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Research on split-field monocular stereo cameras using mirrors

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For an advanced driver assistance system (ADAS) that automatically controls and operates the vehicle system in order to realize a safe and secure society in which vehicles and people coexist, we examined a method to realize stereo vision with an inexpensive configuration in a monocular camera. Generally, a monocular camera can construct an ADAS system at low cost, but there is a problem in terms of distance measurement accuracy. On the other hand, a stereo camera that can measure the imaging range three-dimensionally using two monocular cameras with the same mechanism as the human eye has high distance measurement performance, which is advantageous for the sophistication of the ADAS system, but the cost increases. It becomes an issue. Therefore, in this research, we investigated an inexpensive stereo camera and devised a method to realize stereoscopic vision by dividing the field of view of a monocular camera using two reflective mirrors with different postures.

A schematic of optical system of split-field monocular stereo camera is depicted in Fig. 1. The monocular stereo camera has a configuration in which two reflective mirrors with different postures are arranged in front of the monocular camera. Each range that can be captured through these two reflective mirrors has a different field of view. The field of view of the monocular camera placed in front of the reflection mirror is divided into two. In single image sensor mounted on a monocular camera having a divided field of view in this method, the field of view through each reflection mirror is imaged by dividing the image sensor plane. It is possible to realize imaging with a monocular camera by virtually arranged stereo camera with a baseline length *B*. The baseline length *B* is given by;

$$B = 2L \sin\frac{\theta}{2}$$

where length from input pupil of the lens to the mirror is *L*, a field of view of the camera is *θ*. In the obtained baseline length *B*, the measurement distance *Z* is given by;

$$Z = \frac{fB}{D}$$

where focal length of camera lens is *f*, the disparity is $D = a_1 - a_2$.

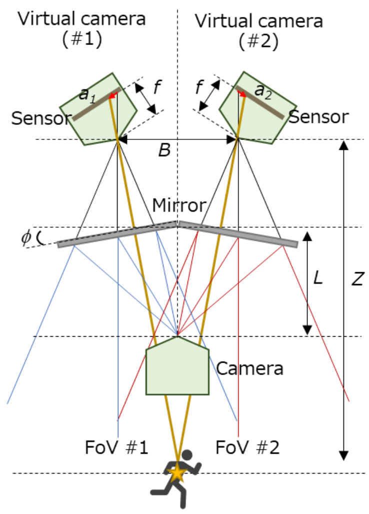

Fig. 2 shows the appearance of the prototype. It can be confirmed that the optical system has a configuration in which two reflective mirrors with different postures are arranged in front of the monocular camera.

To evaluate accuracy of the disparity calculation with prototyped camera, a random pattern chart is placed at predetermined distances to the prototyped camera. The actual distance to the chart is compared with the result of calculating the distance from the prototype. Fig. 3 shows the results of the accuracy verification of distance measurement. The circles of the classification displayed as "Average" shows the average value of the distance measurement results within the range of the captured random pattern chart area. Similarly, the plots shown as "Max." and "Min." show the maximum and minimum values of the distance measurement results, respectively. The measured distance by the prototype shows good linearity, and the error of the distance measurement is within 5% at the distance of 20 m. In addition, even at a distance of 30 m, the error in distance measurement is within 12%.

As shown above, we developed a prototype of a split-field monocular stereo camera using reflection mirrors, and verified that disparity images can be generated by stereoscopic vision, and realized 3 dimentional distance measurement at a distance of 30 m.

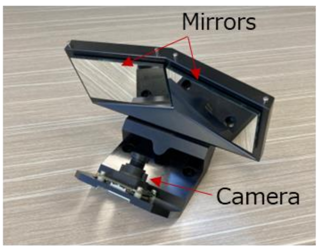

Fig. 2 Overview of prototyped monocular stereo camera

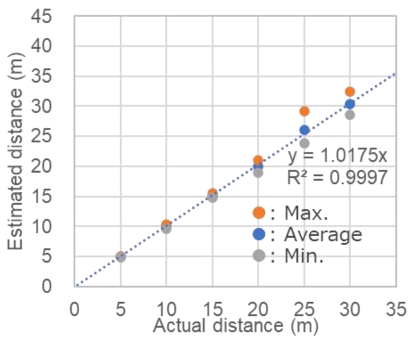

Fig. 3 Distance estimation accuracy

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