Improved cardiac diagnosis and treatments using holographic 3D ultrasound

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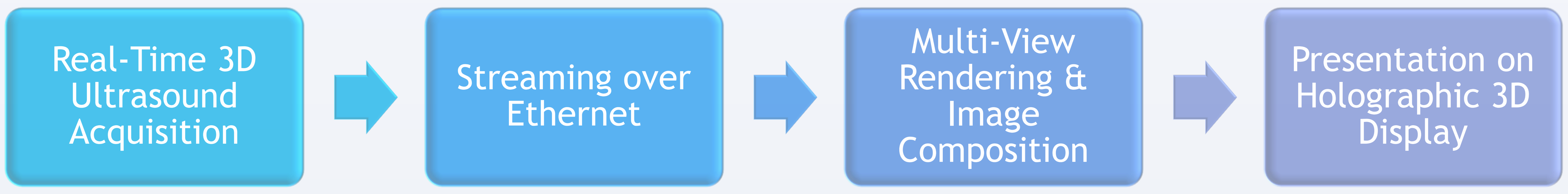

Figure 1. Processing steps of visualization pipeline

INTRODUCTION

Standard volume rendering techniques, which are being used to visualize 3D ultrasound data on a 2D displays are not effective enough for some minimally invasive cardiac procedures. 3D echocardiography aids some of these procedures significantly better than 2D echocardiography (Silvestry, 2009). According to empirical visualization studies on the effectiveness of stereoscopic display in medicine (Beurden, 2012), stereoscopic displays increase the performance of various procedures and enhance visualization of anatomical structures. Such display methods can decrease surgery time and increase its accuracy, when compared to monocular viewing conditions with similar resolution. These results have been proven to be true especially for application of stereoscopic display together with 3D ultrasound in guiding an anchor placement task (Vasilyev, 2008).

Figure 4. 3D ultrasound data being presented on holographic 3D display

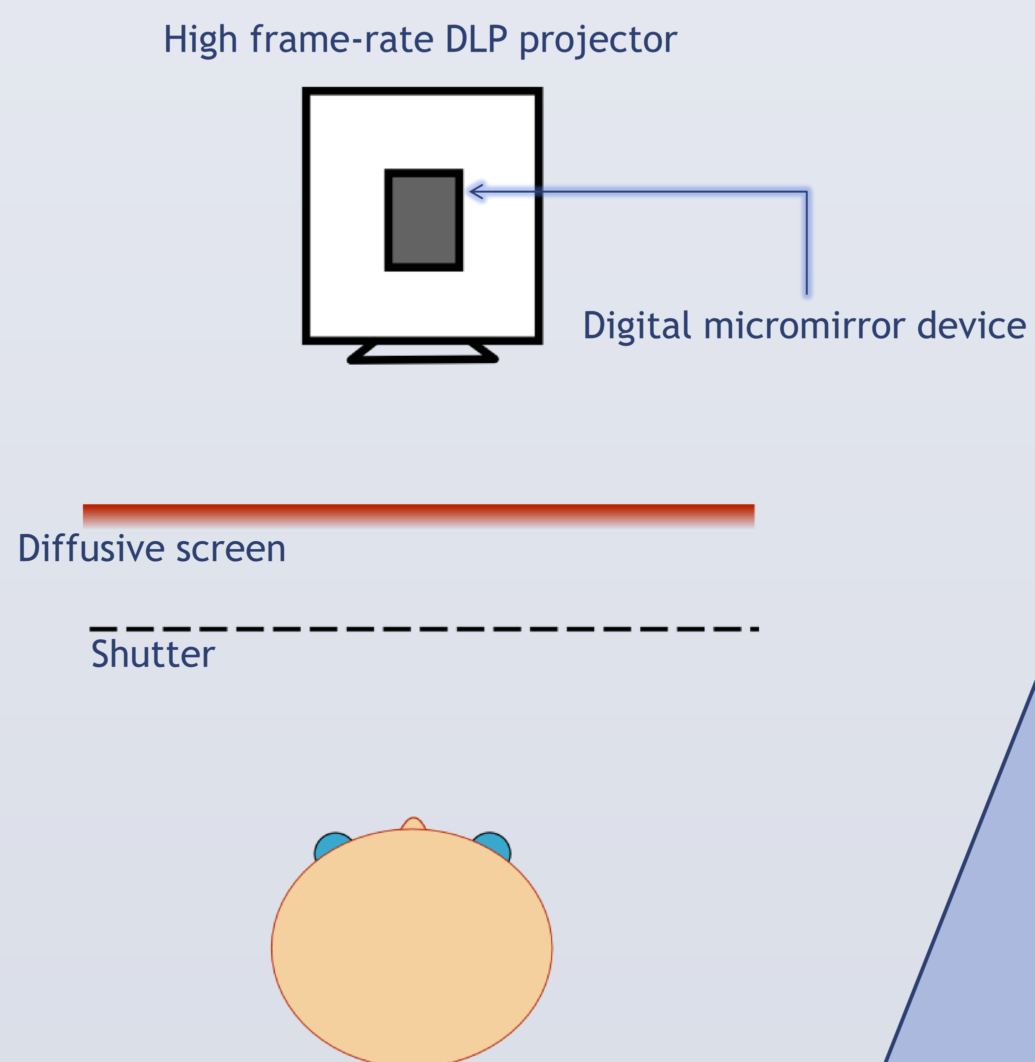

Figure 2. Schematic drawing of the autostereoscopic display

MATERIALS AND METHODS

We used Vivid E9 cardiovascular ultrasound system built specifically for 4D imaging (GE Healthcare, Horten, Norway, fig. 3) together with 20-inch holographic 3D display (Setred AS, Oslo Norway, fig. 7).

