Research on Ultra-Realistic Communications

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ABSTRACT

National Institute of Information and Communications Technology (NICT) is researching ultra-realistic communications system that provides natural and real communications to everybody. Main research subjects are holographic 3D image and sound systems and necessary requirements for ultra-realistic systems based on underlying principles of human information processing. The Ultra-Realistic Communications Forum was established on March, 2007 to ensure efficient industry-academia-government collaboration in research, development, verification experiments, and standardization on ultra-realistic technologies.

1. INTRODUCTION

The Expo 2005 Aichi Japan showcased a variety of high-resolution, large-screen, three-dimensional image display systems, including a 360-degree dome-shape display, the Super Hi-Vision system, and the Laser Dome. Visitors to the event were captivated by these and other advanced display systems.

Ultra-realistic Audio-Visual systems have long been in high demand for use in exhibitions and fairs, highlighted as the "image display systems of the future." However, once a given event had closed, research and development in the relevant field often slowed markedly. This effect was probably due to the widespread view that these systems were somewhat far-fetched in terms of day-to-day life. I have heard that engineers and researchers in this field, particularly those employed by private companies, were feeling less than useful within their organizations, as this field of technology was not seen as offering significant business potential.

However, with the recent spread of broadband networks, advanced digital technologies, and improved performance in image acquisition & display and other electronic devices, it has become possible to manufacture high-resolution displays and three-dimensional imaging systems at a reasonable cost. While previous applications had been limited to areas such as video games, medical systems, driving simulators, and automobile design, these systems are now expanding into digital cinema, stereoscopic movies, and Super Hi-Vision (UDTV) systems for use in museums, for example.

Meanwhile, the Ministry of Internal Affairs and Communications has stressed the importance of research into ultra?realistic communication systems with the aim of addressing a range of societal issues, such as those arising as a result of the aging population and a diminishing number of children in Japan. Specifically, the ministry has emphasized the need to strengthen the research conducted by the National Institute of Information and Communications Technology (NICT) and to promote active research collaboration among industry, academia, and government. The Ultra-Realistic Communications Forum, involving the participation of researchers and engineers from industry, academia, and government, was established against this backdrop.

2. RESEARCH ON ULTRA-REALISTIC COMMUNICATION SYSTEM AS A STRATEGIC NATIONAL PROJECT

In December 2005, the Ministry of Internal Affairs and Communications presented a report by the Study Group on Universal Communications Technologies (Leader: Dr. Hiroshi Harashima, Professor, University of Tokyo) [1]. This report emphasized the need to move the present state of telecommunications toward a system of "universal communications" that will be both human-friendly and economically valuable. The report highlighted three issues that must be resolved in order to realize this goal.

(1) Overcoming barriers: Surmounting the impediments that hamper mutual understanding - language, culture, values, knowledge, experience, and physical abilities, among others

(2) Natural expression and communication: To enable smooth communication through natural expression that allows visual, auditory, and olfactory perceptions based on a so-called "shared reality"

(3) Creation of a sense of safety, trust, empathy, and sensation: To allow accurate communication of meaning, intention, emotion, and ambience, even if the conveyed information contains inadequate expressions or uncertain information, in order to create a sense of safety, trust, empathy, and sensation

In work relating to the ultra-realistic communication technology discussed in this report, the following research is of particular importance:

□ Understanding human visual perception and its characteristics, auditory perception, and multimodality (interaction among stimulations received from

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multiple sensory organs), as well as the enhancement of techniques for expression and presentation of content appropriate to the relevant advanced technologies

□ Innovations in eliminating the sense of discomfort resulting from the differences between the actual world and the virtual world, and mechanisms to allow people to recognize these differences when necessary

□ Development of a method for automatic evaluation of the authenticity of visual information that may contain intentional errors, in order to ensure an adequate level of confidence among users, and research on interpersonal communication based on a combination of virtual reality and elements of the real world.

Research in these areas requires advanced knowledge in information processing, psychology, cognitive science, neurological science, design, communications, and many other fields.

