensing devices.

The objective of the concept of "Openness" is to activate the face-to-face communication by giving high priority concern to privacy issues. Since users don’t want to display private information on public displays, the project will design a secure way of sharing information.

In this project, we are continuing evaluations of the developed systems through long-term user studies such as a half-year workshop-style lecture. Moreover, to open our researches to general public, we are holding an exhibition at the Miraikan museum of emerging science and innovation. The name of the exhibition is “The Studio -Extend Your Real World-”. In this exhibition, we gathered the following six projects that extend real world through information technology: Graphic Shadow[1], MorPhys[2], Photochromic Carpet[3], Thermo-key[4], MARIO[5], and EchoSheet[8] (Figure 1).

In this paper, we introduce three concept of "Human Harmonized Inter-Personal Display Project", and report of concrete examples for each concept to demonstrate the intuitive understanding and promote face-to-face communication in everyday living.

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2 INFORMATION MEDIA OF “SPATIAL INTERACTION”

The objective of the concept of “Spatial Interaction” is to eliminate the physical constraints of display devices by controlling the position and direction of information in the real world. Users can interact with spatially arranged information with direction-dependency.

When displaying information about a physical object, it is not desirable to use an existing display device apart from the object. Therefore we implemented the method that superimposes visual information directly onto the object; led by that the users can interact with the information without diverting the gaze from the object. Especially in the case of multiple users, users can understand the other user’s pointing act with spatial consistency, and keep face-to-face communication. This feature will promote the emergent effect like increase of the amount of conversation and intellectual curiosity.

Aiming at seamless spatial mixing of physical objects and virtual images, we developed a system that provides a tangible and interactive interface for such mixing. “Mid-air Augmented Reality Interaction with Objects (MARIO)” system enables virtual images to be displayed at precise positions and various depths in mid-air in combination with physical objects (Figure 1 Bottom-Center) [1]. Since the viewing angle in this system is limited, it allows only a few participants to observe the synthetic image at the same time.

To overcome the limitation of the MARIO system, we developed the MRsionCase, a glasses-free mixed reality showcase system (Figure 2)[6]. It has four directional see-through visual displays, so it can superimpose flat mid-air images on the real showcase object, and allow viewers to observe the synthetic image from multiple directions. However it needs a see-through device between users and the real object, that makes that users cannot touch the object directly as in the MARIO system, as well that the floated image is 2D.

One of the solutions is iVisiOn, a novel glasses-free tabletop 3D display (Figure 3) [7]. It display floating virtual 3D images on an empty, flat, tabletop surface and enables multiple viewers to observe raised 3D images from any angle at 360°. This glasses-free 3D image reproduction method employs an optical device together with an array of projectors to produce a continuous horizontal parallax in the direction of a circular path located above the table. The optical device shapes a hollow cone and works as an anisotropic diffuser. The circularly arranged projectors cast numerous rays into the optical device. Each ray represents a particular ray that passes a corresponding point on a virtual object’s surface and orients toward a viewing area around the table. At any viewpoint on the ring-shaped viewing area, both eyes collect fractional images from different projectors, and all the viewers around the table can perceive the scene as 3D from their perspectives because the images include binocular disparity. The technology is installed beneath the table, in order to keep the tabletop area clear so that no ordinary tabletop activities are disturbed. Many people can naturally share the 3D images displayed together with real objects on the table.
Figure 2: MRvisionCase: a glasses-free mixed reality showcase. Viewers can observe the synthetic image from multiple directions.

Figure 3: fVisioN: glasses-free tabletop 3D display. A float virtual 3D image and real object are on a tabletop surface display.

3 INFORMATION MEDIA OF “COMPATIBILITY”

The objective of the concept of “Compatibility” is to enhance the compatibility between daily commodities and information devices and to remove the barrier separating real and information worlds. Here, we focus on two tools, pen and paper, which are typically used in cooperative work, and enhance function of these tools by combining these with information technology.

As combining pen with information technology, we developed two systems, EchoSheet (Figure 1 Bottom Right) and dePENd (Figure 5). EchoSheet focus on sound of drawing, and dePENd focus on motion of drawing.

EchoSheet augments feelings of drawing with emphasized auditory feedback of drawing sound. This system comprise of the stereo piezoelectric microphone attached on the back of the easel, an amplifier, and a stereo speaker. The microphone picks up drawing sounds while users write on the paper, and the speaker provides auditory feedback through amplifying the sound in real time. We evaluated the effectiveness of the auditory feedback among Without Feedback (No), Monaural Feedback (MF) and Stereo Feedback (SF) for writing during a task involving the tracing of Chinese characters [8]. In Figure 4, the ordinate axis means the number of written characters per minute during writing task and the abscissa is experimental condition (feedback factor and writing task time factor). This figure showed that auditory feedback of writing produced more written characters independent of between MF and SF.

Figure 4: Number of written characters between feedback factor and time factor.

dePENd is a novel interactive system that assists sketching using regular pens and paper [9]. The system utilizes the ferromagnetic feature of the metal tip of a regular ballpoint pen. A computer controlling the X and Y positions of the magnet under the surface, guides the pen, and provides entirely new drawing experiences. Haptic guides using regular tools are expected for rising drawing skills for users. For example, users can draw diagrams and pictures, add an arrangement, use a communication function and copy and re-draw function.

Figure 5: dePENd: Augmented sketching system that assists sketching using regular pens and a paper.

