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Holography, Stereoscopy and Blender 3D

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Abstract: - This paper shortly describes Blender 3D modification and its use for the design of mechanical parts. The 3D modification of the Blender modeling system and experiments made brought interesting results especially from the human-computer interaction field. The modification relies on the stereoscopy based devices which are currently available at the market. However, the stereoscopy has some drawbacks described. We also described shortly some alternative approaches including holography based devices which are considered as future "ultimate" display technology.

The modified Blender 3D system can be downloaded from the WEB site for experiments and testing perception issues in a design of geometrical models.

Key-Words: - computer graphics, stereoscopy, holography, 3D display, Blender 3D, modeling.

1 Introduction

3D displays and 3D films are becoming a hot topic from the user's point of view. Available systems are based on different principles. 3D images, capturing, transmission and displaying can be seen even with such systems like SKYPE etc., see Fig.1.

Fig.1

Generally 3D devices are based on a stereoscopy principle, in which slightly different images are produced; one for the left eye, the second one for the right eye. Images are produces by two cameras displaced with a disparity (distance between cameras), usually 65 mm, and their axes are parallel, convergent or divergent. There are two basic principles of stereoscopic displays:

- auto-stereoscopic (no glasses are required) and
- stereoscopic using some kind of glasses [28].

If pseudo-colors can be used, ChromaDepth glasses might be used as well [22]. This technology is based on optical refraction as different light wave lengths have different refractions. Also anaglyph glasses are quite popular [14], [18]. This technology is based on filtering in principle. Those technologies can be used for 3D printed images as well.

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The Infitec technology [25] is primarily based on filtering and filters for each eye have different wave lengths for RGB:

- Left eye: R: 629[nm], G: 532[nm], B: 446[nm]
- Right eye: R: 615[nm], G: 518[nm], B: 432[nm]

However, it is necessary to note that stereoscopy, in principle, creates only an illusion of 3D perception. Also if a user uses a stereoscopy system for a longer time, he might have a serious problem as his eyes are forced to be focused at the projection plane that is mostly fixed.

The auto-stereoscopy displays mostly use lencticular arrays [26] or parallax barrier approach [19]. Other stereoscopy based displays use passive polarization of the light, time or wavelength multiplexing.

There are three significant disadvantages of all systems based on stereoscopy. The images have to be generated for the given resolution of the stereoscopic device and expected size of the projection screen.

- If the resolution is changed, the image has to be regenerated or re-sampled.
- If the screen size is changed, the disparity is changed as well and divergence parallax can occur.
- The "correct" visual perception has only one user, other user, e.g. users of virtual reality systems, has slightly incorrect perception.

There are also volumetric displays [29]. Volumetric displays are quite technologically complex devices.

They have an advantage that the generated 3D image can be observed from different angles even from the opposite sides. However they are very expensive and require not a small space for an installation.

On the other hand, displays based on a holography principle are quite promising for the future as the optical wave is actually generated. However there are several limitations due to the current technology and amount of data generated, transmitted and rendered [6] - [10]. A complete overview of stereoscopic and auto-stereoscopic displays is given in [15].

If a spherical optical field is generated Full Parallax (FP) hologram is obtained. In the case of the Horizontal Parallax Only (HPO) hologram a cylindrical light filed is generated. In the case of FP, the user have a valid view from all points for which the hologram was generated – generally in E^3, while in the case of the HPO the user's perception is valid only if he moves horizontally. Generally speaking, if users are at different positions their perception is correct and different as in the reality [24].

2 Holography

Digital holography is quite challenging topic. It simulates the light propagation in the space. As the wave length is very small 380-780 nm, many physical phenomena plays a significant role. The main difference between photography and "standard" image rendering is that we need to

- record intensity and
- the phase of the light wave.

If captured data are to be displayed or rendered the coherent light is needed. There are several obstacles in holography:

- image capturing day light is not coherent
- data compression – it is an unsolved problem how to compress holographic data
- data transmission – large amount of data for each frame as we need to transmit "all possible" views of the scene (from this point of view a practical use will be probably multi-view technology)
- displaying the data – we need to produce a light field actually. Current Spatial Light Modulators (SLM) are very expensive and have a very low resolution in the relation of the wave light length needed etc.