The report showed Fig. 1 as an example of a broadcasting application by an ultra-reality system.

Fig.1: *Examples of ultra reality broadcasting applications (3D TV live broadcasting from a soccer stadium)*

3. RESEARCH ON ULTRA-REALISTIC COMMUNICATIONS AT NICT [2][3]

Universal Media Research Center was established at NICT in fiscal 2006 for the purpose of realizing an ultra-realistic environment that will allow communication of multimodal information (vision, hearing, touch, and smell) with the aim of spearheading development of a natural-communications and realistic-communications infrastructure and a range of multimedia technologies. The Research Center has been promoting research on three-dimensional image and sound reproduction technologies, on perceptual and cognitive mechanisms related to ultra-realism, and the development of systems to apply the results of such research. The overall goal of this research and development is to establish modes of natural and realistic communications that will allow people in remote locations to have a genuine sense of being in the same place at the same time.

The Universal Media Research Center has two research groups: the 3D Spatial Image and Sound Group and the Multimodal Communication Group.

3.1 3D Spatial Image and Sound Group

This group is involved in research into hardware for three-dimensional image and sound systems. The group's research goal for its 3D image technology is to develop a type of electronic holography that does not require the viewer to wear special glasses. This is referred to as an "ultimate 3D image system".

Holography records and reproduces images based on minute fringe patterns created by interference between the reference laser beam and the reflected beam from subjects. In ordinary still image holography, a photographic plate with more than 1,000 lines per millimeter is used as a recording material. On the other hand, electronic image display devices (LCD panels in most cases) used for moving picture feature a pixel density of at most 100 lines per millimeter-far from the required performance. As a result, only coarse fringe patterns can be recorded and displayed. If the resolution were as high as required, holography would reproduce virtually the same light rays as those reflected from the subjects, by using fringe patterns to control this light in various ways. However, because these fringe patterns are at present represented only coarsely, the use of diffraction angles (which provide control over light direction) is very limited. The specific problems caused by coarse fringe patterns include the following: (a) the reference beam, which is component directly transmitted from the illumination light enters the field of vision, (b) a false image (called a "conjugate image") is superimposed on the correctly reproduced image, causing interference, and (c) the observation range (visible region) is narrow.

The group is working to improve the basic characteristics of electronic holography to arrive at a system that will allow observation of interference-free full-parallax images with a sufficient visible region (Fig. 2). In addition to its work on display technologies, the group is also researching and developing a technique to enable input of actually shot moving pictures, in order to create a visual system equipped with image input and output interfaces. The group is also examining techniques to achieve full-color reproduction of 3D images. Ultimately, the group is working to realize a real-time three-dimensional moving picture color image system such as the one shown in Fig. 1.

The group is also researching sound reproduction systems capable of matching the high-reality image display system. Specifically, the group examines acoustic field reproduction technologies that can be combined with a three-dimensional holographic image display system.

