Accuracy Analysis of Structured-Light Sensor Based on Non-mechanical VCSEL Beam Scanner

Photonics Integration System Research Center, FIRST, Tokyo Institute of Technology,
(M1) Ruixiao Li, (D1) Zeuku Ho, Xiaodong Gu and Fumio Koyama
E-mail: li.r.ae@m.titech.ac.jp

1. Background

Structured-light technology is widely adopted to achieve 3D sensing because of its excellent accuracy in short range detection, such as Face ID. One of the most important parts of a structured-light system is the projector of patterns, which can be formed by using diffractive optical elements. Alternatively, we are able to use laser scanning technology in structured-light system, which brings larger signal to noise ratio at the same output power that means better accuracy. However, the scanning speed and complexity of conventional mechanical scanning system remain critical issues to be solved. Therefor we proposed Structured-Light Sensor Based on Non-mechanical VCSEL Beam Scanner [1].

2. Basic structure of structured-light sensor

The structured-light sensor should be composed of projector, CMOS sensor and object as shown in Fig.1(a). Non-mechanical VCSEL Beam Scanner (Fig.1(b).) here is used as the projector, which could project stripe beam and change the angle of emergence by tuning the wavelength of input light.

3. Accuracy Analysis

The system is influenced by the shot noise of laser, shot noise of sunlight, CMOS internal noise and speckle noise. The standard deviation of depth measurement was regarded as depth accuracy in our analysis. The theoretical depth accuracy could be calculated based on the references [2, 3]. The noise except for speckle noise could be suppressed by extremely high power and speckle noise could be improved by using a digital median filter. The original results of theoretical analysis are shown in Fig. 2 and the results with median filter are shown in Fig. 3 (Blue and orange lines).

In our experiment, a 2 mm-long, 845-nm VCSEL beam was used as the projector, of which the output power is changed from 7-14mW and a flat sample was placed 35cm away from the CMOS sensor. Then a digital background of 64ADUs/Pixels was introduced to simulate the sunlight. The experiment results are shown in Fig. 2 and Fig. 3 (Orange and blue points)

4. Conclusion

The theoretical analysis of structured-light sensor was proposed and the experimental results fits the theoretical result well.

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Reference

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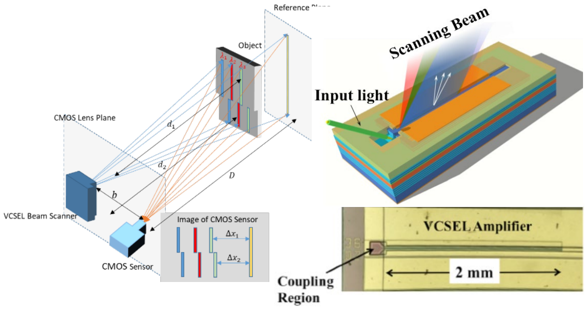
[2] Baribeau R, Rioux M. Centroid fluctuations of speckled targets[J]. Applied optics, 1991, 30(26): 3752-3755.

[3] Ma X, Rao C, Zheng H. Error analysis of CCD-based point source centroid computation under the background light[J]. Optics express, 2009, 17(10): 8525-8541.



(a) (b)

Fig.1. (a) The schematic of the system and (b) VCSEL Beam scanner

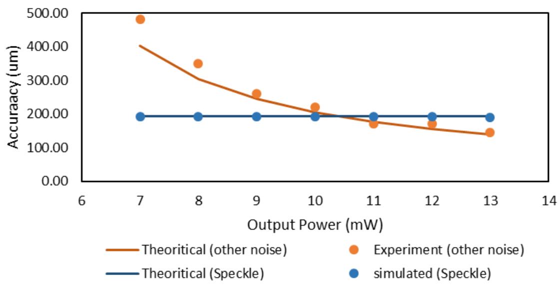


Fig.2. The depth accuracy of system

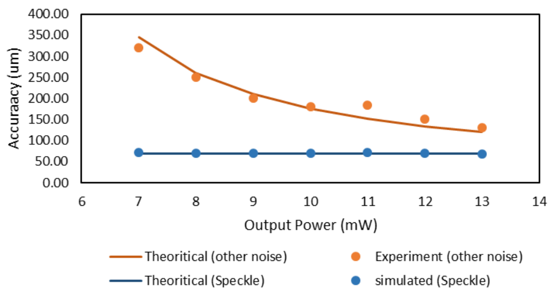


Fig.3. The depth accuracy with median filter