Pushing 3DTV frontiers: 3D holoscopic imaging

Creating a truly realistic 3D real-time viewing experience in an ergonomic and cost-effective manner is a fundamental engineering challenge. Dr AMAR AGGOUN, Reader in Information and Communication Technology at Brunel University, describes the EU-funded 3D VIVANT project he coordinates which seeks to advance the 3D holoscopic imaging technology.

Creating 3D content has been the goal of many researchers in academia and industry as well as artists for many years in cinema, TV and performing arts. Today's digital era is characterised by a user-led digital media renaissance that expands from taking photos and video to producing 3D content.

Creators always look for new forms and ways of improving their content and adding new sensations to the viewing experience. High definition video has been the latest innovation in the area of content enrichment. 3D is the next single greatest innovation in filmmaking.

Recent film releases such as *Avatar* have revolutionalised cinema through the extensive use of 3D technology and 3D content production along with real actors, and in doing so creating a new genre at the outset of the 2010s.

The success of 3D cinema has led several major consumer electronics manufacturers and broadcasters to launch 3D-capable TVs and offer 3D content. 3DTV will require the integration of a diversity of key technologies from computing to graphics, imaging to display, and signal processing to communications.

There are a number of competing 3D technologies available, and the decision to support 3D will require an understanding of the relative merits and drawbacks of each technology in the context of the home. The provision of 3D content into the home will require significant cooperation between content providers, service providers and consumer electronics manufacturers to ensure consumer confidence in the technology and avoid a repetition of the confusion surrounding the introduction of HD technologies.

Today's 3DTV technology is based on stereo vision, where left-eye and right-eye images are presented to the viewer through temporal or spatial multiplexing by wearing a pair of glasses. Usually, the content is captured using two cameras mounted on a rig. Nevertheless, there are few manufacturers that provide a single camera setup for the capture of the left-eye and right-eye images.

The next step in 3DTV development could be the multiview autostereoscopic imaging system, where a large number of pairs of video signals are recorded and presented on a display that does not require glasses for viewing.

Although, several autostereoscopic displays have arrived on the market, there are still limitations on resolution and viewing position. Furthermore, stereo and multiview technologies rely upon the brain to fuse two disparate images to create the 3D immersion. As a result, such systems tend to cause eye strain, fatigue and headaches after prolonged viewing as users are required to focus on the screen plane (accommodation), but to converge their eyes to a point in space in a different plane (convergence), producing unnatural viewing.

With recent advances in digital technology, some of these human factors, which result in eye fatigue, have been eliminated. However, some intrinsic eye fatigue factors will always exist in stereoscopic 3D technology.

The 3D holoscopic solution

Creating a truly realistic 3D real-time viewing experience in an ergonomic and cost-effective manner is a fundamental engineering challenge. Future 3D technology should seek to advance the current existing technologies, not only in capturing and manipulating 3D content, but also in creating a new 3D content format which offers fatigue-free viewing for more than one person, independently of the viewer's position.

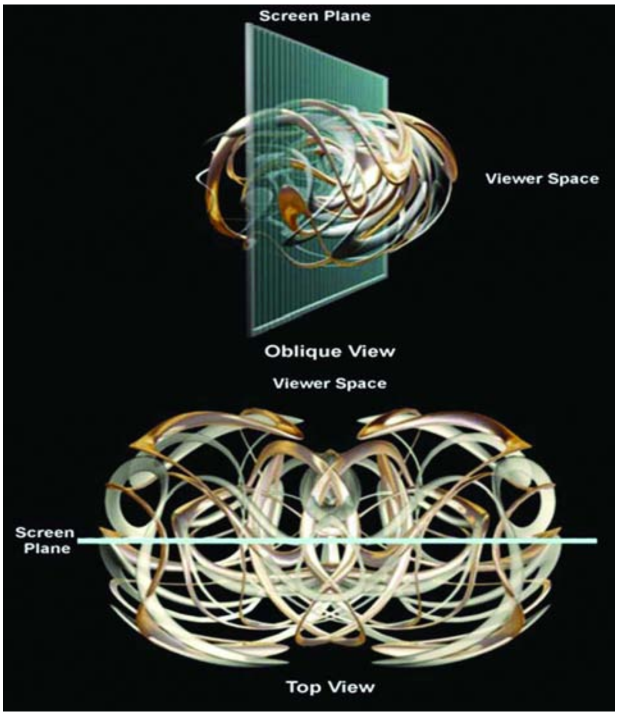
3D holoscopy and holography are two technologies that overcome the shortcomings of stereoscopic imaging, but their adoptions for 3D TV in the home are still in their infancy. The next-generation 3D TV systems will require the creation, development and integration of a range of components from both technologies.

