Retinal Projection Display for Low Vision Aid

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Abstract

We developed a Retinal Projection Display for a low vision aid. This device can be applied to a low vision whose visual sense is weak. In the device, a digital image was formed with spatial light modulator(SLM) and projected onto a retina with the Maxwellian View. The image on this display can be seen clearly without our ocular accommodation and a low vision can see it without correction of a refraction error.

1. Introduction

Our ocular accommodation, that is focusing on a image on a display, is necessary in watching TV, movie, PC, and so on. In other words, conventional display is designed for the people whose vision is emmetropia(normal vision). The low vision whose correction of a refraction error is not enough could not observe a conventional display clearly. Then we propose the Retinal Projection Display for them. This display has extremely deep focal depth and its image can be seen without our ocular accommodation. The low vision can see the electronic dynamic image clearly without a magnified lens or another vision aid. It is realized by using the Maxwellian View and electrical device and optical elements.

In this paper, we introduce the principle and structure of Retinal Projection Display and the experiment on validity of optical characteristics and the prototype for clinical examination.

2. Maxwellian View

In the Maxwellian View[1], parallel rays are converged directly at the center of the pupil, and projected on the retina directly. It is used to measure the sensitivity of the human vision system or in experiments of psychological visual perception[2]. Fig.1 shows the principle of the Maxwellian View. The collimated rays irradiates transparent object M which is located on the front focus plane of lens L2, and the pupil of the human eye is located on the back focus plane of lens L2. In this case, Object M and the retina are conjugate, and the light stimulus, which has an extremely deep focal depth, can be observed. The function of this optical system is to have the real image from the small aperture(pinhole) be seen on the pupil[3]. Using this principle, we developed a Retinal Projection Display that can provide an extremely deep focal depth image without causing ocular accommodation.

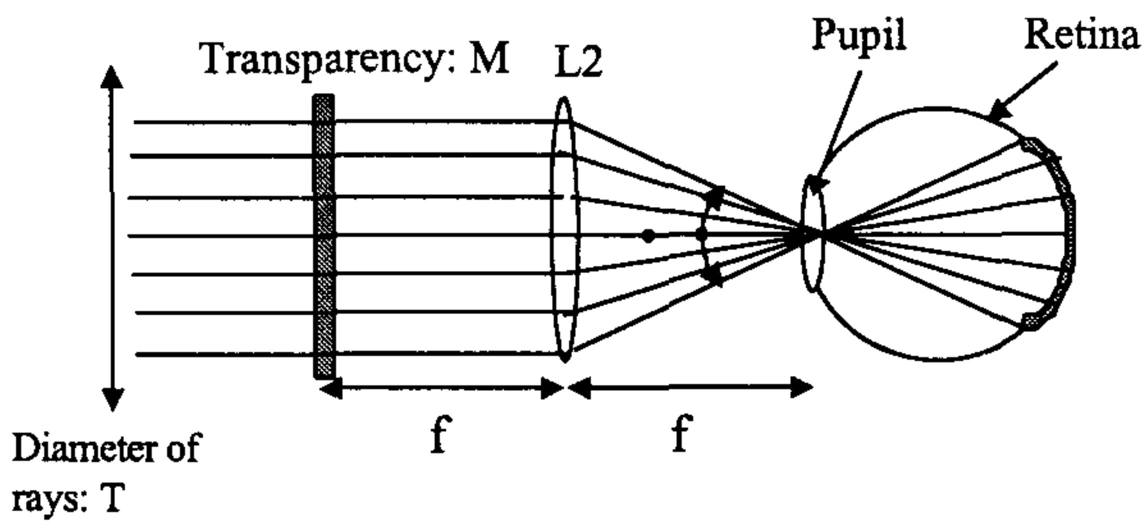

Fig.1 Principle of Maxwellian View

3. Structure of Retinal Projection Display

The structure of the Retinal Projection Display with the Maxwellian View is shown in Fig.2. It converges the parallelrays at the center of the pupil and projects the rays directly on the retina. If parallel rays are emitted from the aperture of the SLM, for example LCD, one straight ray is emitted from each pixel and all the straight rays from the SLM are converged at one point, which in this case is the center of the pupil.