The display is autostereoscopic. There is no need for glasses and it allows multiple viewers. Spectator can experience stereopsis and motion parallax. The display with the same image on the screen from different perspective is shown on fig. 5. The main components of the display are presented in fig. 2.

Main idea is that if two eyes of a spectator are looking through a narrow vertical slit, they will see different part of the image on the diffusive screen (fig. 6). Appropriate prepared image sequence being shown on diffusive screen is synchronized with the state of vertical slits.

Prototype application has been implemented, which is capable of rendering a 3D ultrasound data and sending properly prepared images to the display. Unfortunately, frame-rate is far too low to be called interactive.

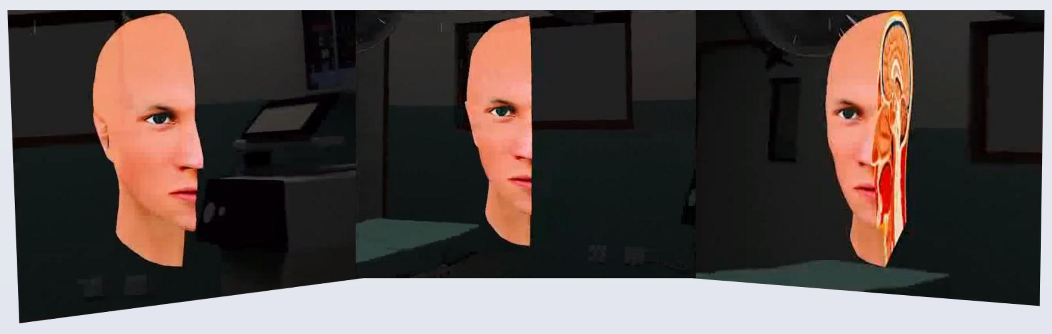

Figure 5. Holographic 3D display being seen from different perspectives

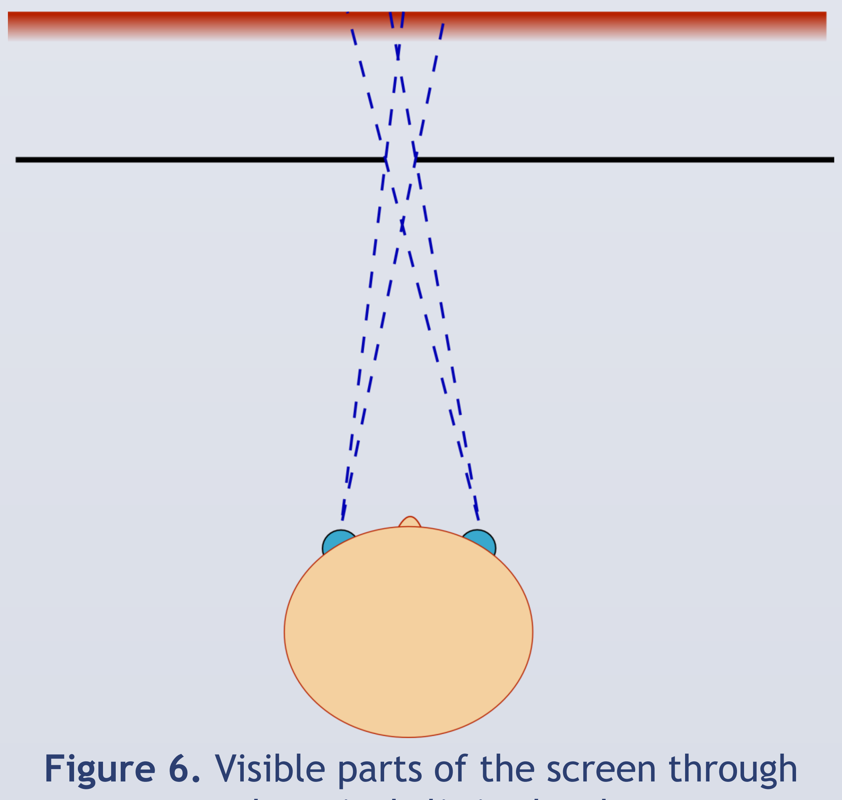

Figure 6. Visible parts of the screen through opened vertical slit in the shutter

DISCUSSION

Rendering process has to be profiled in details and different algorithms for volume rendering will be revisited to find the most promising solutions for bottlenecks. What is more, multi GPU setup can be utilized.

After interactive frame-rate will be achieved, some rendering techniques, to improve image quality and depth perception on holographic 3D display even more, are planned to be implemented and tested.

REFERENCES

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Figure 3. Cardiovascular ultrasound system

Figure 7. Holographic 3D display