A project funded by the European Union – EU-FP7 ICT-4-1.5 – Networked Media and 3D Internet, entitled "3D Live Immerse Video-Audio Interactive Multimedia" (3D VIVANT) will attempt to make a number of advances in the 3D holoscopic imaging technology for capture, representation, manipulation and display of 3D content.

3D holoscopic imaging (also referred to as Integral Imaging) is a technique that is capable of creating and representing a true volume spatial optical model of the object scene in the form of a 'planar intensity' distribution, by using unique optical components.

It is akin to holography in that 3D information recorded on a 2D medium can be replayed as a full 3D optical model. However, in contrast to holography, coherent light sources are not required. This conveniently allows more conventional live capture and display procedures to be adopted.

Furthermore, 3D holoscopic imaging offers fatigue-free viewing to more than one person,



independently of the viewer's position. With recent progress in the theory and microlens manufacturing, 3D holoscopic imaging is becoming a practical and prospective 3D display technology and is attracting much interest in the 3D area. It is now accepted as a strong candidate for next-generation 3D TV.

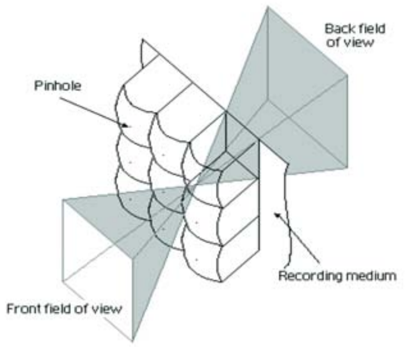


Figure 1. Recording of Integral Photography

The merits of 3D holoscopic imaging technology can be summarise as follow:

- 3D holoscopic imaging methodology uses the principle of 'Fly's eye' and hence allows natural viewing of objects (i.e. fatigue-free viewing);
- Based on physics, duplication of light field, true 3D technique;
- Uses incoherent radiation and forms an image that is a sampled representation of the original object space, to scale and in full colour;
- The 3D content is captured using a single-aperture camera in real-time;
- The 3D content can be viewed by more than one person and independently of the viewer's position;
- The original scenes are replayed in full colour and with continuous parallax in all directions (both horizontal and vertical).

The first 3D holoscopic imaging method was 'Integral Photography.' The recording of an integral photograph use a regularly-spaced array of small lenslets closely packed together in contact with a recording medium. Each lenslet views the scene at a slightly different angle to its neighbour and therefore a scene is captured from many viewpoints and the parallax information is recorded (Figure 1).

After processing, if the photographic transparency is re-registered with the original recording array and illuminated by diffuse white light from the rear, the object will be constructed in space by the intersection of ray bundles emanating from each of the lenslets.

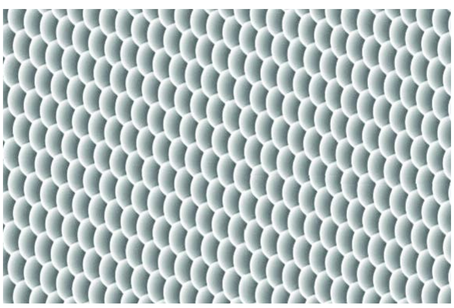


Figure 2. Magnified section of a microlens panel

One of the main drawbacks of this process is that replay of the reconstructed images were pseudoscopic, or depth reversed, where the foreground becomes the background and vice versa.

Optical and digital techniques to convert the pseudoscopic image to an orthoscopic image (i.e., with correct depth) have been proposed over the last two decades. The 3D VIVANT project is investigating a number of solutions to provide a 3D holoscopic camera which can capture 3D video in real-time and with correct depth perception.

A 3D holoscopic camera system comprising microlens array, relay lens and digital camera sensor has been constructed. The microlens array has a hexagonal arrangement of lenses to maximise the fill factor. The system will record live images in a regular block pixel pattern. The planar intensity distribution representing a 3D holoscopic image is comprised of a 2D array of MxN micro-images due to the structure of the microlens array used in the capture.

Figure 2 shows a magnified section of full parallax 3D holoscopic image capture using the 3D holoscopic camera. The hexagonal shape of the microlens array is clearly visible. It shows a mannequin with 50x50 pixels

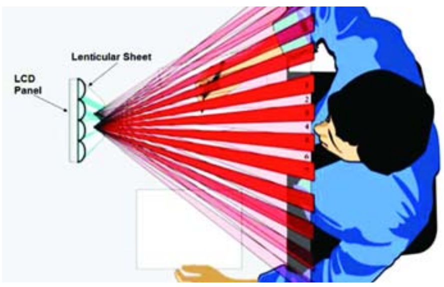


Figure 4. Viewing 3D holoscopic images

under each microlens.

