Design and testing large FOV retinal displays on the basis holographic combiner

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Abstract

We report principles and results of design large FOV retinal display systems by software WinDEMOS and software for computer testing display systems TEDiS. We discuss results design head mounted and head up display. As combiner we are used volume interference recorded or synthetic HOE, and as the sours of the image high resolution transmitting or reflective liquid crystal matrixes on silicon (LCOS) or CRT.

1. Introduction

A retinal display usually presents to the user infinity projected image which combing over his natural field of view. The retinal displays are used for virtual and augmented reality applications such as trainings, games, aviation and automotive systems. Comparison retinal (collimation) and panel displays are resulted on a figure 1. Collimation displays differ an opportunity considerably to reduce time of reaction of the operator for the new information, to reduce fatigue of the operator, owing to absence of necessity for accommodation of sight of the operator, reception of the three-dimensional image and another is possible.

We investigate principles for design large FOV optical systems of displays. The optical systems of display include image forming device, relay lens and combiner. We optimize all this components using software WinDEMOS[1]. We compared and analyzed various optical systems of the retinal display. Specially we discuss design optical system of displays on the basis holographic optical elements. In conclusion we demonstrate computer aided method for testing and aliment optical display systems and software TEDIS.

Retinal (Collimation) vs. Panel display

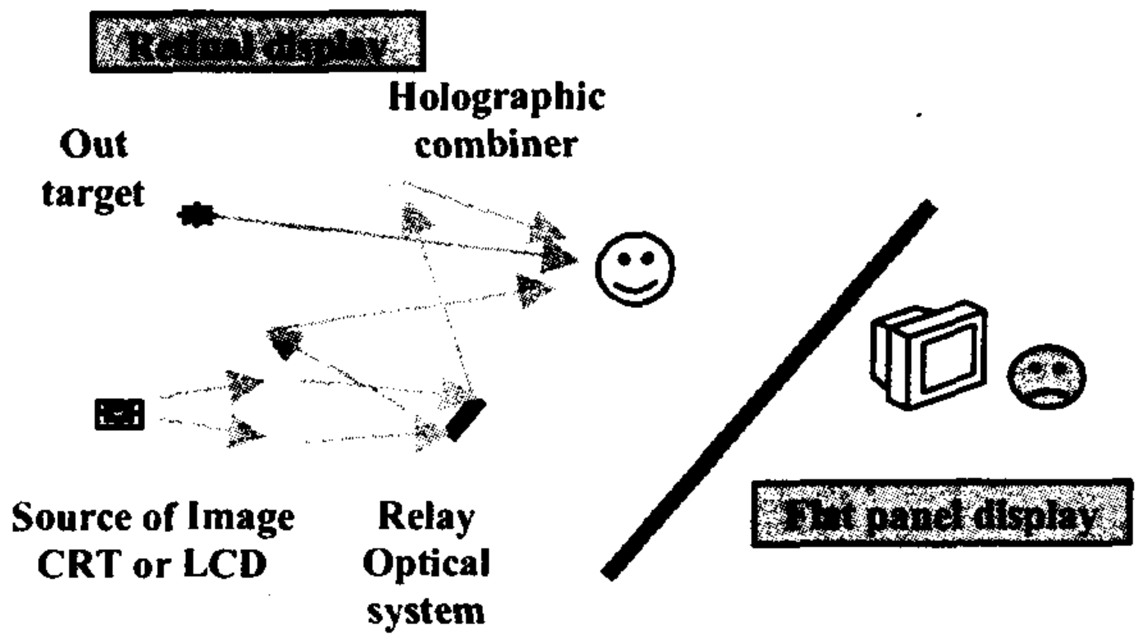


Figure 1

2. Analysis display optical systems and results of design

The principles for design large FOV optical systems of displays:

Theoretical synthesis and numerical optimization Aberration Combiner and relay lens:

- Distortion
- Defocusing and Astigmatism
- Coma
- Spherical aberration
- Parallax errors
- Binocular errors

