학술활동
국제 학술발표 대회
- 3DIT2009
- 3DIT2008
– Invitation
– Program
– Invited Speakers
– Photo
– News
- 3DIT2007
- 3DID2006
- 3DID2005
- 3DID2004
국내 학술발표 대회
- 14회 3차원 영상 미디어 기술 워크샵 (2009)
- 13회 3차원 영상 미디어 기술 워크샵 (2008)
- 12회 3차원 영상 미디어 기술 워크샵 (2007)
- 11회 3차원 영상 미디어 기술 워크샵 (2006)
- 10회 3차원 영상 미디어 기술 워크샵 (2005)
- 9회 3차원 영상 미디어 기술 워크샵 (2004)
- 8회 3차원 영상 미디어 기술 워크샵 (2003)
- 7회 3차원 영상 미디어 기술 워크샵 (2002)
- 6회 3차원 영상 미디어 기술 워크샵 (2001)
- 5회 3차원 영상 미디어 기술 워크샵 (2000)
- 4회 3차원 영상 미디어 기술 워크샵 (2000)

3DRC 연구센터 주최의 학술대회

광운대학교 3DRC에서는 매년 3D 기술관련 국내외 학술발표대회 및 단기강좌를 개최하고 있습니다.

Invited Speakers

1. An Overview of European 3DTV Research Achievements and Ongoing Research Activities
- Prof. Levent Onural (Bilkent Univ., Turkey)

The four-year EC funded 3DTV Project is now completed as scheduled. Nineteen partner, 180 researcher project has contributed to the knowledge in all aspects of the 3DTV chain: capture, representation, compression, transmission and display. Furthermore, diverse and somewhat competing alternative technologies were among the interests of this broad project. There are now more than 350 published scientific/technical papers, one edited book, and a broad range of developed data and software packages as the main throughput of the 3DTV Project. This presentation will provide a brief overview of the main results and achievements of the 3DTV project. There are now a significant number of new EC funded more-focused 3D-related projects where most of them are spin-off projects of the recently completed 3DTV Project. Eleven 3D-related projects, including these new FP7 projects formed a 3D Media Cluster in April, 2008. A brief overview of the focus and objectives of these cluster projects will also be presented. Finally, a special emphasis will be given to the recent developments in holographic 3DTV-related issues; in particular, recent work on signal processing aspects of optical wave propagation, diffraction and holography will be discussed. LED-based reconstructions from iteratively computed multiple holograms using spatial light modulators will be presented.

Levent Onural received the B.S. and M.S. degrees from Middle East Technical University, Ankara, Turkey, in 1979 and 1981, respectively, and the Ph.D. degree in electrical and computer engineering from the State University of New York at Buffalo in 1985. He was a Fulbright scholar between 1981 and 1985. After a Research Assistant Professor Position at the Electrical and Computer Engineering Department, State University of New York at Buffalo, he joined the Electrical and Electronics Engineering Department, Bilkent University, Ankara, Turkey, in 1987 where he is currently a Full Professor. His current research interests are in the areas of image and video processing with emphasis on very low bit rate video coding, texture modeling, non-linear filtering, holographic TV and signal processing aspects of optical wave propagation. He has published more than 150 papers and received about 1000 citations. (Publications). In 2006 and 2007, two papers that Onural co-authored ranked among the top cited papers published in IEEE Transactions on CSVT. He was a member of the COST211ter Project Management Committee and the director of the Turkish COST211 Team team between 1991-1997. He and his team have contributed to MPEG-4 activities through COST211 Analysis Model. COST211ter project was a research collaboration activity of European Union; more information can be found here. Levent Onural has a video object segmentation patent. (US 6,337,917). Currently, he is the Coordinator of EC funded 3DTV Project.

2. Large Size Real-Time Video Hologram made possible using Multiple Tracked Sub-Holograms
- CSO Armin Schwerdtner (SeeReal Technologies GmbH, Germany)

Displaying 3D video content with true depth impression is pursued by almost all big display and panel manufacturers as well as major Hollywood's movie makers. However, despite enormous advancements with respect to technology and cost efficiency stereoscopic video displays have not yet reached the consumer market. A crucial drawback is the mismatch between focusing and convergence inherent to stereoscopy. This was the reason we focused more and more on developing holographic video display devices while reducing our stereoscopic efforts. For about five years we have fully focused on large-sized computer-generated holography for display purposes. The biggest problems encountered are the extreme high resolution required and the tremendous amount of computational load. In contrast to other approaches we solved the resolution issue or high space-bandwidth requirement by using one diffraction order in the plane

- 3회 3차원 영상 미디어 기술 워크샵 (1999)
- 2회 3차원 영상 미디어 기술 워크샵 (1999)
- 1회 3차원 영상 미디어 기술 워크샵 (1998)

단기강좌

- 제4회 3D 입체기술 단기강좌 (2008)
- 차세대 3차원 입체영상 기술 단기강좌 (2007)
- 실감 유비쿼터스 IT 기술 단기강좌 (2006)
- 3차원 디스플레이 기술 단기강좌 (2004)

of the light source image, i.e., the Fourier plane as a Virtual Viewing Window (VW) through which the viewer may peer to see the reconstructed 3-D scene. The size of this VW may be as small as some 2cm x 2cm which reduces the SLM pixel pitch dramatically making the usage of today's SLMs (TFT) feasible. The 3-D scene is reconstructed in the frustum between the VW and the Spatial Light Modulator (SLM) and beyond encoded with the holographic information. That way, the VW is formed by the Fourier transform of the hologram and the 3-D scene is mathematically be described by a Fresnel transform. The VW for the viewer's other eye is time-sequentially produced. In a similar way the eyes of other viewers are served. The free viewer movement is made feasible by tracking the VWs to the viewer eyes´ locations. In order to avoid the perception of periodical replications which are generally produced by regularly sampled SLMs no higher order overlap must occur in the VW diffraction order. We therefore decompose the hologram into multiple Sub-Holograms (SH) with each SH reconstructing a single point of the 3-D scene. The pixel pitch of the SLM defines the (rectangular) shape of the VW in the Fourier plane. We then project the VW through each 3-D scene point onto the SLM defining the shape and location of the associated SH. The SH is lens encoded in such a way as to produce together with the Fourier transform lens the considered point at the proper location. This spatial constraint of the SH ensures that no overlap into the VW diffraction order will occur. There are as many SHs as there are reconstructed points of the 3-D scene. They will generally overlap each other. Meanwhile, prototypes have been built and demonstrated at many conferences and before representatives of most large panel and display makers. To ensure real-time computation several solutions have been developed including approaches based on PC graphics cards and on special hardware.