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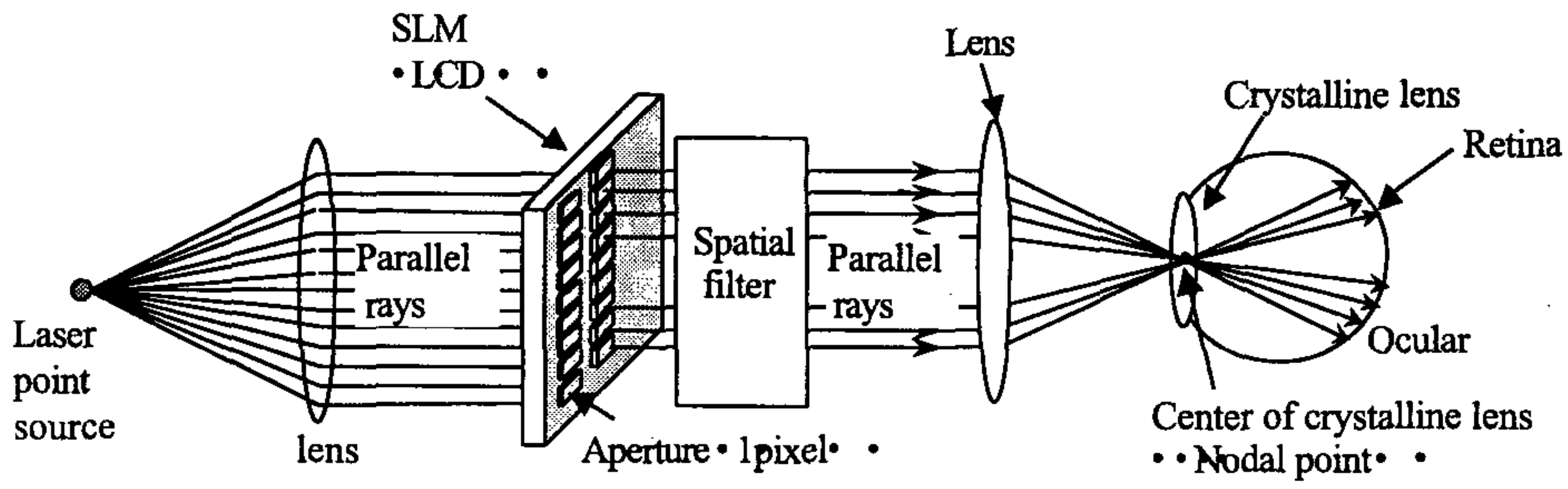


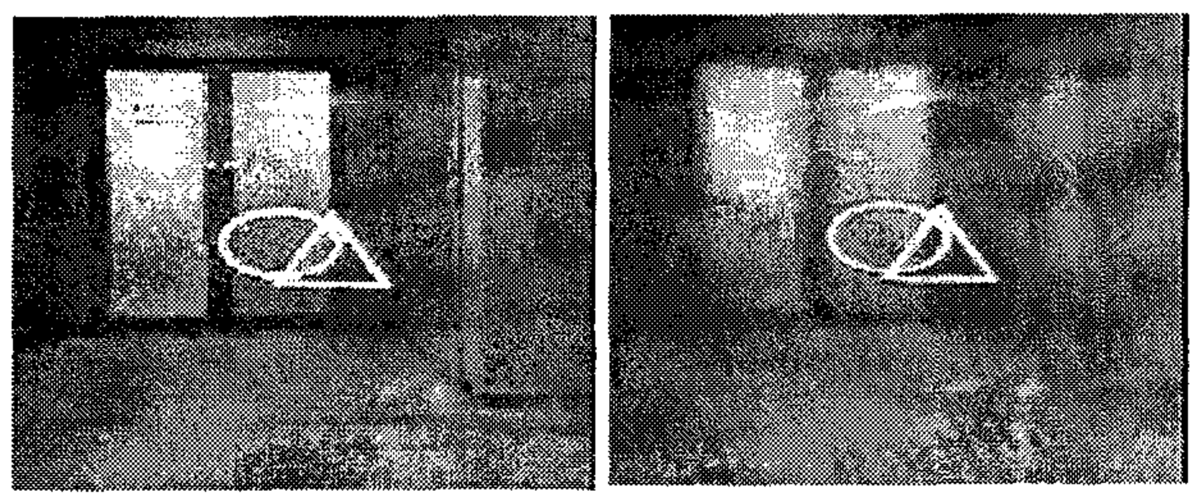
Fig.2 Structure of Retinal Projection Display