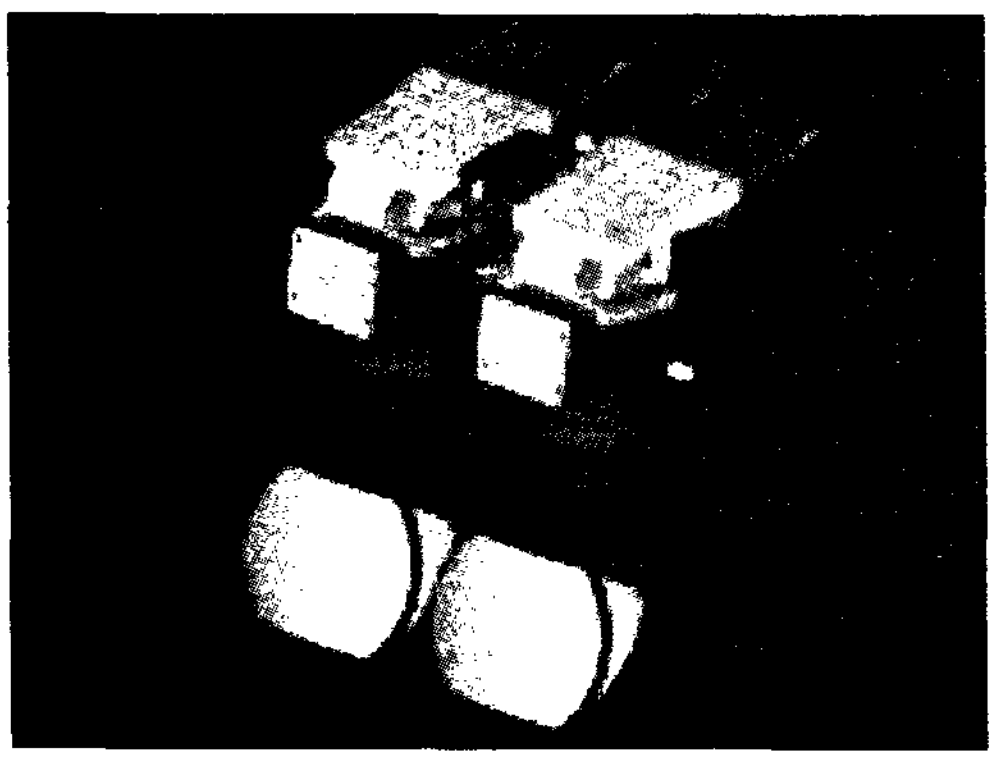
Optimization Diffraction effectiveness of the Combiner

- Spectral and Angular selectivity
- Polarization selectivity

Synthesis and optimization of optical systems of displays have been made with the help of professional software WinDEMOS, the basic futures which are shown below[1-7]:

- ✓ Friendly description language for optical systems data
- ✓ Patent databases (about 3.000 patents)
- ✓ Multiconfiguration analysis and optimisation of optical systems
- ✓ Analysis and optimisation of arbitrarily located surfaces
- ✓ Materials: 8 glass catalogues, IR&UV material catalogue
- ✓ Analysis of beams apertures
- ✓ *Kinoform and Holograms optics*
- ✓ Synthesis of HOE and aspherical correctors
- ✓ *HOE modelling*
- ✓ *Array lens and prisms*
- ✓ *Diffraction analysis*
- ✓ *PSF and images simulation in true colours*
- ✓ *Analysis of polarisation*
- ✓ *Design of coatings*
- ✓ *Design lighting system*
- ✓ *Stereo 3D layout of optical systems*
- ✓ Computer Aided Design (CAD) program interface
- ✓ *Transfer data in ISO 10303 and NODIF-STEP*

As examples we discuss results design head mounted binocular system display on Fig.2,3.



Type	binocular
FOW	30 x 40 deg
Brightness	2000 cd/m2
Mass	350 g
LCOS pixels	1280 x 1024
Image color	Mono - green
Resolution	1 pixel

Figure 2
The optical system of the HMD

Figure 3
Head mount binocular display[8].

This display is basis on reflective LCOS matrices and LED illumination system.