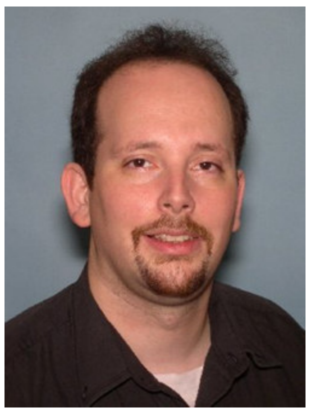
Armin Schwerdtner has been instrumental in the creation of SeeReal Technologies and the development of the company's innovative holographic and stereoscopic display solutions. He is the mastermind behind the company's development of its new, disruptive holographic 3D technology, and has played a significant role in the development of the company's NextGen stereoscopic 3D technology. He has published numerous papers, has filed numerous patent applications and has been invited as a presenter at numerous international conferences. He has earned the Federal Cross of Merit for his role in the development of methods for three-dimensional visualization by means of re-configurable computer-generated holograms (CGHs) leading to the creation of the first auto-stereoscopic 3D display (ASD). He completed his studies in physics at Technische University Dresden (TUD).

3. Progresses in 3D Multi-perspective Display by Integral Imaging
- Prof. Manuel Martínez-Corral (Valencia Univ., Spain)

Nowadays, much visual information is presented to users through computer moni-tors, TV screens, or even through cellular-phone or PDA screens. The displayed images can have entertainment or information values, or even be aimed at the dif-fusion of research results. Three-dimensionality is currently considered an important added value in im-aging devices, and therefore the search for an optimum 3D imaging and display technique is a hot topic that is attracting important research efforts. As main value, 3D monitors should provide the observers with different perspectives of a 3D scene by simply varying the head position. Three-dimensional imaging techniques have the potential to establish a future mass-market in the fields of entertainment and communications. Integral imaging (InI), which can capture true 3D color images, has been seen as the right technol-ogy to 3D viewing to audiences of more than one person. Due to the advanced degree of development, InI technology could be ready for commercialization in the coming years. This development is the result of a strong research effort performed along the past few years by many groups. Since Integral Imaging is still an emerging technology, the first aim of the "3D Imaging and Display Laboratory" at the University of Valencia, has been the realization of a thorough study of the principles that govern its operation. It is remarkable that some of these principles have been recognized and characterized by our group.
Other contributions of our research have been addressed to overcome some of the classical limitations of InI systems, like the limited depth of field (in pickup and in display), the poor axial and lateral resolution, the pseudoscopic-to-orthoscopic conversion, the production of 3D images with continuous relief, or the limited range of viewing angles of InI monitors.

Manuel Martinez-Corral received the M. Sc. and Ph. D. degrees in Physics from the University of Valencia in 1988 and 1993, respectively. In 1993 the University of Valencia honored him with the Ph.D. Extraordinary Award. He is currently Full Professor of Optics at the University of Valencia, where he leads, since 1999, the "3D Imaging and Display Laboratory". His teaching experience includes lectures and supervision of laboratory experiments for undergraduate students on Geometrical Optics, Optical Instrumentation, Diffractive Optics and Image Formation. Lectures on Diffractive Optics for Ph.D. students. His research interest includes scalar and vector properties of tightly focused, resolution procedures in 3D scanning microscopy, and 3D imaging and display. He has supervised on these topics five Ph. D. thesis. Two of them were honored by the University of Valencia with the Ph.D. Extraordinary Award. He has supervised up to six M. Sc. thesis, as well. He has published on these topics over sixty technical articles in major journals. He has published over 60 conference proceedings, including 10 invited and three keynote presentations in international meetings. He has been member of the Scientific Committee in over twelve international meetings, and was the president of the Organizing Committee of the international conference Focus on Microscopy 2007. He is co-chair of the Three-Dimensional Imaging, Visualization, and Display VII Conference within the SPIE meeting in Defense, Security, and Sensing 2009.

4. Incoherent Multiple Viewpoint Projection Holography
- Prof. Joseph Rosen and Dr. Natan T. Shaked (Ben-Gurion Univ., Israel)



