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Development of Ultrasonic Liquid Crystal Fovea Sensor which can Change Position of Optical Axis and Focal Length without Any Mechanical Part

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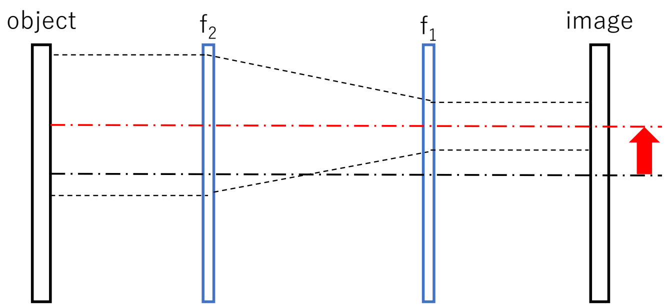
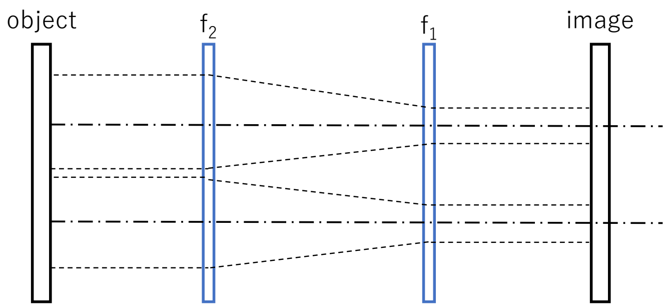
In order to perform functions such as avoiding collisions and assisting vehicle maneuvering, it is necessary to understand a surrounding environment. There are several types of sensors, including laser rangefinders (LRF), millimeter-wave radar, visible-ray cameras such as CCD and CMOS, and a combination of these sensors. However, these sensors have a comratively-short measurement range. On the other hand, a system using a visible-ray camera can measure long distances by combining a telephoto lens. However, with existing camera modules, there is a trade-off between increasing telephoto performance and narrowing a viewing angle, and conversely, increasing wide-angle performance and not being able to detect objects with a small size. Furthermore, complicated combinations of lenses require a mechanical zoom system with actuators, which increases space, weight, and energy consumption and reduces reliability.

In this study, the authors propose a ultrasonic liquid crystal fovea sensor, composed of a visible-ray camera, an imaging lens, and two ultrasonic liquid crystal lens cells with variable optical axis position and focal length. This unique sensor was inspired from not only a conventional wide-angle fovea sensor but also a combination of a liquid crystal wide-angle fovea sensor, a liquid crystal zoon lens system, and the ultrasonic liquid crystal lens cell. With respect to such wide-angle fovea sensor, by applying the two ultrasonic liquid imaging lenscrystal lens cells with variable focal length, we realize characteristics of the wide-angle fovea sensor that provides a wide field of view and high magnification at an attention region, thus achieveing both wide-angle and telephoto lenses' characteristics simultaneously. In addition, since the ultrasonic liquid crystal lens cell can change the position of the optical axis and can make multiple attention regions on the same time, we detect more objects more in detail than the conventional wide-angle fovea sensor. Furthermore, since these operations are achived without any mechanical component, our proposed ultrasonic liquid crystal fovea sensor contributes to space and weight reduction, energy conservation, and reliability improvement. This is expected to improve ability to monitor multiple pedestrians and vehicles on the same time, for example, regardless of distance, thereby improving ability to understand the surrounding environment.



(a) Shifting attention region



(b) Multiple attention regions

Fig.1. Changing the optical axis position(s) and its (their) number