Figure 3 shows a unidirectional 3D holoscopic image. In this case the hexagonal microlens array is replaced with a cylindrical lens array which provides horizontal parallax only.

The replay of the 3D holoscopic images is achieved by placing a microlens array on top of a high resolution flat panel used to display the recoded planar intensity distributions (Figure 4).

A software tool that extracts high resolution viewpoint images was developed. Figure 5 shows an example of two high resolution viewpoint images extracted from the 3D holoscopic image shown in Figure 3. The two images represent two distinct views of the captured scene which can be used to form a stereo image.

In a nutshell, the major innovations 3D VIVANT envisions lie in the research and development of:

- Novel visual sensations and experiences beyond HDTV to the content production and user communities;
- Use of a single camera to capture real 3D

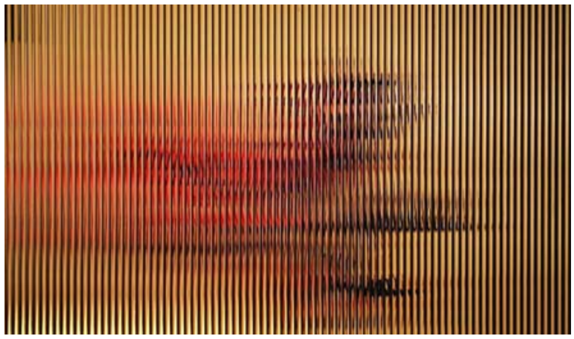


Figure 3. Unidirectional 3D holoscopic image

Figure 5. Two viewpoint images extracted from Figure 3.

content in live outdoor events and settings (beyond the studio constraints), and hence allowing for conventional live capture procedures to be adopted;
- Ultra high resolution (Bbond HDTV) image sensor devices and 3D cameras;
- Display of 3D content with high quality as well as lower quality from a single camera capture; using various technologies to display 3D Holoscopic content;
- Fatigue-free viewing of high resolution 3D content by audiences of more than one person, independently of the viewer's position and without the need for head tracking;
- Novel intelligent 3D content generation and display including both real and virtual 3D content; real-time techniques for generating virtual 3D Holoscopic content;
- Novel 3D audio generation and playback techniques;
- Novel techniques for 3D object extraction and recognition;
- Novel algorithms for 3D Holoscopic content indexing and searching;
- Novel algorithms for coding and delivery of 3D Holoscopic content.

The author gratefully acknowledge the support for this work that is funded by the EU under the ICT programme as the project 3D VIVANT (ICT-2010-248420).

BIOGRAPHY

Dr AMAR AGGOUN is a Reader in Information and Communication Technologies in the School of Engineering and Design at Brunel University, in the UK. He has led and contributed to a number of research projects on 3D TV technologies, some in collaboration with Princeton University. Amar is currently the principal coordinator of the EU-funded project '3D Live Immersive Video-Audio Interactive Multimedia' (3D VIVANT), a project examining 3D holoscopic imaging technology for capture, representation, manipulation and display of 3D content. Contact: Amar.Aggoun@brunel.ac.uk

kdg

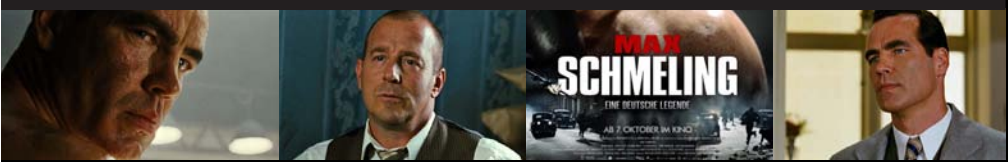
best utility.*

tag2play™

in cooperation with kdmds

Barcode activates trailer.
Simply scan with a
2-D barcode app.

* It's so simple: just attach tag2play™ barcodes to your posters, advertisements and media products. One click on a smartphone is all it takes to download the relevant trailer. And the really smart thing about it all: tag2play™ automatically recognises which video format needs to be activated and transmitted. Now isn't that clever? But don't take our word for it, try it out for yourself, right now!
kdg. service innovation in best condition.



(A) (G) Tel +43 (0) 5634 500, sales@kdg-mt.com
(I) Tel +39 0473 209505, frontdesk@kdg.it
(F) Tel +33 (0)146 100210 kdg.france@kdg.fr
www.kdg-mt.com

www.kdg-mt.com

kdg international
austria germany france italy