This talk will review several methods for acquiring and processing multiple viewpoint projection (MVP) holograms of 3-D objects under incoherent illumination. Holography is able to provide the most authentic illusion of observing a 3-D scene with no special viewing devices, as well as an efficient way to store the acquired 3-D information. In the conventional holographic acquisition techniques, an interference pattern is recorded, while requiring an extreme stability of the optical system, as well as using a relatively strong laser with long coherence length. The practical meaning of these limitations is that conventional holograms usually cannot be recorded outside of a well-equipped laboratory. To avoid these problems, our group has proposed new methods for processing holograms under incoherent illumination. The main idea is to acquire many two-dimensional perspective projections of the 3-D scene using a simple digital camera, and then to process these projections digitally into a hologram of the 3-D scene. To enable the acquisition of MVP holograms of moving objects, we have also proposed several methods to overcome this problem and to acquire all of the perspective projections in a single camera shot. The prospective goal of this field of research is to facilitate the design of a simple and portable holographic camera which can be useful for many applications involving 3-D medical imaging, microscopy, and 3-D video acquisition. The generation of MVP holograms is in fact a hybrid technique combining tools employed in both the optical and the digital worlds. On the one hand, we optically acquire MVPs of real-existing 3-D objects, but on the other hand, the optical acquisition is not the end of the process and digital computations are required to yield the final hologram. The integration with the digital world makes it possible to define new types of holograms which have not been available till now. This is actually a new branch of holography since now we are not limited anymore to the regular types of holograms (such as Fourier, Fresnel, or image holograms), traditionally generated by recording an interference pattern of two coherent optical beams. Therefore, we also propose new types of digital holograms in order to obtain certain advantages over the known types of holograms. Firstly, we propose an efficient, direct, and accurate method for processing digital incoherent modified Fresnel hologram. Secondly, we propose the digital incoherent protected correlation hologram. This hologram yields better reconstruction resolution, in addition to the encryption of the 3-D scene. Both of these new holograms have an interesting feature, namely, that all objects of equal size in the 3-D scene are reconstructed at the same size without dependency on their axial distances from the acquisition plane. We show that this feature can be used for performing efficient 3-D object recognition. Additional applications of the new MVP holograms, that might be useful for biomedical imaging applications, are processing multicolor holograms of fluorescently labeled objects, as well as 3-D imaging through scattering media. These applications are demonstrated experimentally.

Joseph Rosen received his BSc, MSc, and DSc degrees in electrical engineering from the Technion-Israel Institute of Technology in 1984, 1987, and 1992, respectively. He is currently a professor in the Department of Electrical and Computer Engineering, Ben-Gurion University of the Negev. He is a fellow of the Optical Society of America and has coauthored more than 70 scientific papers in refereed journals. His research interests include image processing, holography, diffractive optics, interferometry, pattern recognition, optical computing, and statistical optics.

Natan T. Shaked received his BSc and MSc (Summa Cum Laude) degrees in electrical and computer engineering from Ben-Gurion University of the Negev, Beer Sheva, Israel, in 2002 and 2004, respectively, and has finished his PhD studies in electrical and computer engineering at Ben-Gurion University of the Negev lately. His PhD research interests include incoherent white-light holography and optical computing and processing. He has coauthor 11 refereed journal papers. Currently, he is a postdoctoral scholar in the Department of Biomedical Engineering, Duke University, North Carolina, USA.

5. Prospects for 3DTV and Other 3D Markets
- President Chris Chinnock (Insight Media, USA)

3D technology is maturing rapidly and creating many new consumer market opportunities. Lead by the 3D digital cinema revolution, there is now a strong desire to create a 3D TV industry. This will require much new 3D content, a delivery and fixed media mechanism for this content, and affordable 3DTVs so consumer can enjoy it. In addition to movies, sporting content and gaming is expected to lead 3D into the home. But 3D will also come to the home in mobile handsets, cameras, electronic picture frames and even printers. We are now at the beginning of a profound transformation of the home from a 2D to 3D visual environment that will be a major trend for the next 20 years. This presentation will review some of the key questions that the TV industry is facing in its desire to offer 3D content, delivery and TV sets for consumers. We will review these factors and some of the methodology, and assumptions Insight Media used to create a forecast on the prospects for 3DTV in the next 5 years. In addition, we will provide some insight into how 3D will be used in professional markets, especially no-glasses 3D for digital signage and other applications. These professional markets will help refine and cost reduce the technology to eventually allow glassless 3D TV in the home.

Chris Chinnock is the President of Insight Media, a market research publishing and consulting form founded in 1998 to focus on the emerging parts of the display industry. Staffed with a group of world-class display experts, the company looks at technology and market trends to identify opportunities for companies to create new products and services. Insight Media publishes newsletters and in-depth technology/market reports, provides strategic consulting advice, organizes conferences, performs display testing services and is a co-founder of the 3D @ Home consortium.

6. Three-Dimensional Holographic Microscopy
- Prof. Ting-Chung Poon (Virginia Tech., USA)

Optical scanning holography (OSH) is a unique technique in that holographic information of a three-dimensional (3-D) object is acquired with a single 2-D optical heterodyne scanning. OSH has several opportunities of applications in areas such as 3-D holographic microscopy, recognition of 3-D objects, 3-D holographic television, 3-D optical cryptography as well as 3-D optical remote sensing. In this talk, I will concentrate on the use of OSH to 3-D microscopy and discuss some of the recent results. At the end of the talk, I will mention some of the topics such as real-time pre-processing in holography and 3-D partial coherent image processing that can be further investigated in the context of OSH.

Ting-Chung Poon is Professor of Electrical and Computer Engineering at Virginia Tech. His current research interests include acousto-optics, 3-D image processing, optical scanning holography and its applications in 3-D cryptography, 3-D display, and 3-D microscopy. Dr. Poon is the author of the monograph Optical Scanning Holography with MATLAB (Springer, 2007), and is the co-author of the textbooks Engineering Optics with MATLAB (World Scientific 2006), Contemporary Optical Image Processing with MATLAB (Elsevier 2001), and Principles of Applied Optics (McGraw-Hill 1991). He is also Editor of the book Digital Holography and Three-Dimensional Display (Springer 2006) and has served as a panelist for the National Institutes of Health and the National Science Foundation, and as Guest Editor of, among other journals, International Journal of Optoelectronics and Optical Engineering. Dr. Poon currently serves as Topical Editor for Applied Optics. He is the founding Chair of the Optical Society of America (OSA) topical meeting Digital holography and 3-D imaging. He is also on the editorial board of Optics and Laser Technology and the Journal of Holography and Speckle. Dr. Poon is a fellow of the OSA and the Society of Photo-Optical instrumentation Engineers (SPIE).