The research activities at the University of West Bohemia (UWB) were targeted to a hologram generation from synthetic scenes. Geometrical modeling systems were used to produce 3D scenes. One of them was the Blender system [20], [21].

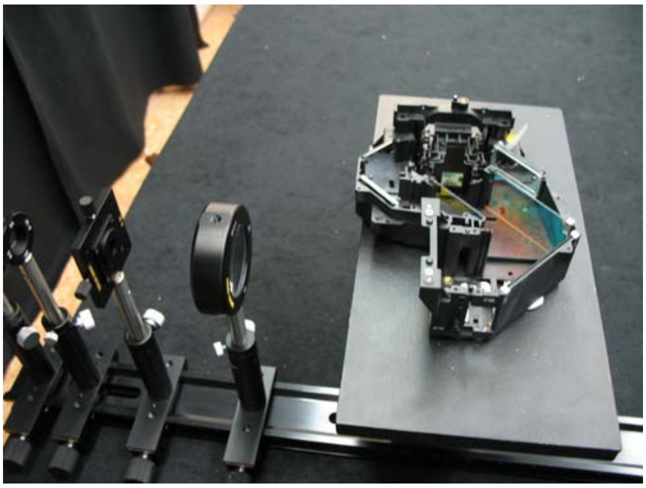

Fig.2: Laboratory set up for 3D scene holographic rendering using optical bench at the UWB

For a hologram rendering a coherent light is needed. A red laser was used the beginning of experiments latter on a LED light source has been used especially for the safety reasons. The experimental system was built using a standard data projector. It enables also a color set up as white LED actually emits RGB wave lengths. This practical solution enabled us to verify principles of holograms generation for **static** scenes. The computed holograms were recorded on a high resolution film for those purposes. This set-up enabled us to verify methods developed for a hologram generation from synthetic scenes.

Experiments made were part of the EU MUTED project [27] and of the FP5 EU 3DTV - Network of Excellence project [16].

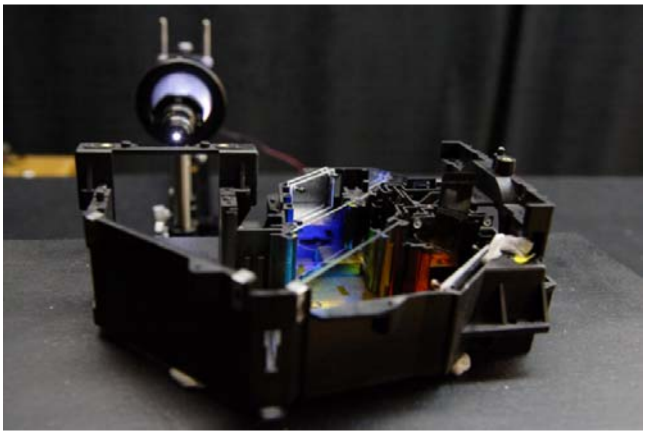

Fig.3: Detail of the Holographic display (static images) prototype at the UWB, Plzen

It seems to that a holographic display, full parallax or horizontal parallax only, is still beyond the level of today's technology especially due to resolution, time of rendering and data transmission.

Another approach has been taken within the MUTED project in which user's position was tracked and hologram generated for his position. The system was designed for up to 8 users, see Fig.4, and cameras were tracking user's position. The MUTED system itself was developed at the De Montfort University (DMU), U.K.

Fig.4: An early prototype of the MUTED display at the DMU used with the Blender 3D system.

Fig.5: The MUTED prototype display set up at the DMU.

However the system was quite complicated also from the mechanical set up, Fig.5 [3]-[5].

Unfortunately, the holography displays technology is far from being mature and ready for deployment.

On the other hand, stereoscopy displays are available today and 3D TVs are ready at the market as well. They are based on the both principles, i.e. on active or passive glasses and on barrier parallax. The advantage of stereoscopy approach is that today's technology enables data capturing and rendering of synthetic scenes as well.

