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Low-Cost 3D Sensor System: Using Image-based Laser Triangulation

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Abstract Recently the demand for 3D sensors is increasing in areas such as robots and 3D deep learning. So we analyzed applicability of laser triangulation, which is easy and simple to use in these fields. The results of the experiment shows that the depth was measured at a maximum error of 2cm from 150cm to 50cm. These results are expected to be available within a certain margin of error, and will be used for future research in 3D deep learning and robotics.

Keywords Low-cost Sensor, Depth Measurement System, Laser Triangulation, 3D sensor,

1. Introduction

Recently, the demand for 3D sensors has been increasing due to growing interest in the 4th Industrial Revolution, such as robots and artificial intelligence[1]. This paper suggests a low-cost depth measurement system using laser triangulation.

2. Related Work

For simplification, We will assume that the image sensor is a pinhole camera model (Fig. 1)[2].

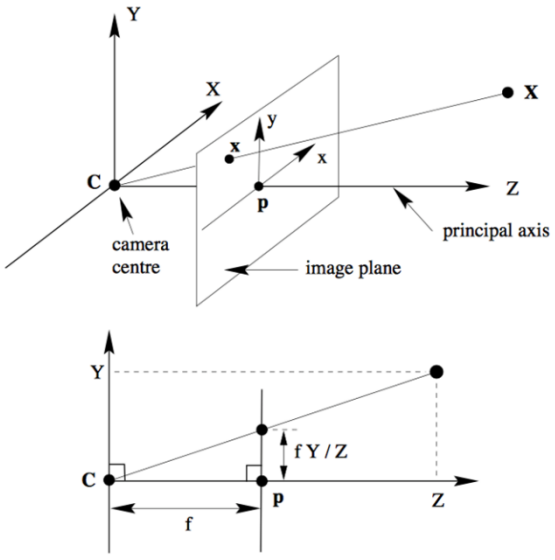

Figure 1. Simple Pinhole Camera Model. Note the image plane is placed in front of the camera centre.

의 지원을 받아 수행된 기초연구사업임(No.NRF-2019R1A6A1A09031717) 또한, 이 논문은 농촌진흥청 “농업과학 기술 개발 협력 연구 프로그램(No. PJ01389105)”의 지원으로 수행된 연구임.

The laser and camera place the y-axis plane in sync, and the z-axis of the camera intersects with the z-axis of the laser (Fig. 2)[3]. Depending on the depth, the position of the phase on which the laser line attaches to the image sensor will vary.

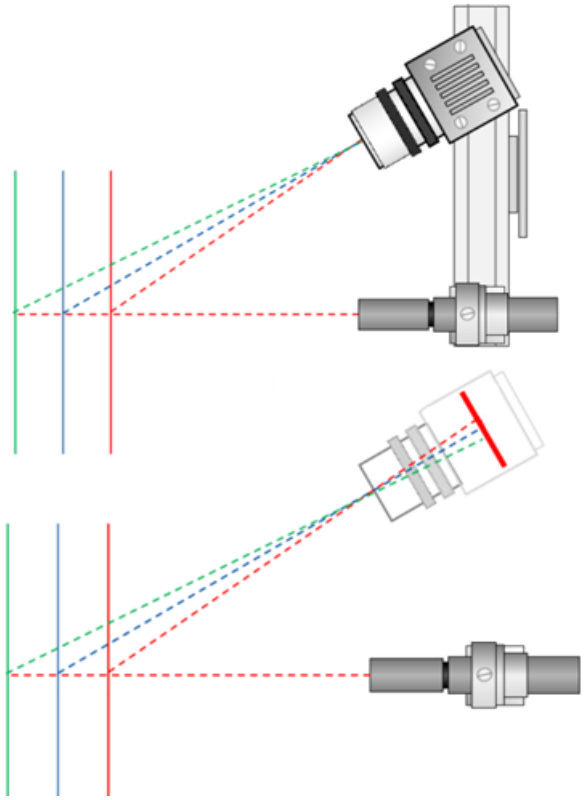

Figure 2. Laser Triangulation.

Using this principle, we tested and evaluated systems

that could measure depth.

3. Image-based Laser Triangulation system

3.1 Laser Triangulation System

To know about depth, the pixel position of the image with laser line shall be known. As shown in Figure 1, the pixel height (p) is zero on the principal axis, and the p value varies according to the y-axis.