7. Passive ranging from partial coherence and 3D pupil optics
- Prof. George Barbastathis (MIT, USA)

Traditional optical design emphasizes shift invariance as a method to achieve uniform optical response over the entire field of view. While this approach provides safe design margins for imaging systems operating in two spatial dimensions (2D) such as cameras and microscopes, it is known to be insufficient for three-dimensional (3D) imaging: the extreme example is confocal microscopes, where shift invariance is imposed by a pinhole or optical nonlinearity such as two-photon absorption. We have devised a new approach to implement controllable shift invariance by using the Bragg selectivity property of volume holograms. We have shown, for example, that it is possible to perform confocal-like optical slicing in parallel over several depths and lateral positions by a volume holographic pupil recorded as a series of multiplex exposures. In this seminar, we will review volume holographic optics and review experiments on optical slicing with laser line scanning, rainbow illumination, and scanning-free (real time) fluorescent. We will conclude with the most recent experiment showing that passive ranging is possible even for targets of extremely low spatial bandwidth, such as large uniform walls with uniform illumination. In this case, the 3D pupil by itself does not provide depth contrast, so we cascade the 3D optical system with a wavefront folding interferometer that measures the coherence function. We have shown that the resulting contrast suffices for binary depth discrimination with low error probability.

George Barbastathis is Associate Professor of Mechanical Engineering at MIT. He received the Diploma in Electrical and Computer Engineering from the National Technical University of Athens in 1993, and the M.Sc. and Ph.D. in Electrical Engineering from Caltech in 1994 and '97, respectively. Other academic appointments: Post-doctoral Research Associate with the Beckman Institute at the University of Illinois, Urbana-Champaign (1997-99); Visiting Scholar with the School of Engineering and Applied Science at Harvard University (2006-07) and faculty resident in Singapore with the Singapore-MIT Alliance for Research and Technology (SMART) Centre (2008-09.) He has been the recipient of the Nikolaos Kritikos award in Mathematics, the 3M Innovation Award, the NSF Young Investigator Award, and the J. S. W. Kellett award at MIT. His research is centered on the physics and engineering of 3D optical imaging systems based on volume holography and 3D nanostructures with applications to optics, in particular mechanically reconfigurable photonic crystals and non-periodic subwavelength photonic structures with high index contrast.

8. Optics for Flat Panel 3D
- Dr. Adrian Travis (Microsoft Corporation, UK)

If a conventional flat panel display is to be modified so as to display an autostereoscopic image, it must acquire the ability to modulate the direction of rays and importantly, must be able to do this over a wide field of view. However, it must also manage the high data content of an image in which each pixel is angularly modulated and it can do this either by having high data rates or by compressing the image with a technique such as head-tracking. Each is considered in turn.

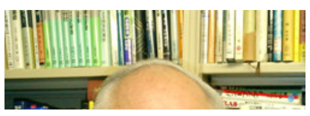
Adrian Travis completed a PhD at Cambridge University in 1988 and became a college fellow and lecturer there in 1989 when he started working on view-sequential 3D. The ideal of a ferroelectric liquid crystal display using poly-silicon transistors was too difficult at the time so he developed shuttered projection displays but these were bulky. He found that he could eliminate the bulk by projecting through a wedge light-guide which acts as a lens that he now realise is applicable to many areas of optics. He resigned his lectureship at the end of 2007 and now works for Microsoft but continue to be a college fellow at Cambridge.

9. Some approaches for 3D Information Systems design
- Prof. Vladimir V. Petrov (Saratov State Univ., Russia)

The ideas of reconstruction of three-dimensional (3D) moving scene are usually based on several main known principles: stereoscopy, holography and volumetric medium. Each of these principles might have, of course various divisions of realization. The question is how to find the best and optimal and cheapest way for design of the system that allows reconstruction of closed to real bulk scenes. In the paper several methods of 3D image reconstruction (including stereoscopic and holographic methods), which are developed in some research centers of Russia are considered. Each of these approaches has some shortcomings and advantages and at the moment it is not exactly known the best way to be chosen for development and further mass production of 3D visualization systems. Nevertheless modern technology allows already today creating laboratory and some production samples of 3D capturing and reproduction systems. For today there is a range of stereoscopic displays providing high-quality 3D images. However there are still a number of distortions found in produced stereoscopic images. This distortions lead to wrong perception of relative objects distances on the display. One part of the report is devoted to the method for correction of depth plane curvature – one of stereo image distortions. Another part of the paper is represents the consideration of new type of auto stereoscopic display design. The 3D visualization system based on the application of volumetric medium is also considered. The holographic approached based on the acoustooptical effect for 3D display design is the matter of discussion of separate part of the paper. The main principle of such an approach based on the design of electronically controlled optical hologram that represents the dynamic acoustical field, which propagates in transparent acoustooptical medium. Such acoustical field can be considered in fact as the optical hologram, that can be switched on and off and allows to reconstruct the moving 3D scenes. One more problem that is touched in the paper is how to capture the balk image data and then transform these data to electrical signal so that to pass it through communication line for further reconstruction. One of possible ways for bulk image capturing is considered and discussed.

Vladimir V. Petrov received the diploma of Engineer and the degrees of Candidate and then Doctor of Physics and Mathematics - in radio-physics from Saratov State University in 1977, 1987 and 2000 respectively. He got the academic status of Professor from Russian Federation Ministry of Education in 2002. He is currently a Professor of Applied Optics and Spectroscopy chair of Saratov State University, Director General of "SpectrAcoustics" Corporation and President of Scientific–Production Firm "Excentre". His scientific interests concern to optical information processing, optical and acoustical holography, 3D information displays development, high frequency acoustics, acoustical microscopy, spectroscopy, and tomography, acousto-optics. He holds 25 patents and author's certificates and has had more than 100 scientific publications. He is an active member of Russian Academy of Problems of Quality; the fellow of SPIE; the member of Scientific Council on Acoustics of Russian Academy of Sciences.