3 Data capturing

Stereoscopy principles, stereoscopy displays and rendering are well known and used many years. The main advantage is availability of technology needed and also displays or TVs are already at the market. Also the recording is not so complicated. There are several affordable set ups for stereoscopy data capturing.

Fig.6 and Fig.7 presents the setups used for experiments at the UWB. The setup with two cameras, Fig.6, was used to capture 60th anniversary of the Plzen City liberation [23] at the end of the Second World War II. Fig.8 presents a simple system when one frame is captured for one eye and the second for the second eye, i.e. time multiplexing system.

Fig.6: 3D setup with two cameras at the UWB

Fig.7: Time multiplexing system with a single camera at the UWB

Also professional stereo cameras are available as well or close to a production, Fig.8-Fig.9. Today's 3D "home" cameras can be bought at an affordable cost.

Fig.8: 3D HD Camera (courtesy of Panasonic)

Fig.9: SONY 3D camera (courtesy of [17])

Fig.10**:** 21st Century 3D stereo camera (courtesy of 21stcentury3d [17])

4 Crosstalk

If the parallax barrier principle is used, there is one more issue – a crosstalk, i.e. some pixels for one eye are seen by the second eye. This is a severe factor in some applications.

There are a lot of problems connected with the stereoscopic images, especially: crosstalk, flickering (especially if temporal multiplexing is used), gradient, frequency response, brightness, dynamic range, banding and resolution [12]. A result of a simple measurement of the crosstalk is on Fig.11.

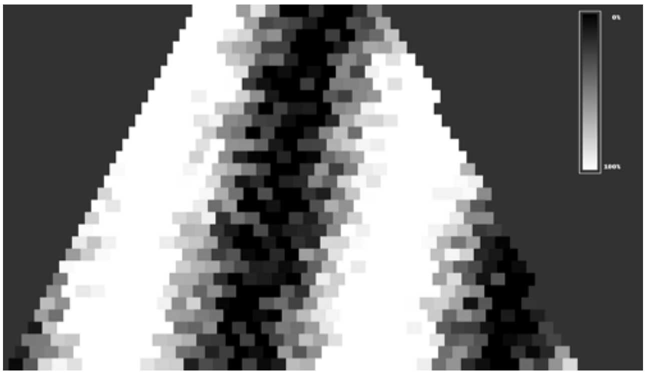

Fig.11: Crosstalk along measured

Fig.11 presents crosstalk measured for the parallax barrier system for the given vertical position as a function of the viewer's horizontal position and distance from a screen. It can be seen that the optimal position (black) depends on the distance from the screen. In an ideal case the image should be symmetrical along the vertical axis.

The crosstalk minimization required a user to be within a very small area that was prohibitive for CAD/CAM applications and also lower resolution due to the barrier principle was not acceptable for precise work. However today's resolution of 3D displays is much higher.

6 Blender 3D

The Blender system is a commonly used for 3D modeling and animation. It is quite powerful and freely available modeling system. As it is intended for the "non-professional" use, the rendering system offers only 2D image. As the code is available, it was a challenge to prepare a modification that would enable rendering of geometrical models on 3D displays using stereoscopy principles.

The modification was actually simple as a scene is needed to be rendered twice in order to get two images for each eye. However there was a complication with the menu and cursor as they are not actually 3D primitives. At the end menu was rendered just for one eye and placed to the projection plane.

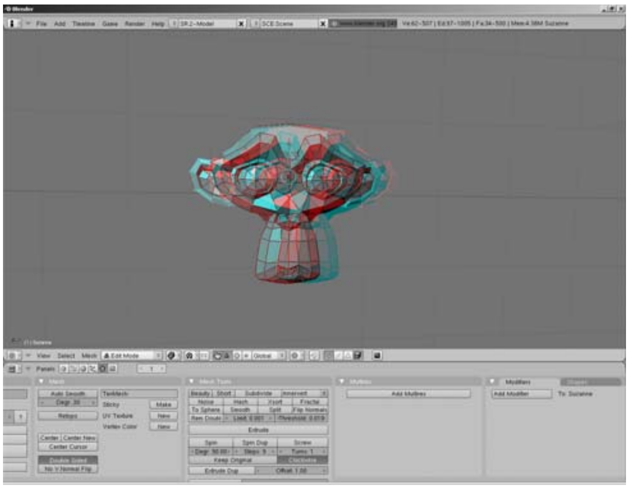

Fig.12: Example of the Blender 3D output

Detailed technical description, documentation and code can be downloaded from [21].