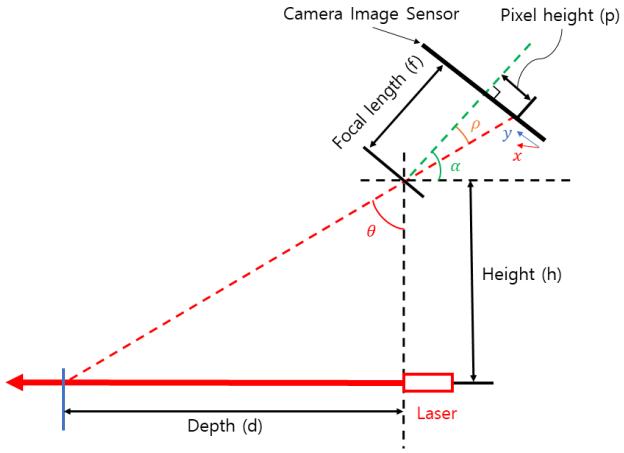

Figure 3. Laser Triangulation System.

Using p value, ρ is calculated by pixel height and focal length [5](Fig. 3).

$$\rho = \tan^{-1}\frac{p}{f} \quad (1)$$

f is focal length, and it depends on which camera you choose. And you can get a θ through ρ and eventually calculate the depth.

$$\theta = \frac{\pi}{2} - (\alpha - \rho) \quad (2)$$

$$d = h \times \tan\theta \quad (3)$$

α is camera setting angle, d is depth and h is height.

3.2 Experiment

The experiment was conducted from 150cm to 50cm with a total of 101 data in 1cm intervals.

Camera setting angle is 25°, and camera is iPhone 8 plus rear camera, so focal length is 4mm, Image sensor height is 3.5mm, image size is 3762×2794 and height is 28.4cm. and laser is 'Diffusion 2way safety laser' which is line laser, 650mm, class II B. The calculation was carried out using Python programming.

3.3 Result

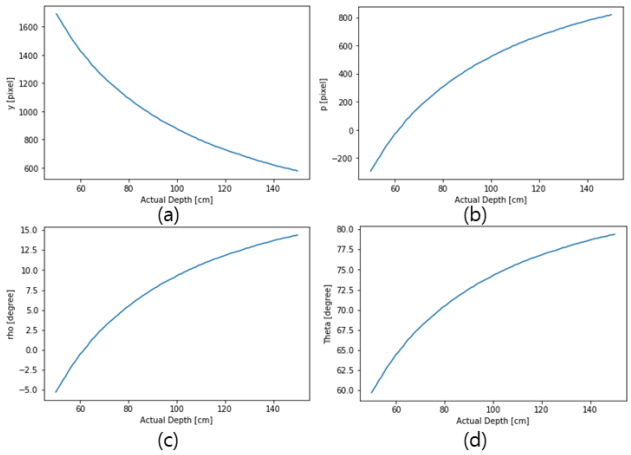

Figure 4. Each parameter according to the actual depth. (a) is position of y pixel in image, (b) is pixel height(p), (d) is **ρ** which is pinhole model angle, and (e) is **θ** which is actual coordinate angle.

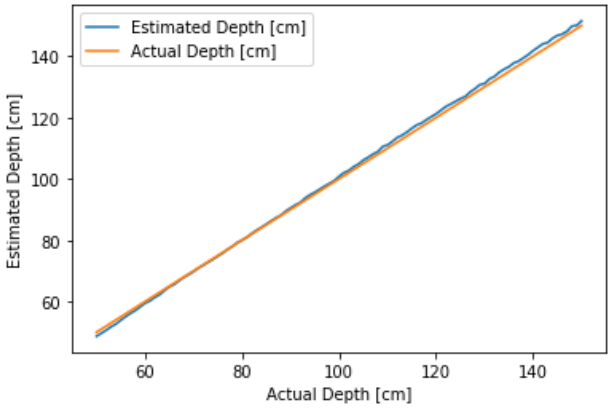

Figure 5. Comparison of Actual and Estimated Depth.

As shown in Figures 4 and 5, it can be seen that the depth estimation was done well within 2cm of error.

4. Conclusions

Using Image-based laser triangulation, it showed the usability of cheap sensors available in some areas. Using these results, it will be used for further research related with 3D deep learning and robots.

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