10. Three dimensional microscopic imaging based on Fourier spectrum synthesis for pathological applications
- Prof. Toyohiko Yatagai (Utsunomiya Univ., Japan)



New methods for 3-D holographic imaging of microscopic objects are proposed, in which computer-generated holograms (CGHs) are synthesized from several projection images recorded with white light. The absence of a coherent light source in these methods makes them suitable for CGHs of real existing objects. The proposed method is based on the relationship between one projection image recorded by a CCD camera and its Fourier plane, similar to the principle of computer tomography. In our case, however, not a planar component but a paraboloid of revolution in 3-D Fourier spectrum of the object is calculated with one projection image of the object. With some projection images, full components of 3-D spectrum are calculated. Synthesis of a hologram of the object from 3-D spectrum is made by selecting components of the spectrum.

For 3-D observation and display of pathological samples, a microscopic imaging system with rotation equipment is developed. For examples, we have synthesized 3-D spectrum using breast cancer specimen. 360 projected images with 512×512 pixels are obtained. Typical spatial resolution is 19μm. Experimental demonstration has verified the principle and the validity of this method. This method is concerned with the components on paraboloid of revolution in 3-D Fourier space. By using 3-D spectrum, we have calculated computer-generated holograms for 3-D image display.

The method we have proposed can be applied in the fields using 3-D Fourier spectrum such as X-ray CT, MRI imaging, diffraction tomography, and others.

Toyohiko Yatagai received the BE and DE degrees in applied physics from the University of Tokyo , in 1969 and 1980, respectively. From 1970 to 1983 he was with the Institute of Physical and Chemical Research, where he worked on optical instrumentation, computer-generated holography, digital image processing, and automatic fringe analysis. He has been a Professor of Applied Physics at the University of Tsukuba, Ibaraki, since 1983, and Director of Institute of Applied Physics. He is a member of Japan Society of Applied Physics and Optical Society of Japan, and a fellow of OSA and SPIE.

11. Recent activities on holographic 3D video displays in Japan - Prof. Hiroshi Yoshikawa (Nihon Univ., Japan)

Recently, researches on holographic 3D video display are getting very active, though the goal is still challenging. This paper describes recent research activities on the holographic video in Japan. The holographic stereogram approach is often used to generate a hologram from the real scene. However, the generated hologram usually has horizontal parallax only. The full parallax hologram of the real scene is calculated from the integral photographic image taken by the two-dimensional lens array and single HDTV camera. Although, the hologram is made from the array of 2-D images, the reconstructed image gives focus effect to the camera. Real-time (30 fps) calculation system with two PCs is also developed. A liquid crystal (LC) panel for a video projector is often used for holographic television. However, its pixel size and pixel number are not enough for practical holographic 3D display. Therefore, multi-panel configuration is often used to increase the viewing angle and displayed image size. We have proposed a novel method to increase the viewing angle with single LC panel. The method is implemented by a mirror module to reconfigure the beam shape reflected by the LC panel. The reconfigured beam has double resolution in horizontal direction. Inversely, the vertical resolution is decreased because the human get more 3D information in horizontal direction. From the experimental results, the horizontal viewing angle is almost two times wider than that without the mirror module. Another method to redistribute the resolution of SLM is proposed. The slanted array of four illumination point light sources and 4f lens generates four slanted Fourier-transformed image of SLM aligned in horizontal. This is equivalent to make the horizontal resolution four times and the viewing angle is increased to 14.4 degrees. To realize a full color holographic video display, people usually uses three different wave-length illumination and three spatial light modulators (SLM). To combine lights from SLMs, dichroic mirrors and other optics are used. These elements are already built in the conventional video projector. Therefore, it is easy to build a full color holographic video display with the video projector and a white-light LED. It is also reported to realize a full color display with single LC panel and time sequential illuminations. It is also proposed that the full color hologram camera with three lasers and single CCD with a color filter. The new approach for horizontal parallax only display is proposed. The display uses single high speed digital micro-mirror device (DMD) and horizontal scanner. Since the vertical resolution is same as the DMD, no vertical scan is required. The DMD is driven at the frame rate of 13.3 kHz and the holographic frame rate is 60 Hz. Therefore, it is equivalent to display 222 elemental holograms in horizontal. The displayed hologram size is 73.1 mm by 52.5 mm and has the viewing area of 14.6 degrees. At the moment, major breakthrough is required on the spatial light modulator. The band-width, or product of pixel number and speed, is not enough for full parallax display. The pixel pitch is not small enough for practical display. In contrast, horizontal parallax only display seems approaching practical stage.

Hiroshi Yoshikawa received the B.S. degree, the M.S. degree and the Ph.D. from Nihon University, all in electrical engineering, in 1981, 1983 and 1985, respectively. He joined the faculty at Nihon University in 1985 where he currently holds the position of Professor of Electronics and Computer Science. From Dec. 1988 to Apr. 1990, he was a research affiliate of MIT Media Laboratory. From Oct. 1992 to Sep. 1997, he was a sub-leader of TAO (Telecommunications Advancement Organization of Japan) Advanced 3D Telecommunication Project. He is a member of SPIE, Optical Society of America, Institute of Television Engineers of Japan, Optical Society of Japan, Institute of Electronics, Information and Communication Engineers in Japan, 3D Forum, and HODIC. His current research interests are in electro-holography, computer-generated holograms, display holography and computer graphics.

12. User Experience Research on 3D Image Representations
- Prof. Takashi Kawai (Waseda Univ., Japan)

Stereoscopic 3D images (3D) have been expected as one of next-generation media technologies for long time, and the movements have been activated in recent years. For instance, in Japan, the number of 3D theaters is increasing rapidly, and broadcasting of 3D TV programs has been started since 2007. In Korea, 3D mobile phone was also commercially released in 2007. Therefore, multi-purposing of 3D content from large size screen to small mobile display is required. However, the depth sensations of 3D content are varied by viewing conditions such as screen size and viewing distance, and previous studies have not revealed how the difference in the conditions affects user experiences. In addition, the characteristics of 3D have also made the content production difficult. From such point of views, the author has been trying to clarify the user experience of 3D images and contribute producing 3D content. In this talk, the author will introduce the outline of his past projects and related activities in Japan, and report the latest results of his user experience research on 3D.