These are then projected on the retina directly. One point source of each pixel on an SLM stimulates a certain point on the retina and each straight ray of each aperture of an SLM stimulates a different point on the retina. In this way the image pattern projected on the retina directly can be recognized.

The image by the Maxwellian View can be recognized without ocular accommodation because the rays from each pixel pass through the center of crystalline lens (nodal point). In this optical system, an electrical SLM with a small aperture is used. If the SLM is illuminated by coherent laser rays, the rays being passed through the SLM are diffracted by the small aperture of the SLM. They contain high order diffracted rays. This condition is different from that in which a still image is used as the SLM, as shown in Fig.1. Therefore, to prevent this phenomenon, a spatial filter is installed in this optical system. A prototype of the Retinal Projection Display was fabricated by using the following components: the lens, the electrical SLM, the Spatial Filter, and the laser point source. By using laser rays as the backlight of the LCD, high-order diffracted rays appear in the rays which are emitted from the aperture in the LCD, and they produce images with shallow focal depth. In order to eliminate them, we proposed a double diffraction optical system as the Spatial Filter.

4. Experiment

In the case of the Retinal Projection Display, ocular accommodation is unnecessary, and we proved that even a person with myopia could observe the Maxwellian View images without glasses. And we achieved the experimental optical system we can see an outside scene as well as the dynamic images displayed on the computer by Maxwellian View[4]. Experimental results photographed by a CCD camera are shown in Fig.3 for when the focus to the outside world through the HOE was changed. Fig. 3 (a) shows the case of focusing on real objects correctly and the virtual images produced by the Maxwellian View can be observed clearly. Meanwhile Fig.3 (b) shows the case of defocusing of the CCD camera. Even though the focus to the outside world is dim, the virtual image produced by the Maxwellian View is clear. These results show that the virtual images are recognized clearly even when the focus of the camera changes. These virtual images are dynamic pictures displayed on the computer. We proved that the Retinal Projection Display produced by the Maxwellian View could be observed clearly anytime ocular accommodation was changed because its image had extremely deep focal depth.



(a) Focusing (b) Defocusing

Fig. 3 Images on experimental optical system

5. Prototype for clinical examination

A visually handicapped person can perceive an image by the Retinal Projection Display because it has deep focal depth and it can project the images on the retina directly through a spot like an artificial pupil. Therefore, we have developed this kind of experimental display for clinical examination in order to prove that it would be effective for a visually handicapped person. Our main purpose in this prototype for clinical examination is to prove the effectiveness for a visually handicapped person using this type of display. The prototype for clinical examination is a desktop optical system.

The monocular retinal projection display for clinical examination is shown in Fig.4. It uses a 06-inch LCD and a semi-conductor laser, and its field of view is 30 degrees. The ocular of this optical system is a combination of a concave mirror and a half mirror. The focal length of the ocular is 20 mm in order to realize a field of view of 30 degrees with the 0.6 inch LCD. The concave mirror is used as the short focus lens without color aberration, and the half mirror is used as the see-through combiner.

Visually handicapped persons suffer from various symptoms and it is difficult for them to observe the images on a display when the visual axis and optical axis are different. This optical system is equipped with an XYZ stage and a jaw rest. An observer will see the images on the display with their face fixed on the forehead and jaw rest. For a visually handicapped person whose retinal cells near the fovea are damaged, the images must be projected around the fovea. This optical system is equipped with rotating mechanics that can intersect the visual axis and optical axis in the center of pupil in order to project the images to an optional area of retina.