We design optical systems with one, two and three holograms combiner. Examples of the three holograms combiner systems[9] on the basis CRT with FOV 22*30 deg. are shown on Fig. 4,5.

For reduction of the time design and production we used CALS technology and preliminary variant *NODIF-STEP* for exchange data between optical and mechanical CAD.

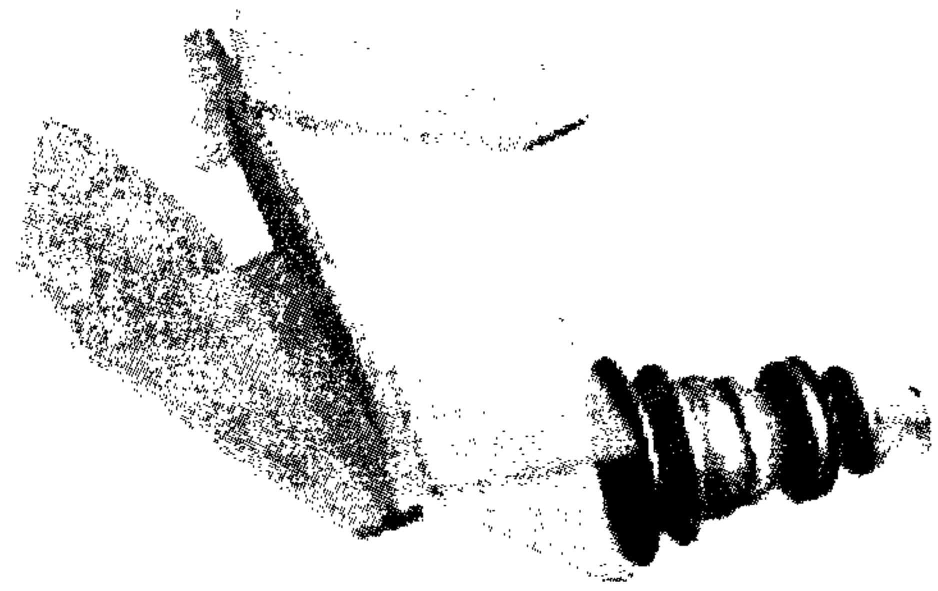


Figure 4
The optical system head up display

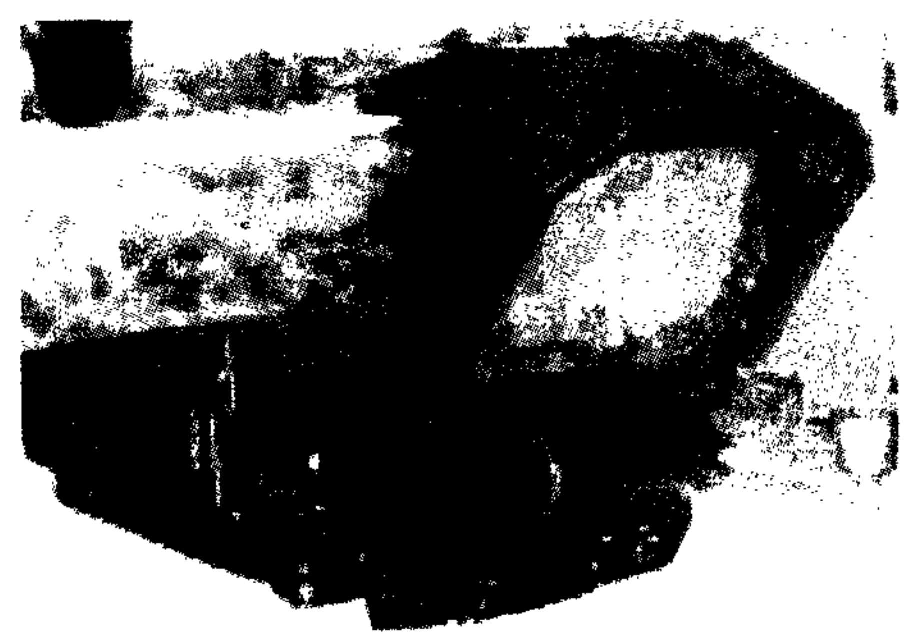


Figure 5
Head up holographic display[9].