Takashi Kawai is a Professor of Graduate School of Global Information and Telecommunication Studies (GITS), Waseda University, Japan. He graduated from School of Human Sciences, Waseda University in 1993. He received his B.A., M.A. and Ph.D. degree in Human Sciences from Waseda University in 1993, 1995 and 1998, respectively.
He is leading "Ergonomics in Advanced Media" Project in GITS. His recent research interests are ergonomic evaluation, practical application and content creation of advanced media technologies, including 3D displays, virtual reality systems and ubiquitous computing devices.

13. R&D activities on 3D display and natural 3D display in Japan
Prof. Yasuhiro Takaki (Tokyo University of Agriculture and Technology, Japan)

The Japanese industry starts thinking about commercializing 3D displays. Several leading electronic companies are developing several kinds of 3D displays, a glass-type 3D display, a glass-free binocular display, a multi-view 3D display, and so on. Last year, Nippon BS Broadcasting (BS11) started broadcasting a TV program in 3D.
There are two industrial consortiums, "3D consortium" and "Consortium of 3D Image Business Promotion (Rittai-kyo)" in Japan. Last year, Ultra-Realistic Communications Forum (URCF) was established as a joint forum among industry, academia, and the government.
The Japanese government now considers that the 3D display technique is an important technology for the future. This year, the council for science and technology policy complied "Strategy for Technological Innovation." Twenty-three technologies were selected as innovative technologies and 3D image technique was one of them. The comprehensive research about integral photography is conducting in NHK. The National Institute of Information and Communications Technology (NICT) is developing electronic holography as a ultra-realistic communication technique.
The researches about 3D images had been studied separately in several academic societies in Japan. The 3D image conference is an annual joint conference among five major academic societies. In 2006, "3D image technology research group" was established in the Institute of Image Information and Television Engineers. The aim of the research group is enabling remarkable progress in 3D technology and covers many fields of 3D technology, such as 3D display, 3D camera, human factor, and so on.
Many universities are conducting researches about 3D image techniques. The major study topics are natural 3D display, holography, integral photography, volumetric display, free viewpoint display, and so on.
The natural 3D display, which is free from the visual fatigue, has been developed continuously in Japan. The concept of "super multi-view (SMV)" was proposed by Telecommunications Advancement Organization (TAO) of Japan. Recently, the high-density directional (HDD) display has been developed in Tokyo University of Agriculture and Technology (TUAT). The SMV display makes the pitch of the viewpoints small, and the HDD display makes the angle pitch of rays small. In both techniques, two or more rays passing through an identical 3D point enter into a pupil of an eye simultaneously. Several prototype HDD displays were demonstrated, such as 64-direction QVGA display, 128-direction QVGA display, and 128-direction SVGA display employing a multiple-projection system, and 72-direction half-VGA display, 72-direction VGA display, and 30-direction mobile display employing a flat-panel system. The ray sampling pitches are between 0.2~0.4°. The accommodation responses to these HDD displays were measured. The time-multiplexing projection module was developed in order to reduce the number of projectors required to construct the multiple-projection system. Because the HDD display can control the ray direction precisely, the HDD display can reproduce not only the depth of objects but also the appearances of objects, such as glare, transparency, softness, etc. The subjective evaluation was performed in order to evaluate the object appearances reproduced by the HDD displays. The generation of natural 3D images using holography is also tried in TUAT. The viewing zone angle was enlarged to approximately 15° using the resolution redistribution system in order to allow 3D images to be observed by both eyes.

Yasuhiro Takaki received B.S. of Applied Physics in 1986, M.S. of Physics and Applied Physics in 1988, and Doctor of Physics and Applied Physics in 1992 from Waseda University. He worked at Waseda University from 1991-1994 as a research assistant, at Nihon University from 1994-2000 as an associate professor, and he has been an associate professor in Tokyo University of Agriculture and Technology from 2000. His major field of study is three-dimensional image technology, especially three-dimensional display. He is a group leader of 3D Image Group of Ultra-Realistic Communications Forum, and a chairman of 3D Image Technology Research Group of the Institute of Image Information and Television Engineers.

14. Recent Progress in 3D Industry and Research Activities in Taiwan
- Dr. Jon S. Hsu (ITRI., Chinese Taipei)

The presentation includes 3 parts: Activities in 3DIDA, 3D research in ITRI and 3D Activities in industries and academia in Taiwan. I will share the recent 3D-related activities from Taiwan. Both industry as well as ITRI's research status will be reported. 3DIDA is an industrial alliance that was organized and led by ITRI. ITRI is a non-profit research organization doing apply research with industrial applications in mind.

Jon S. Hsu served as a Science & Technology Advisor at the Ministry of Economic Affair (MOEA) before joining ITRI,. Before that he was the VP of OCBG at Foxconn group and held various positions in different industries as well. Dr. Hsu received his EMBA from National Chiao Tung University and Ph.D. in Electronic and Computer Engineering from State University of New York at Buffalo in 2000 and 1986 respectively. As the founding Chairman for Taiwan's 3D Interactive & Display Alliance (3DIDA), we strive to bridge all sectors of 3D related local industries with international partners in an effort to promote market and product development. 3DIDA hosted its first annual international conference in 2006 and invited 8 speakers from overseas this year. We also made a joint announcement about the alliance among ARMI (Alliance of Realistic Media Industry) of Korea, URCF (Ultra Realistic Communication Forum) of Japan and 3DIDA of Taiwan that together we will jointly promote one 3D-specific international conference – 3DSA in the future. Our first 3DSA 2009 will be held on 4/27~30, 2009 in Taipei, Taiwan, R.O.C..