As combining paper with information technology, we developed two systems, Hand writing (Figure 6) and Inkantatory Paper (Figure 7), which can control the color phenomena on a paper from both users and computer. There exists an obvious difference on a paper between color phenomena of pen ink and luminous phenomena of projector light. The goal of both researches is to eliminate this difference.

Hand-rewriting is a special desk environment in which both users and computer systems can write and erase freely on the same piece of paper [10]. When the user writes on a piece of
paper with a pen, for example, the computer system can erase what is written on the paper, and additional content can be written on the paper in natural print-like colors. We achieved this hybrid writing and erasure on paper by localized heating combined with handwriting with thermochromic ink and localized ultraviolet-light exposure on paper coated with photochromic material.

Though Hand-rewriting can import digital paint function to ordinary papers, it requires a special desk equipped with the laser systems. To minimize the systems, we developed Inkantatory Paper, a simple interactive paper interface that can automatically erase printed and handwritten contents and highlight printed contents on paper anywhere [11]. We achieved these two functions with the local thermal control of the printable conductive silver ink on the back of the paper. For erase function, we use Anoto pen filled with bistable thermochromic ink that becomes colorless at 65°C. For highlight printed contents, we use reversible thermochromic ink changes its color around 29°C, for instance, red/transparent at 30°C and black at 28°C.

Figure 6: Hand-rewriting: a special desk environment in which both users and computer systems can write and erase freely on the same piece of paper.

Figure 7: Inkantatory Paper: a simple interactive paper interface that can automatically erase printed and handwritten contents and highlight printed contents on paper anywhere.

4 INFORMATION MEDIA OF “OPENNESS”

The objective of the concept of “Openness” is to activate the face-to-face communication by giving high priority concern to privacy issues. Since users don’t want to display private information on public displays, we designed a secure way of sharing information.

On the Net, in addition to the existing e-mail service which is the typical example of the private information, twitter and Facebook are pioneering a new paradigm of information sharing by loosely connected public information. The meaning of the loose connection is that you are allowed to see the public information, but not enforced to see it. I believe this loose connection can change the atmosphere of the place where users meet in the real world. To achieve this situation, I propose to utilize a secondary display to show public information that you can allow to share with the other users while keeping private information in the primary display. This secure way of information sharing will realize loose connection among multiplayer and give an opportunity for the face-to-face communication. This feature will promote the emergent effect like increase of the amount of information sharing and unforeseen discussion.

SHelective is a prototype of this approach in case of sharing external displays with others (Figure 8) [12]. In sharing external displays, there are several problems. In “Mirroring”, there is unintended personal information leak. In “Extension”, it needs complicated operation on external displays. To solve these problems on each method, we realize a new method of information sharing by “Selective Mirroring” each window.

Figure 8: SHelective: a new method of information sharing by “Selective Mirroring” each window.

Another example is Inter-Personal Browsing (IPB) (Figure 9) [13]. This is designed for such situation that multiple users get together to cooperatively search something on the Net. While private applications are displayed just in user’s own PC, a web browser is cloned in his/her secondary public display. User A can copy the web page which user B is watching to User A’s PC by touching the user B’s public display.

To examine how the quality of group work is changed by using IPB, we have applied this system to half-year group-work lecture. The specific aim of practical research through this course is to use Inter-Personal Browsing in a comparative study to see if it changes the face-to-face communication of group work. For comparison, we prepared 3 conditions: group work with notes and paper (method 1), group work with PC (method 2), and group work with Inter-Personal Browsing (method 3). As shown in Table 1, the questionnaire included two questions where students were asked to reflect on the level of activity in the discussions. In methods 1 and 3, the students responded that they had all actively participated in the group work and that the group itself facilitated active discussions. On the other hand, in method 2 where group work was performed using PCs, some students responded that they had been unable to participate actively in the group work or play an active role in discussions.

This result suggests that the use of IPB allows for more communication than existing PC-based group work, and a high level of activity close to that of traditional paper-based group work.
Table 1. Results from questionnaire 1 (average ratio of participating students who answered affirmatively)

<table>
<thead>
<tr>
<th>Question</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1-1 Did you actively participate in the group work?</td>
<td>100%</td>
<td>63%</td>
<td>100%</td>
</tr>
<tr>
<td>Q1-2 Were there active discussions in your group?</td>
<td>100%</td>
<td>44%</td>
<td>100%</td>
</tr>
</tbody>
</table>

5 CONCLUSION AND FUTURE WORK

We have presented some concrete examples of each of the research concepts: Spatial Interaction, Compatibility, and Openness. What is significant here is that they should not be investigated separately. Integration of each technology to develop new systems will open up a different paradigm. We will continue the evaluation of the developed systems as human-harmonized information media through long-term user studies including a half-year workshop-style lecture and a half-year exhibition at a museum. Moreover, some of our research results will be distributed as a set of research toolkit.

In conclusion, as shown in Figure 10, the objective of our project is to pioneer a new field of information media technology which comprise of spatial interaction, compatibility, and openness in everyday living environments and public spaces, and to explore the methodologies for promoting the emergent effect like spurring intellectual curiosity and creative drive by not just giving information, but providing intuitive understanding and promoting face-to-face communication.

REFERENCES


[7] Shunsuke Yoshida; fVisiOn: glasses-free tabletop 3D display to provide virtual 3D media naturally alongside real media. Proc. SPIE 8384, Three-Dimensional Imaging, Visualization, and