3. Testing of display systems

In this report, we introduce a method and software for computer aided testing and evaluating field and pupils aberrations for large FOV display optical systems - TEDIS (TEsting DIsplay Systems). The method based on distogramm registration. Distogramm – is a distribution of distortion aberration at the fixed point on the exit pupil of system.
The setup of registration is shown on the fig.6

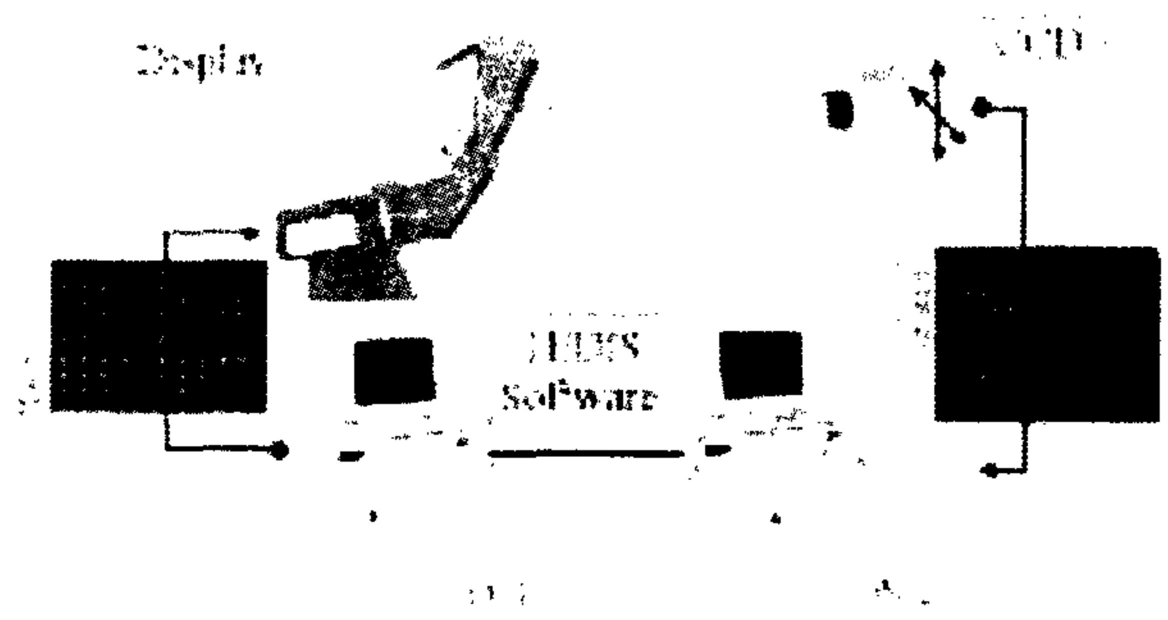


Figure 6

The test equipment consists from the estimated display, the digital camera established on a motorized table and two personal computers, one of which is intended for a conclusion of the test image to the display, and the second for registration and processing of the image. Serial ports of computers are connected to the help of a cable.

The firs personal computer was used to display a test image. The test image consists from elements which coordinates have been designed with account of residual distortions. At formation of the test image it was necessary to provide an opportunity of fast identification of elements of the image. Each element of the image represented a cross shape. Elements of the image settled down as a rectangular grid. The central column and a line have been allocated twice far from the next lines and rows to facilitate their identification. It has provided an opportunity of automatic identification of elements with the help of a computer.

The second computer was intended for registration and processing of the image (see Figure 7). Processing of the image has consisted of several stages. The first stage was recognition of elements and allocation on the image. At the second stage there was an automatic identification of elements of the image. For estimation distortion the following method was used. At first, the central elements were used to estimate a scale and a turn of a grid of elements. Then the distortion was calculates concerning this grid of elements brought by the display in the given point. The assumption that distortion of the central elements is small enough, is fairly only in the certain degree, however calculated thus distortion can be measured more precisely using several iterations.

