

Compact Refractive Error Measuring Device

Feng-Ming Yeh
Department of Optometry
Yuanpei University of Medical
Technology
Hsinchu, Taiwan
optfmy@yahoo.com.tw

Chun-Yu Chiang
Ph.D. Program of Electrical and
Communications Engineering
Feng Chia University
Taichung, Taiwan
hank4681898@gmail.com

Chao-Kai Chang
Department of Optometry
Yuanpei University of Medical
Technology
Hsinchu, Taiwan
chaokai@ms17.hinet.net

Hsuan-Fu Wang
Department of Aeronautical
Engineering
National Formosa University
Yunlin, Taiwan
hfwang@nfu.edu.tw

Chuen-Lin Tien
Department of Electrical Engineering
Feng Chia University
Taichung, Taiwan
cltien@fcu.edu.tw

Der-Chin Chen
Department of Optometry
Yuanpei University of Medical
Technology
Hsinchu, Taiwan
kanatatan.tw@yahoo.com.tw

Abstract—In this study, a reflective aspheric optical system is used to establish an eye examination device for distance and near vision tests. The system includes a micro-display with a rotating device, an off-axis parabolic mirror, an off-axis ellipsoid mirror, a chin-fixing bracket, and vision software. The display contents of the micro-display include English C and E charts, Chinese words, graphics, and animation. The off-axis parabolic mirror and off-axis ellipsoid mirror are confocal, and the micro-display is placed at the confocal point. The micro-display is projected through an off-axis parabolic mirror for myopia's distance vision testing, and an off-axis elliptical mirror for myopia's near vision testing. Others, the graphics and animation, provide visual checks for young children. In addition, CCD cameras and AI recognition can be used as visual examinations for people with language impairment. In this study, twenty-five subjects with the refractive error were tested using E-chart and this device to obtain the decimal point VA value, and the trial frame and lens were used to obtain the diopter of glasses. The date of the experimental results was used as a reference value for ophthalmological examination. This system uses an off-axis parabolic mirror and an off-axis ellipsoidal mirror. Optical alignment is a challenge to solve for the system. Students participating in the study obtained good optics training. The advantages of the developed device include the convenience to carry with a multi-purpose and straightforward use.

Keywords—parabolic, ellipsoid, distance vision testing

I. INTRODUCTION

Optometry is conducted to assess vision and the ability to recognize objects. In physics, "refraction" is the mechanism in which an object's light beam creates a bending path as it travels through two different media. Refraction also occurs as the light from an object travels from the air through the eyeball to the retina of the eye. In optometry, the term diopter is used to determine the ideal correction for refractive error. Refractive error is an optical imaging abnormality in which the eyeball's shape fails to focus light on the retina, resulting in blurred or distorted vision. An objective refraction is assessed using an automatic refractor or retinoscope without any feedback from the patient. Auto-refractors are equipment that automatically determines the correct lens prescription for the sample's eyes. It is "essential" to choose how many diopters are needed to correct for eyes. This is confirmed by measuring the change in light as it enters the human eye. Most automatic refractometers calculate eye correction by using a photodiode that detects reflections from a cone of infrared light. Myopia is an

eye disease in which light is focused in front of the retina rather than on it. The subject with nearsightedness can see a certain distance or far point of the eye, but objects placed beyond this distance appear blurry. At present, optometry instruments measure the refractive error of distance and near vision separately or together to avoid refractive errors caused by separate tests and save optometry time.

II. PRINCIPLE

Off-axis parabolic mirrors (OAP) have achromatic and diffraction-limited imaging properties, which, in combination with off-axis optical paths, are useful for most imaging systems. The disadvantage of OAP is that it is difficult to adjust during assembly and it is not easy to achieve ideal imaging. A point light source placed at the focal point of a parabolic mirror forms a collimated beam. In the reverse operation, parallel light is incident on the parabolic mirrors to create a point light source at the focal point. The optical parameters of off-axis parabolic mirrors are defined as follows. The parent axis is the optical axis perpendicular to the vertex of the parent mirror, and the parent focal length is the distance from the vertex of the mirror to the focal point along the parent axis. The segment of the optical axis is the off-axis parabolic segment drawn parallel to the parent axis and corresponds to the geometric center of the segment's surface. The focal length of the segment is the distance from the geometric center of the segment's surface to the focal point. The off-axis distance is the distance between the parent and segment's optical axes. The off-axis angle is the angle between the segment axis and the parent axis.

An ellipsoid mirror has two conjugate foci, and a point light source from one focal point is reflected and passes through the other focal point. Because elliptical mirrors enhance light collection without significantly increasing heat in the illuminated plane, it is ideal for projection and lighting applications. An elliptical mirror provides ideal imaging at its two conjugate foci and is also a good imaging system. Figure 1 shows an Ellipsoidal mirror. In the figure, the a , b , and c are defined in the elliptical mirror function $(x^2 + y^2)/b^2 + (z - c)^2/a^2 = 1$, where a and b are the lengths of long and short axes of an elliptical mirror, and $c = (a^2 - b^2)^{1/2}$. As shown in Fig. 1, a point-like source at F_1 is supposed to be a tight spot focused by an aplanatic lens. The sample is placed in another focus F_2 . Under the condition of radially polarized beam illumination, the electric field near focus F_2 consists of longitudinal and transverse components.

