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A New Method for 3-D Shape Measurement and Surface Reflectance of an Object with Rangefinder

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Abstract: An object for computer graphics application requires two following information: three dimentional (3-D) shape and surface reflectance property of the object. We proposed a 3-D shape and surface reflectance measurement system using the new sensor, which can detect the incidence position and the angle of the light simultaneously. Experimental results successfully demonstrate the efficacy of the method.

Keywords: laser rangefinder, 3-D shape and surface reflectance of an object.

1 Introduction

An object for computer graphics application requires two following information: three dimentional (3-D) shape and surface reflectance property of the object. In ordinary approaches, information of the 3-D shape and the surface reflectance are acquired using a CCD camera. Recently, a rangefinder is used to improve the accuracy of 3-D shape measurement.

However, ordinary rangefinder can be applied only to Lambertian objects. This characteristic of the rangefinder has severe drawback in applying the rangefinder to CG applications. Therefore, it would be of great value to have a rangefinder that could not only determine the 3-D shape but also estimate the reflectance properties of objects that have non-Lambertian reflectance characteristic.

We here propose a novel laser rangefinder, which can measure the 3-D shape and the surface reflectance of an object simultaneously. The rangefinder is used the image sensor which can detect the incidence position and the angle of the light simultaneously[1][2].

2 Measurement system

2.1 System configuration

Fig.1 shows the system configuration. The light-stripe projected from laser is received by the image sensor after reflected by objects. This image sensor is able to detect the incidence position and the angle of the light-stripe[1], as shown in **Fig.2**. By using this sensor, 3-D positions of objects with both Lambertian surfaces and specular surfaces can be found[2][3].

The position of the light-stripe in the measured space is determined, as shown in **Fig.3**, and its position (x, z) is computed by triangulation. The equations are as follows:

$$x = z\tan(\alpha+\alpha_x) - s_1\cos\alpha\{\tan(\alpha+\alpha_x)-\tan\alpha\} \quad (1)$$

$$z = \frac{d+s_1\cos\alpha\{\tan(\alpha+\alpha_x)-\tan\alpha\}}{\cot\gamma+\tan(\alpha+\alpha_x)} \quad (2)$$

where s_1 , α_x can be express as

$$s_1 = \frac{f\cdot(\omega_x+l\cdot\tan\varphi)}{\omega_x+(l-f)\cdot\tan\varphi} \quad (3)$$

$$\alpha_x = \tan^{-1}\frac{\omega_x+(l-f)\cdot\tan\varphi}{f} \quad (4)$$

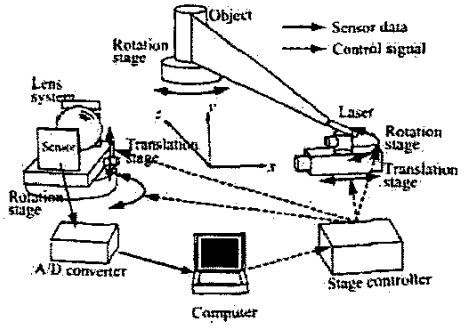

Fig. 1 : System configuration

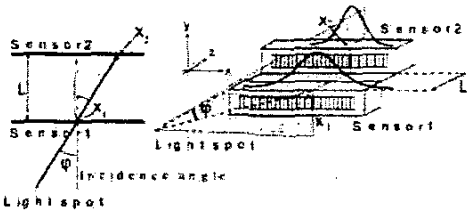

Fig. 2 : Sensor system

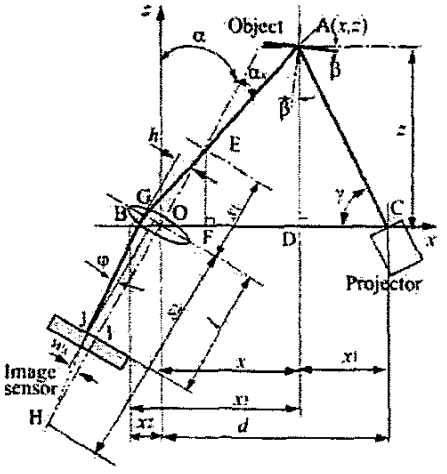

Fig. 3 : Coordinate system

2.2 Measurement procedure

The procedure to measure a 3-D shape and surface reflectance simultaneously are as follows:

Step1: First, the laser was projected from initial projection angle, and 3-D position of the object was evaluated with the pixel position of the image sensor. At the same time, the intensity of the light received by the image sensor was measured.

Step2: Next, the projection angle was changed while the projected point was fixed, and then the intensity was measured by the image sensor. This process was repeated from 30 degrees to 120 degrees of projection angle.

Step3: The projected point was changed, and Step2 was repeated.

In this way, we can acquire the data of the 3-D shape and the surface reflectance of the object.

3 Experimental results

Fig.4 shows the results of 3-D shape measurement and rendered image based on the measured surface reflectance for "Bizenyaki"(a famous pottery in Bizen) and "Kinpai"(a cup painted gold). The experimental results demonstrate that our rangefinder can measure both the 3-D shapes and surface reflectance properties of objects.

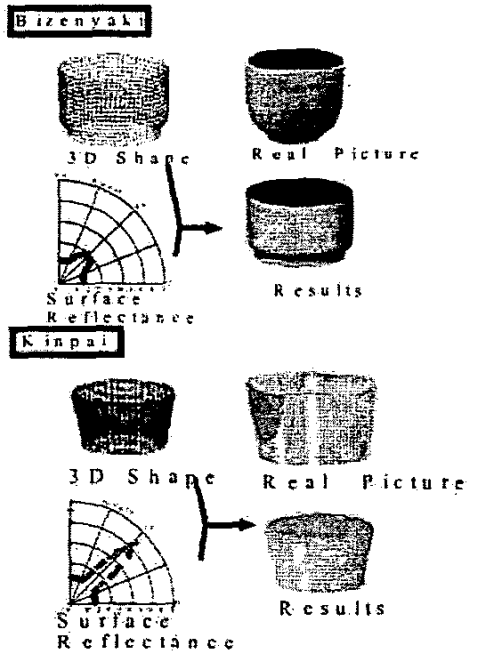

Fig. 4 : Experimental results

4 Conclusions

We have explored the measurement system which can measure 3-D shape and surface reflectance property of the object simultaneously. This experimental results show that our system is effective for computer graphics application.

References

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