For the determination of a parallax, the image taken in various points of the pupil zones was compared to the image in the center of a pupil. The deviations characterize a parallax. The received map distortions and parallactical errors approximated by a method of the least squares.

Work of measuring equipment is possible in two modes.

- The first is a direct measurement distortion for an estimation and alignment of the display.
- The second mode is the automated search of residual distortions. Residual distortions are used for generating the test image by a computer.

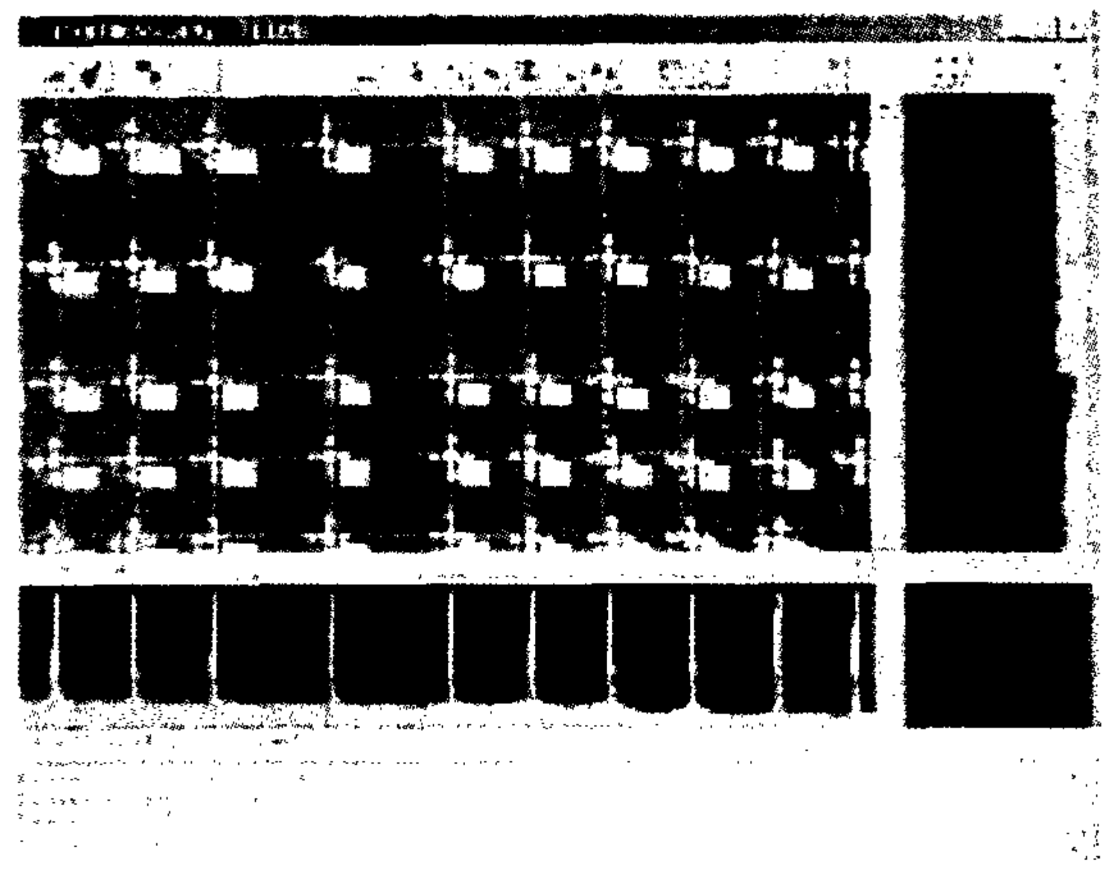


Figure 7

Measuring and processing distogram by TEDIS.

Distorted images compensate residual distortion of the display. Such method, allows achieving good results only in that case when parallactical errors of the display are corrected well enough. In our case the circuit of the display and high quality of its manufacturing allowed to make it.

3. Conclusion

We designed HMD and HUD on the basis holographic combiner for multipurpose applications and computer aided testing method for this systems. This is a pilot project for demonstration effectives of CALS technology in optics.

4. Reference

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