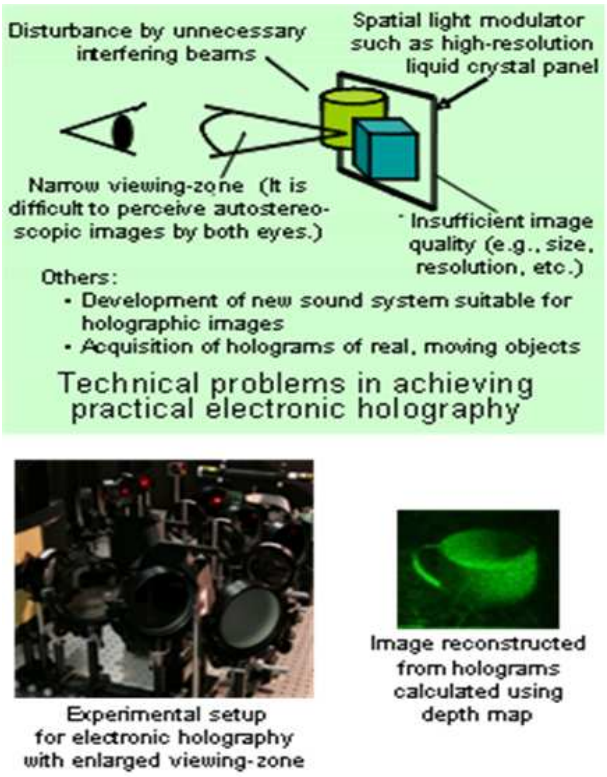

Fig.2: *Research at 3D Spatial Image and Sound Group*

3.2 Multimodal Communication Group

This group conducts research to elucidate the dynamics of human cognition and is working toward the construction of a prototype system with multimodal interfaces capable of generating an ultra-realistic ambience, through optimization of the results of the research on the elucidation of human cognition.

(1) Clarification of perceptual and cognitive mechanisms in establishing a realistic ambience and immersive environment

The group is studying, from the physiological and psychological perspectives, how humans sense a realistic ambience, or an "immersive environment". Researchers in the group are aiming to fill the many gaps in the relatively uncharted areas of research pertaining to the combined effects of multiple perceptions: visual and auditory, visual and haptic, visual and olfactory, and combined visual, auditory, haptic and olfactory perceptions. The group is studying the joint effects of multimodal information through psychophysical experiments, brain activity monitoring, and analysis of biological signs (heartbeat, respiration, perspiration, pupil diameter).

(2) Construction of an ultra-reality system

Ultra-realism refers to the creation of an artificial place and ambience, one that makes a person feel as if he or she is actually in the given virtual space-where, for example, participants may experience the sensation of feeling someone close to them, or manipulating an object with their own hands as if they were directly in front of the object. To generate a sense of interaction with actual places, people and objects, the group is conducting research toward the construction of an integrated system capable of acquiring, transmitting, and presenting information that can be seen, heard, touched, and smelled. Fig. 3 illustrates the research concept and the relevant technical topics.

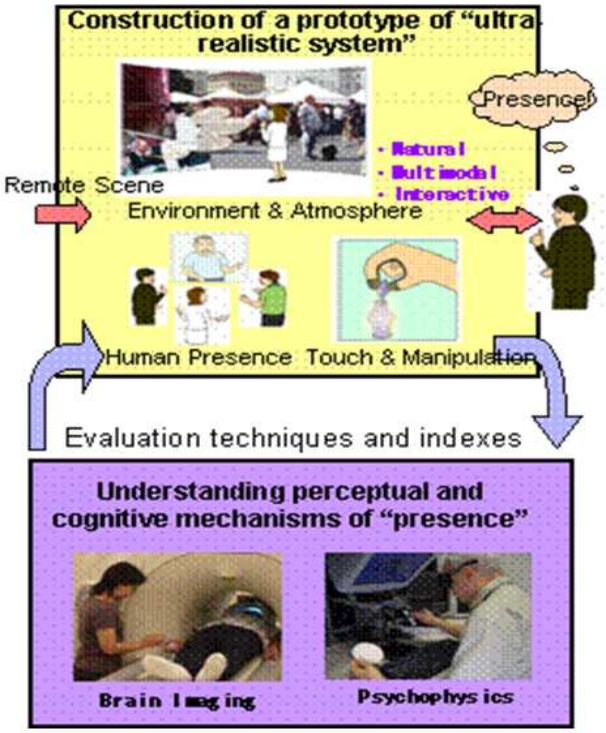

Fig.3: *Research at Multimodal Communication Group*

4. ULTRA-REALISTIC COMMUNICATIONS FORUM

Ultra-realistic communications technology consists of a number of elemental technologies such as super-high-resolution image, three-dimensional image, ultra-realistic sound reproduction, and communication based on the five senses, including haptic and olfactory perceptions. This research and development requires not only a large facility and system resources, but also demands the cooperation of specialists in a wide range of fields -image and sound data input and reproduction, optical equipment, image and audio signal processing, data transmission and communication, content production, human interfaces, psychological evaluation, and cognitive dynamics. Consequently, the expertise and knowledge to be found in governmental institutions, industrial organizations, and universities must be combined in this research; such cooperation will also necessarily entail addressing issues of technological standardization.