15. 3D Large Screen Auto 3D Display
- Dr. Chang Lee (TJ3D, China)

History of Large Screen Auto3D Display
Auto 3D Display with LCD/PDP Panel
Auto 3D Display with LED Panel
Large Screen Auto 3D Display R&D and Market Development in China
Blocks of Large Screen Auto 3D Display Technology and Market
The Future of Large Screen Auto 3D Display

- Prof./ CEO Tenjin 3D imaging and display Co., China

16-17. R&D Activities on 3D Information Technology in China and the Activities of the China Industry Association (C3D)
- Secretary General Levin Tang, Vice Secretary General Flight Lee (C3D, China)

Levin Tang is acting as the Secretary General of the 'China 3D Industry Association (C3D)' sponsored by the Ministry of Industry and Information Technology of China, which was launched out last month this year. He is also the Deputy Secretary General of the 'China Digital Home Industry Association' and the Director of Preparatory Committee of the 'China Stereoscopic 3D industry Association'. In addition, he is the General Manager of the 'China Digital Media Technologies Co'.

Flight Lee is acting as the Vice Secretary General of the 'China 3D Industry Association (C3D)' sponsored by the Ministry of Industry and Information Technology of China. He is also acting as the Managing Director of the Inlife-handnet Co. in China.

18. The present and future perspective of Electro-Holographic 3 dimensional images
- Prof. Jung-Young Son (Taegu Univ., Korea)

The 3 dimensional images based on electro-holography are still in the early stage of development due to lack of supporting technologies, especially a means of display, though its development has been continued for last 20 years. Electro-holography requires a very high density and high resolution display means but it is still far away. The currently available display devices such as AOM and LCD have almost the same fringe resolution which can generate 3-D image that barely be seen by viewers' two eyes. Furthermore, color holographic image display based on LCD chips and DMD is a new progress in electro-holography but it is still far from practical. In this talk, the resolution requirements of realizing electro-holographic display are defined and various ways of fulfilling the resolution requirements are discussed along with reviewing the current status of electro-holographic display developments.

Jung-Young Son received the Ph.D degree from University of Tennessee, Knoxville, in the field of optics in 1985. He is currently a chair professor at School of Computer and Communication Engineering, Daegu University, Gyeongsan, Kyungbuk, Korea. His areas of interests include three-dimensional imaging, electro-holography, and laser-based optical instrumentation. Dr. Son is a fellow of SPIE and chairing SPIE conference "3 Dimensional Imaging, Visualization and Display.

19. Status and Prospects of Integral Imaging after 100 Years of History
- Prof. Byoungho Lee (Seoul Nat'l Univ., Korea)

The concept of integral imaging, which used to be called integral photography, was devised by Gabriel Lippmann in 1908, which was the year of his receiving Nobel Prize in Physics. The idea is quite simple. A pickup device like film or camera picks up different perspectives of an object through a two-dimensional (2D) lens array located in front of the pickup device, which looks like dragonfly's eyes. The picked up image is called elemental image and it is displayed after some signal processing on display device like a flat panel display. Then, three-dimensional (3D) image can be observed through another 2D lens array.

The integral imaging technology has several advantages: It does not require any viewing aids such as polarization glasses. It provides not only horizontal but also vertical parallaxes. It provides quasi-continuous 3D images to multiple observers within a viewing angle. It can be combined easily with current flat panel display technology to display dynamic images. However there are some disadvantages as well. The image resolution is worse than that of some autostereoscopic technologies such as lenticular lens method or parallax barrier method. The implementable depth range with good resolution is limited. The viewing angle is not as large as that of conventional 2D display systems.

Many research groups in Europe, Japan, USA, Greece and Korea have been studying on diverse aspects of integral imaging. Although it is impossible to summarize all works in a short article or talk, I will try to explain some key improvements and also explain some works of my research group.

To increase the viewing angle of integral imaging, the lens switching method was invented. The display panel area behind the closed lenses can be used for open lenses to increase the viewing angle. The switching can be done with 120 Hz by either polarization switching technique or by use of another transparent liquid crystal panel. Other methods such as embossed screen and curved screen have also been proposed. To enhance the expressible depth range with good resolution, the methods such as longitudinal movement of lens array, use of birefringence material, and use of multiple display panels or electrically-controllable screens adopting polymer-dispersed liquid crystal (PDLC) were proposed. To enhance lateral resolution of integrated images, the methods such as lateral movement of lens array, time multiplexing by the movement of pinhole patterns on another display panel, rotation of prisms, spatial multiplexing by using multiple projectors have been proposed.

Another important area is 2D-3D convertible integral imaging. Development of 2D-3D convertible systems is important for the system to get into real market. My group has proposed various methods for this purpose, such as the use of PDLC, double-panel system, fiber array, electroluminescence sheet backlight and organic light-emitting diode backlight.

Recently, there have also been many good research results on signal processing for (or based on) integral imaging, such as intermediate view generation, 3D depth recognition and 3D correlators.

Some good human-interactive demonstration systems of Japanese companies and European research group suggest new application fields of this integral imaging. In the presentation, I will also discuss this issue as well as prospects comparison with other autostereoscopic technologies.