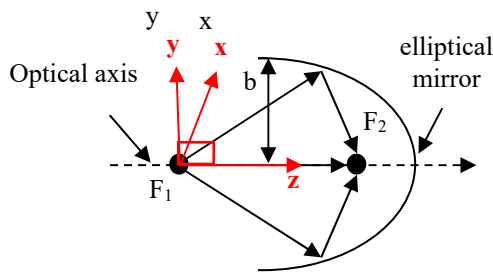


Fig. 1. Ellipsoidal Mirror.

III. EXPERIMENT RESULTS

The proposed system consists of six-part as shown in Fig. 2. There are the off-axis parabolic mirror, off-axis ellipsoidal mirror, microdisplay, E chart software, computer, and CCD camera. The off-axis parabolic mirror and the off-axis ellipsoid mirror are confocal on the position where the microdisplay is placed. The two optical mirrors system are used as the projection of the eye chart for distance and near vision tests, respectively. It is used as a test for a near and distant vision of myopia. This combination is used as an optical test platform for human vision. The microdisplay is connected to the computer and displays the various symbols or the eye chart. There are various eye charts on the computer, such as E chart, C chart, Chinese fonts, graphics, and animation. These E and C cards provide adult refractive error tests, and pictures and animation provide children's examinations. An eye chart is used to measure visual acuity subjectively. Healthcare professionals often use eye charts to screen persons for vision impairment. The optometrist specializing in the eye also uses eye charts to monitor their patient's visual acuity in response to corrects such as refractive error. The eye chart is placed at a standardized distance from the person whose vision is tested. The person then attempts to identify the symbols on the chart, starting with the more significant symbols and continuing with progressively smaller symbols until the person cannot identify the symbols. An eye chart is used to examine a subject's vision to obtain optometric information about eye diseases such as glaucoma and retinal problems. The chart shows several lines of an eye chart which are standardized symbols used to test vision, usually letters, numbers, or geometric symbols.

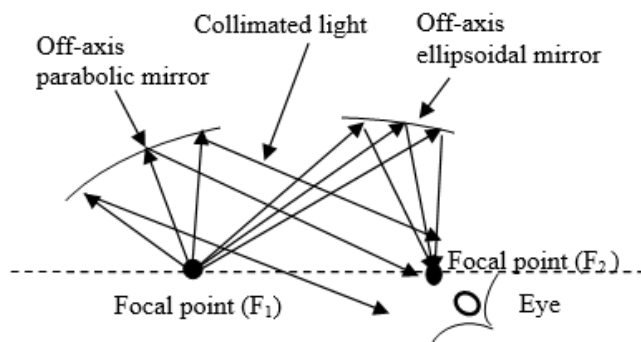


Fig. 2. System Structure.

It is essential to select the specifications of aspherical mirrors to meet the requirements of near and distance of the refractive error of eye examination. After the preliminary system design, the recommended specifications of the two aspheric mirrors are listed in Tables I and II. These parameters are used for the mirror's fixture design and fabrication through the design of optomechanical software.

With the fixture, the system can be assembled. In this study, the experimental data of twenty-five subjects with refractive errors were collected. The twenty-five subjects were tested using E-chart, and the diopter of the best glasses diopter was obtained through trial frames and lenses. Through the statistical analysis, the test data of the E-chart was obtained corresponding to the number of diopters required for glasses. The analysis results are presented in Table 3. These data provide the reference value of eye examination and the actual prescription of the user. The purpose of using the CCD cameras is to record the equipment's safety status and the relevant test data of users. The CCD camera and AI recognition can be used as visual examinations for people with language impairment.

TABLE I. OFF-AXIS PARABOLIC MIRROR'S SPECIFICATION

	Optical Parameter	Specification
1	Off-Axis Angle	45°
2	Diameter	25.4 mm
3	Reflected Focal Length	50.8 mm
4	Parent Focal Length	43.4 mm
5	Thickness	21.8 mm
6	Reflected Wavefront Error	$\leq \lambda/4$ RMS, at 633 nm
7	Bottom Mounting Holes	Three 8–32 Taps

TABLE II. OFF-AXIS ELLIPSOIDAL MIRROR'S SPECIFICATION

	Optical Parameter	Specification
1	Magnification	2.5
2	Reflectance	> 85% (400–700 nm)
3	Image Distance	83.82 mm
4	Object Distance	33.02 mm
5	Substrate	Al
6	Wavelength Range	400–2000 nm

TABLE III. E-CHART TEST DATA OF MYOPIA AND DIOPTR OF MYOPIA WITH GLASSES

E-chart's test data	Diopters required for glasses (°)	E-chart's test data	Diopters required for glasses (°)
1.0	0	0.5	150
0.9	25	0.4	175
0.8	75	0.3	200
0.7	100	0.2	225
0.6	125	0.1	250

IV. CONCLUSION

The eye chart is used to measure visual acuity by determining the level of visual detail that a person can discriminate. The reflective aspheric optical system is used to establish an eye examination device for distance and near vision tests. Its advantages are convenient to carry, multi-purpose and simple system. This system uses an off-axis parabolic mirror and an off-axis ellipsoidal mirror. Optical alignment is challenging in the research and development of optical design, production, and adjustment. Students participating in the study can get good optics training.

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