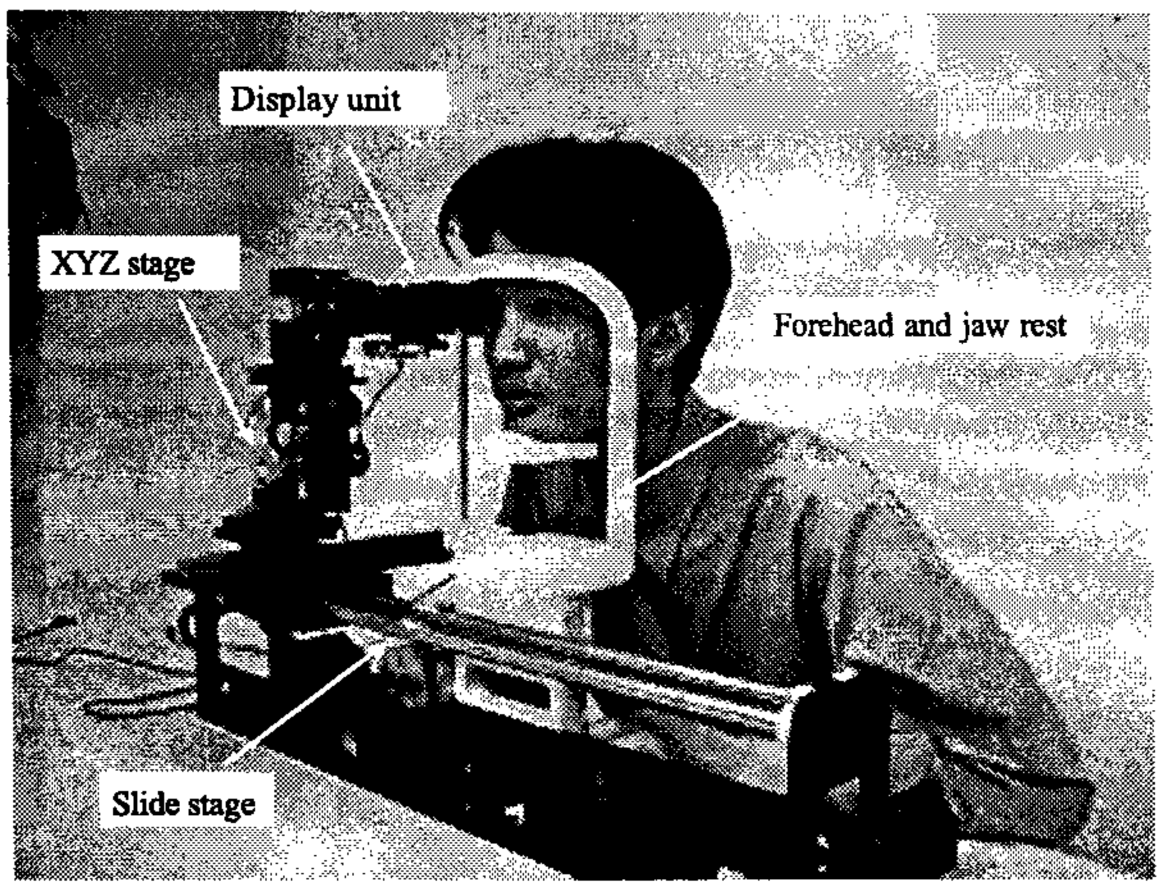


Fig.4 Prototype of clinical examination

6. Conclusion

We produced an optical system as the Retinal Projection Display, which could produce electrical moving pictures with deep focal depth. Images can be seen without ocular accommodation. In other words, our new optical system can produce images with pan focus condition. The Retinal Projection Display consists of a laser illumination, an LCD, and some optical lenses. When applied to persons whose vision is ametropia, clear images in particular can be seen without the influence of an astigmatic. In the future we intend to experiment with the application of our display for persons with low vision or retinitis pigmentosa. Furthermore, we would like to produce a new display as a vision aid for persons with low vision. If it were a binocular stereoscopic display, visually handicapped persons who had no stereopsis so far would be able to enjoy stereoscopic entertainment.

7. References

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