Byoungho Lee received his B.S. and M.S. degrees in electronics engineering from Seoul National University, Korea in 1987 and 1989, respectively. And he received his Ph.D. degree in 1993 from EECS, University of California at Berkeley. Since 1994 he has been with the School of Electrical Engineering, Seoul National University as a faculty member, where he is a full professor now. He became a Fellow of the SPIE in 2002 and a Fellow of the Optical Society of America (OSA) in 2005. Currently, he is a Director-at-Large of the OSA, a member of the Awards Committee of Board of Directors of OSA, and topical (associate) editor of Applied Optics and the Journal of the Society for Information Display. He is also serving as the Director of International Relations of the Optical Society of Korea (OSK) and a Director of Strategic Planning of the Korean Information Display Society. In the past he served as a member in the Engineering, Science and Technology Policy Committee of the SPIE, and an associate editor of Optical Fiber Technology and the Japanese Journal of Applied Physics. His laboratory was honored and supported by one of the first National Research Laboratories by the Ministry of Science and Technology of Korea. Currently his laboratory is honored and supported as a National Creative Research Initiative Center. He received the fifth Presidential Young Scientist Award in 2002 and the 2006 Academic Award of the OSK as well as several awards for research and teaching from the College of Engineering, Seoul National University. He has published or presented more than 220 international journal papers and 350 international conference papers including about 40 invited papers in the fields of diffractive optics, three-dimensional display, fiber-optics and nano-photonics.

20. Stereoscpic Imaging and Diplay Systems for 3-D Mobile Phone Service
- Dr. Min-Chul Park (Principal Researcher, KIST, Korea)

Stereoscopy has a long history over 170 years. In my presentation 3-D imaging and display technology will be reviewed in the aspect of development of commuication stage. General stereoscpic imaging and display systems will be explained, and 3-D mobile phone service as an application will be focused. As 3-D imaging layouts under mobile enviroment the parallel and radial types will be described. Two types of autostereoscopic displays will be introduced.

There is growing interests of displaying 3-D images on the mobile phone for the purpose of gaming, visual communication and new service development. A mobile phone has strength in the networking capability and portability. Now it is becoming a personal mobile multimedia center for communication, broadcasting and internet use. Wired communication methods are already evolved into wireless ones. At the same time the typical telecommunication media is changing from a monotone voice to 2-D multimedia. There has been much attention to 3-D multimedia because it makes people experience similiar environment where they live in. On the other hand, the incompleteness of 3-D display technology had been an obstacle to popularization.

Recent development of technology is making another breakthrough in 3-D display. Some of 3-D technology research groups or companies already presented several types of 3-D mobile phones. Most of them are developed based on a parallax barrier or lenticular lens approach realizing autostereoscopic displays for portability and convenience of their use. At the same time the parallel type layout is assumed in projection-type 3-D imaging systems. Up to now the radial type layout is hardly realized in mobile phone 3-D imaging systems though they have strength in satisfying fusible 3-D images taken in a short distance.

3-D mobile visual communication requires to integrating technologies of 3-D image display, processing and mobile networking. A slanted parallax barrier generates viewing zone to the viewer without Moiré effect, but the complexity of the structure causes computational burden. However, typical parallax barrier strip has a strength in reducing computational burden and it eventually saves electric power. Strength and weakness of each imaging layout and display method for 3-D mobile phone service will be discussed.

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Research interests: 3D display technology, image processing, visual communication, HCI

21. Recent R&D Activities on 3D Information Technologies in Korea as well as 3DRC
- Prof. Eun-Soo Kim (Kwangwoon Univ., Korea)

Thus far, three big technologies of stereoscopy, integral imaging and holography have been mostly employed for implementation of 3D imaging and display systems. Particularly, this year of 2008 is the 170th, 100th and 60th anniversary since the stereoscopy, holography and integral photography has been born in 1838, 1908 and 1948, respectively. In my presentation, development progresses of these technologies are overviewed and their future development prospects are also discussed. In addition, recent R&D activities on 3D information technologies in Korea including the 3DRC are presented and finally several 3D display prototypes developed by the 3DRC are demonstrated.

Eun-Soo Kim received his B.S and Ph. D degrees in electronic engineering from the Yonsei University in 1978 and 1984, respectively. In 1981 he joined the faculty of Kwangwoon University, Seoul, Korea, where he is presently a professor at the Department of Electronic Engineering. He was a visiting research associate at the Department of Electrical Engineering, California Institute of Technology, Pasadena, USA. He's research laboratory was honored and sponsored as a National Research Laboratory (NRL) of 3D Media by the Ministry of Science and Technology of Korea in 2000. In 2003, his research center of 3DRC(3D Display Research Center) was also honored and sponsored as a ITRC(Information Technology Research Center) by the Ministry of Communication and Information (MIC) of Korea, where he has been acting Director of the 3DRC since 2003. At the same time, he served as the President of the 3D Society of 'Korean Information Display Society (KIDS)' and the Chairman of the '3D-SIG of Korea' sponsored by the Electronic Display Industrial Research Association of Korea (EDIRAK) since 2000 and 1998, respectively. Presently he is acting the President of the 'Society of 3D Broadcasting and Imaging (S3BI)' as well as the Vice-President of the 'Korean Information and Communications Society (KICS)'. In addition, he organized and annually held the 'Workshop on

Optical Information Processing' sponsored by the Optical Society of Korea (OSK) since 1996 and the 'Workshop on 3D Display Technology' sponsored by the EDIRAC and 3DRC since 1998. He also established the 'International Workshop on 3D Information Technology (3DIT)' in 2004 as well as he co-organized the 'International 3D Fair' in collaboration with '3D Consortium of Japan' in 2006. He has 50 patents and published about 500 papers in the international journals and international conferences in the fields of stereoscopic/ multi-view 3D imaging & displays, holographic/ volumetric/ spatial 3D imaging & displays as well as he produced about 200 M.S and Ph. D students. He received 7 kinds of scientific and academic awards from the Institute of Electronics Engineers of Korea (IEEK), Korea Information and Communications Society (KICS), Korean Federation of Science and Technology Societies (KFSTS), LG Group and Kwangwoon University. Furthermore, in April 2003, he received the Order of Science and Technology Merit from President of the Republic of Korea, Roh Moo-hyun for his meritorious services in academic achievements and contributions towards national scientific and technological development in the last 25 years.

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