Realization of a dome projection system

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A dome projection system based on a color projector with three microdisplays for image generation, an ultra-wide angle projection lens and a separated light source, was designed and realized. The projection system ensures a wide-angle projection of 160°, spot size and chromatical aberration less than ¼ of the pixel size, and an illuminance of about 900lx.

1 Introduction

Dome projection is required in a wide variety of applications, such as (flight) simulators and planetariums, but also in ophthalmologic diagnostics. Recent systems for simulation domes are high-end and high-cost solutions based on multiple rear projections displays (up to 60 projectors [1]) or laser front projection with multiple projectors [2]. These complex systems require only medium quality optics, but very high performance image processing equipment to perform a perfect image matching and to generate a uniform image quality.

We developed a front projection dome display [3,4] with only one projector, designed for small spheres in ophthalmologic diagnostics (diameter 60-100cm). The intention of this system was to generate a 160° dome projection with full color video input from a standard PC and a high quality projection optics.

2 System realization and specifications

For the completion of a dome projection system for ophthalmologic diagnostics, some technical and optical restrictions result from the application. These constraints had to be considered while realizing this projection system:

- projection inside a dome of at least +/-80°,
- full color, high brightness projection necessary,
- no sequential color processing allowed (with color wheel or something similar).

According to these system requirements, a projection system was realized. An ultra wide-angle projection lens achieves the +/-80° dome projection. A three-chip LCoS projector and color splitting polarization optics perform full color projection. The complete optical system is schematically plotted in Figure 1 and lines out the imaging ray trace of the blue channel. As can be seen, the projection lens realizes a quasi telecentric ray trace on the LCoS side. In front of the LCoS display, a field lens is placed. A 90° redirection is included in the projection lens to ensure the best projection position of the system within the complete ophthalmologic diagnostic instrument. An additional aspect of the system design was to obtain modularity to easily exchange components for new developments.

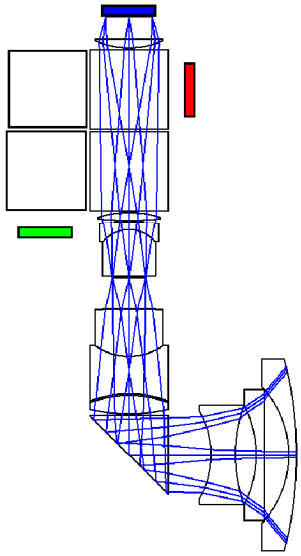

Fig.1 *160° sphere projector with 3-chip LCoS color projection: imaging ray trace for the blue channel.*

The newly developed dome projection system can be characterized by the following parameters:

- illuminance in the projected image approximately 900lx (luminous flux >500lm),
- illuminance homogeneity in the projected image > 75%,
- lateral chromatic aberration < 200 µm (< 1/4 of the projected pixel size),
- optical resolution (spot size) < 280µm (< 1/4 of the projected pixel size),
- modulation transfer function better than 70% absolute for all spatial frequencies down to the pixel size is in the whole dome.

As this new projection system has to fulfill a lot of optical and geometrical restrictions, the optical performance of this system cannot be compared directly with standard multimedia beamers, as these commercially available beamers not fulfill these constraints.

3 System integration

The realized optical system including mechanical mounting, electronics and housing can be seen in Fig. 2. Security aspects for medical products

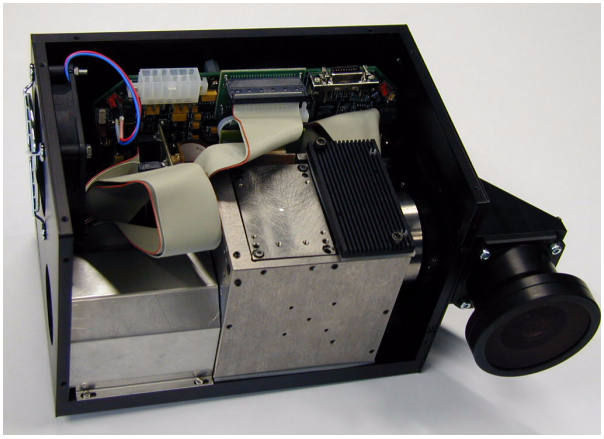

Fig. 2 *Photo of the dome projector.*

(thermal and electrical constraints) have been considered while constructing the projector. Utilizing a 300W Cermax lamp and a fiber optic illumination, a luminous flux of more than 500lm can be achieved.

In Fig. 3, the projection system is arranged in its working position inside a 60cm diameter sphere.

4 Summary

Microdisplays in medical applications offer interesting perspectives for new measurement machines, new system concepts, and extended application areas (e.g. ophthalmology [5]).
For dome projection, systems with an interface to standard electronic image processing equipment (PC or video) are of special interest. Single projector solutions offer this interface, but require specially designed optics for the projection on or inside a dome surface. Thus, the presented optical system opens new applications for low cost dome projection systems, not only for medical applications.
Single projector dome projection as well as medical diagnostic systems is a new application area for microdisplays - both high-technology niche markets with high potential. But for all these devices, specially adapted optical systems are needed. Thus, optical design will play a key role in the development of adequate systems.

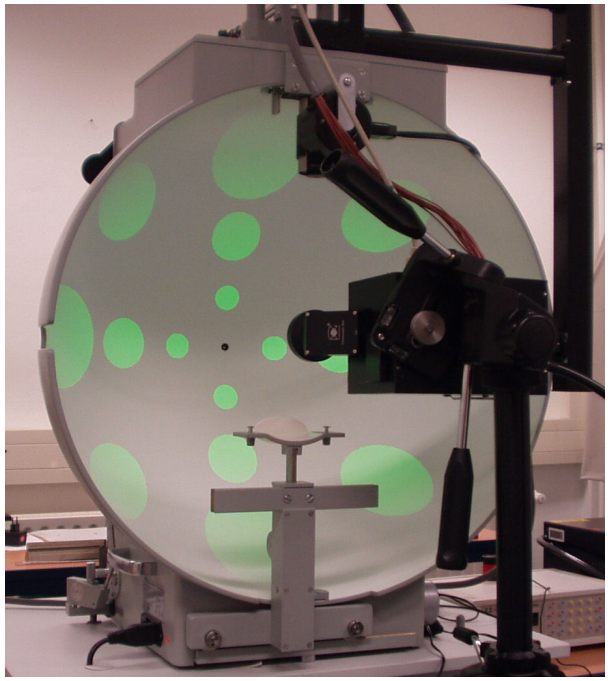

Fig. 3 *Photo of the working dome projection system inside a 60cm sphere.*

5 Acknowledgements

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6 References

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