영상처리에 기반하는 주·야간 보안 카메라용 어안 렌즈

Fisheye Lens for Image Processing based Day & Night Security Camera

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There are many occasions where wide−angle or panoramic lenses can be advantageously used for security and surveillance purposes[(1)]. However, it is substantially difficult and costly to implement a wide−angle or a panoramic lens in purely optical means. One viable alternative has been to obtain a wide−angle image with a fisheye lens and perform image processing to the distorted wide angle image.

For a specific purpose of using the lens in day & night security camera, we have designed a fisheye lens with a field of view of 190° and F# of 2.8. The majority of security cameras employ 1/3−inch CCD sensor. 1/3−inch CCD sensor has a horizontal width B of 4.8mm and a vertical height V of 3.6mm. As illustrated in Fig. 1, the diameter of circular image plane is designed to fit within the horizontal width of the image sensor plane I, so that 180° horizontal field of view can be obtained. Figure 2 shows the optical layout and the ray traces of the designed fisheye lens. It is composed of 8 spherical lens elements and the overall length is 35mm from the first lens surface to the image sensor plane. Optical low pass filter has been modeled as a 3mm thick BK7 glass at the rear of the lens. Figures 3 and 4 show the modulation transfer function characteristics of the lens in the visible (486nm ~ 656nm) and in the near infrared (850nm ~ 940nm) wavelengths range. The graphs show that it has enough resolution to simultaneously provide VGA−grade images in the visible and in the near infrared wavelengths range. Figure 5 shows the relative illumination in the visible wavelength. It is over 0.9 at the full field and it is over 0.8 for the 940nm. Figure 6 shows the real image heights versus the incidence angle for the visible and the near infrared wavelengths. The calibrated f−θ distortion is less than 5%, and the difference in the real image heights for the visible and the near infrared wavelengths is less than 15μm.

In conclusion, we have designed a F2.8 fisheye lens with a FOV of 190° operating simultaneously in the visible and the near infrared wavelengths range.

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(1) J. Kumler and M. Bauer, "Fisheye lens designs and their relative performance", Proc. SPIE, vol. 4093, pp. 360−369 (2000).

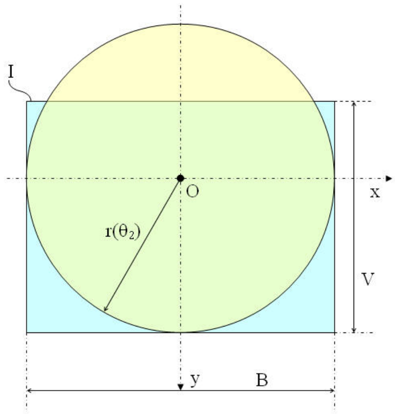

Fig. 1: Schematic diagram illustrating the location of the image plane within the sensor plane.

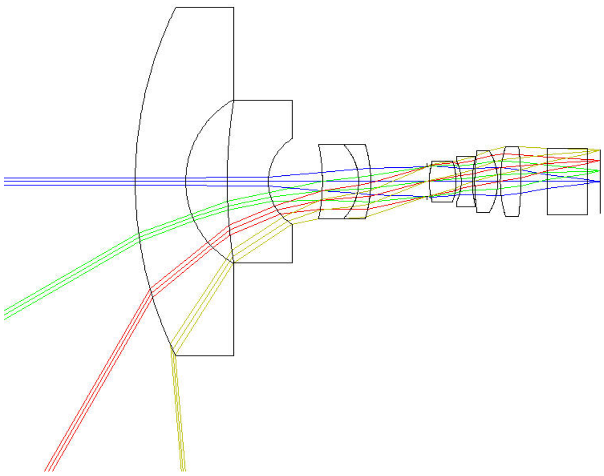

Fig. 2: Optical layout and ray traces of the fisheye lens.

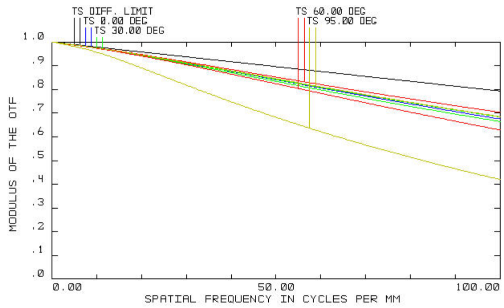

Fig. 3: Modulation transfer function (MTF) characteristics in the visible wavelength range.

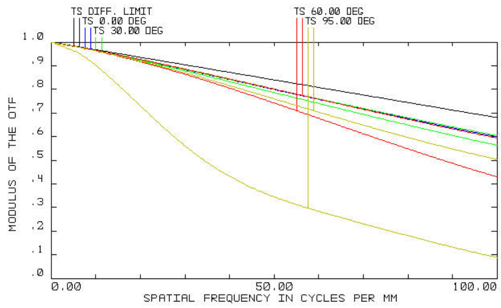

Fig. 4: MTF characteristics in the near infrared wavelength range.

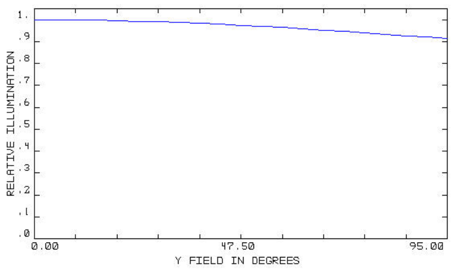

Fig. 5: Relative illumination in the visible wavelength range.

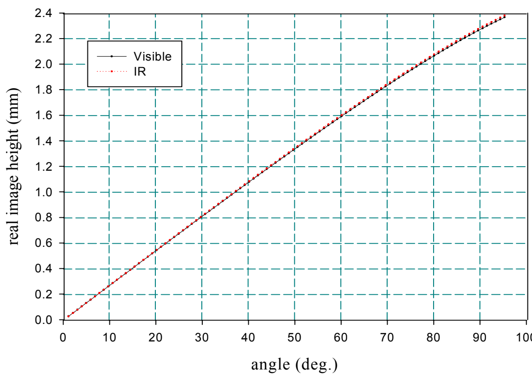

Fig. 6: Real image heights versus the incidence angle for the visible and the near infrared wavelengths.