Fig.12 presents an actual screen copy for a very simple object. It can be seen influence of disparity and also a menu of the Blender 3D.

7 Experimental results

The Blender 3D system was experimentally used and tested by professionals and by students of computer science at the UWB in the context of generation of 3D shapes and technical models inspections. Some objects were quite simply shaped, some were quite complex. Most of data and shape design were targeted to industrial mechanical parts, see Fig.13 and Fig.14.

The experiments were provided in a laboratory with controlled lightening conditions. There were the following main conclusions:

- 3D perception helps in scene understanding, especially for the checking the correctness of the mechanical design

- better control in the shape design

However the following drawbacks were detected

- eye strain due to the fixed position of the projection plane – renderer's influence
- neck strain due to the user's spatial position required by the 3D display
- small resolution – property of the 3D display property. It used parallax barrier system and the horizontal resolution was actually half of 2D mode – technological issue

The Blender 3D system was also experimentally modified for the stereo projection wall with two data projectors with the screen size 2 x 1,5 m. In this case the resolution was full as two separate images were generated with passive glasses used and interaction was acceptable for a user. However, users were not used to use large screen in designing the mechanical parts.

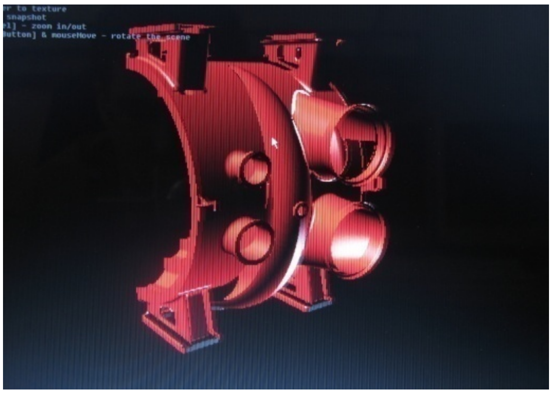

Fig.13: A mechanical part 2 meters in diameter

Fig.14: Ship with 16 cylinders engine model

The cross-talk measurement was made by a digital camera with a precise position setting. However the cross-talk and other measurements were checked by human cross-talk evaluation. A tripod with a precise setting was used, see Fig.15.

Fig.15. Cross-talk measurement verification

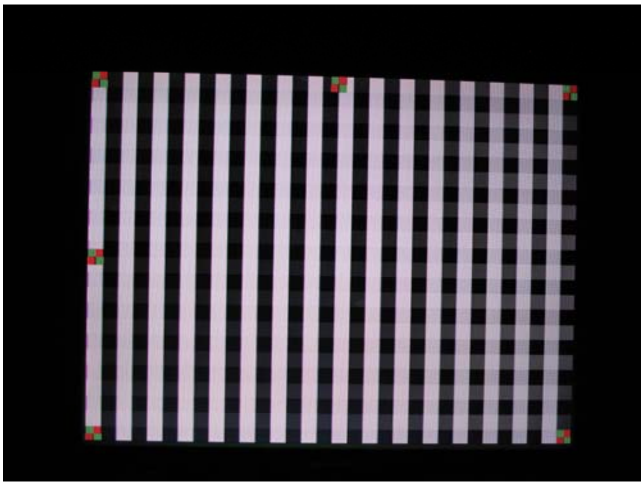

Fig.16: Special screen pattern for cross-talk measurement

In computer based evaluation the image was registered and rotated to a standard position, barrel deformation was corrected and then cross-talk measured for different, but exact positions and evaluated by a computer syste.

8 Conclusion

In this paper we described basic principles for rendering 3D scene and images using 3D output devices based on holography and stereoscopy.

This paper describes the first modification of the Blender for 3D rendering. Originally the system was modified for the SHARP AL3D.

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