In line with the recommendations of the Study Group on Universal Communications Technologies described in Section 2, the Ultra-Realistic Communications Forum (Chairperson: Hiroshi Harashima, Professor, University of Tokyo) was founded on March 7, 2007. The forum was established to promote participation of the relevant researchers, business operators, users, and others in the exchange of information and intercultural communications, and to ensure efficient industry-academia-government collaboration in research, development, verification experiments, and standardization. Accordingly, the forum provides researchers and engineers with a venue for discussion and investigation; the organization also hosts exhibitions and symposia to increase public awareness of the importance of work in ultra-realistic communications. The forum also aims to revitalize research and development in industry, academia, and government and to promote the practical application of research results. The information of the Ultra realistic Communications Forum can be got from (http://www.scat.or.jp/urcf/). Fig. 4 provides an illustration of its organizational structure. The Diffusion Promotion Group (Chairman: Dr. Fumio Okano, Executive Researcher, NHK) shown in Fig. 4 supports verification experiments with member-proposed three-dimensional imaging or ultra-high-resolution display systems, works on the production of reference contents for experiments and the standardization of interfaces for devices using different systems, prepares entries for domestic and overseas exhibitions, and explores fields of application of high-reality systems. The Technology Development Group (Chairman: Professor Fumio Kishino, Osaka University) is clarifying the broad aims of ultra-reality systems, examining high-specification systems for large-screen high-resolution image display and high-fidelity audio reproduction, comparing various three-dimensional image systems, and investigating the functions and performance of ultra-reality systems necessary for communications based on the five senses and a range of cognitive mechanisms.

5. CONCLUSIONS

In light of an aging population, ultra-reality systems are expected to contribute to lifestyles that are richer, safer, and more secure. NICT is one of many research institutions that have begun addressing-on a serious scale-a range of technologies relating to highly realistic sensations, and a collective body drawn from industry, academia, and government has also begun research activities in related areas. In Europe and East Aisa, national projects have also been initiated to promote research in these fields of technology. It is my sincere hope that the collaborative research of experts and specialists both in Japan and overseas will bring even greater progress in these important fields.

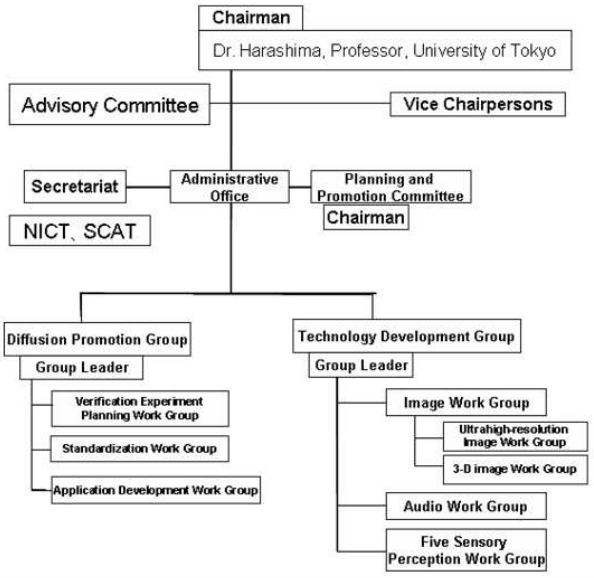

Fig.4: *Organization of Ultra-Realistic Communications Forum*

References

[1] Study Group on Universal Communications Technologies (Leader: Dr. Hiroshi Harashima, Professor, University of Tokyo), final report, http://www.soumu.go.jp/s-news/2005/pdf/051215_3_2.pdf

[2] NICT Homepage on Web: http://www.nict.go.jp/

[3] Enami, Okui, Inoue: "Research on Ultra-realistic Communication at NICT", *ITE Tech. Rep.*, Vol.30, No.58, pp.1-6 (Nov., 2006)

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