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Distance Measurement with Active & Passive Method

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Abstract

Methods for measuring the distance to some objects can be divided into active and passive ones. The active methods are measuring the distance by sending some signals to the object (e.g. laser beam, radio signals, ultra-sound, etc.) while passive ones only receive information about object's position (usually by light).

Keywords: *IBDMS (Image-Based Distance Measuring System), Stereoscopic Measuring Method, Distance Measurement, Triangular Measuring Method, Parallel Measuring Method.*

1. Introduction

In Passive method Stereoscopy is a technique used for recording and representing stereoscopic (3D) images. It can create an illusion of depth using two pictures taken at slightly different positions. There are two possible way of taking stereoscopic pictures: by using special two-lens stereo cameras or systems with two single-lens cameras joined together. Stereoscopic pictures allow us to calculate the distance from the camera(s) to the chosen object within the picture. The distance is calculated from differences between the pictures and additional technical data like focal length and distance between the cameras. In active method configuration of the proposed IBDMS is very simple, consisting of only a single CCD camera and two laser projectors formed in parallel besides the camera. Because of the disposition of the laser projectors and optical origin of the CCD camera which form a straight line, two laser-projected spots will appear on the same scan line in a CCD image.

2. Stereoscopic Measuring Method

Stereoscopic picture can be taken with a pair of cameras, similarly to our own eyes. The most important restrictions in taking a pair of stereoscopic pictures are the following:

- Cameras should be horizontally aligned (see Fig.1), and
- The pictures should be taken at the same instant.

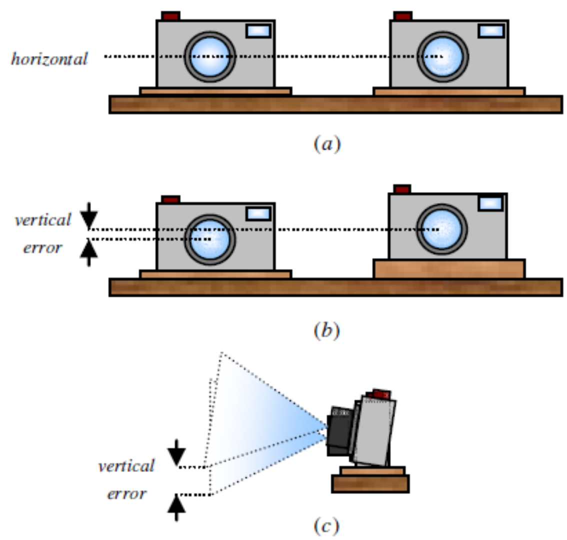

Fig.1 Proper alignment of cameras (a) and alignment with vertical error (b) and (c)

Stereoscopic pictures allow us to calculate the distance between the camera(s) and the chosen object within the picture. Let the right picture be taken in location SR and the left picture in location SL. B represents the distance between the cameras and φ_0 is camera's horizontal angle of view (see Figure 2). Object's position (distance D) can be calculated by doing some geometrical derivations.

We can express distance B as a sum of distances B_1 and B_2:

$B= B_1+B_2= D \tan \varphi_1 + D \tan \varphi_2$ (2.1)

If optical axes of the cameras are parallel, where φ1 and φ2 are angles between optical axis of camera lens and the chosen object.

Distance D is as follows:

$D= B/ \tan \varphi_1 + \tan \varphi_2$ (2.2)

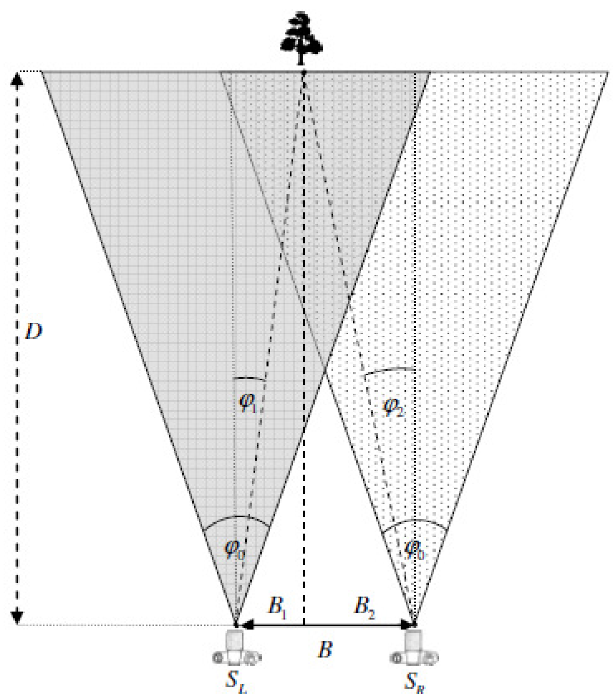

Fig. 2 The picture of object taken with two cameras

3. Review of IBDMS Methods

This section reviews two distance measuring techniques. The traditional triangular measuring method is shown in the first part, followed by the parallel measuring method of the IBDMS.

3.1 The Triangular Measuring Method

Figure 3 shows the triangular measuring method, in which D_{max} and H_{max} are the maximal horizontal distance and maximal photographing distance, respectively. By a triangular formula, we have the relationship:

$$\frac{D_k}{D_{max}} = \frac{H_k}{H_{max}} \qquad (3.1)$$

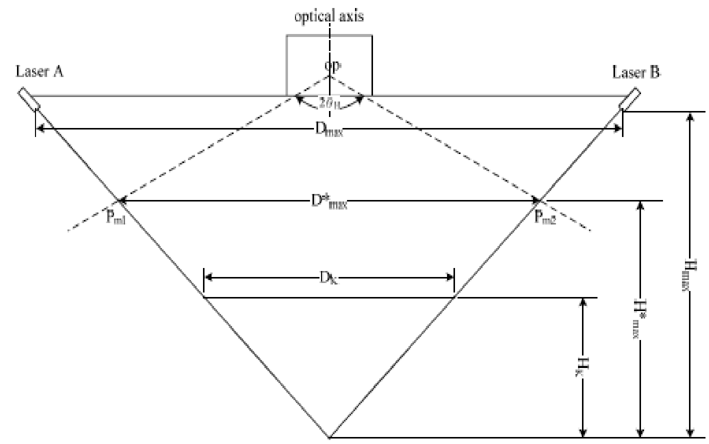

Fig. 3 Schematic diagram illustrate triangular measuring method

Because every CCD camera has a limited view angle $2\theta_H$ as shown in Fig. 3, the effective measuring range therefore lies between two dotted lines. Attempts in measuring objects lying in the invalid range between H^*_{max} and H_{max} will result in fatal errors, because the projected spots will not appear on the image captured by the camera. Therefore, both maximal photographing distance (H_{max}) and maximal horizontal distance (D_{max}) must be suitably adjusted as H^*_{max} and D^*_{max} to prevent from lying in the ineffective zone outside the dotted lines. As a result, (3.1) has to be modified as follows:

$$\frac{D_k}{D^*_{max}} = \frac{H_k}{H^*_{max}} \qquad (3.2)$$

Although redefining measuring range solves the problems of invalid measuring range, it is still difficult to make these two laser beams projected onto an identical position, which is extremely inconvenient for practical applications. That is why the parallel measuring method is proposed to remove the constraints on the triangular measuring method.

3.2 The Parallel Measuring Method

The parallel measuring method presents a new architecture which is easier for deployment. Based on the triangular formula, the parallel measuring method has a relationship as follows:

$$H_k = \frac{H_D \times D_k}{D_{min}} - H_D \qquad (3.3)$$

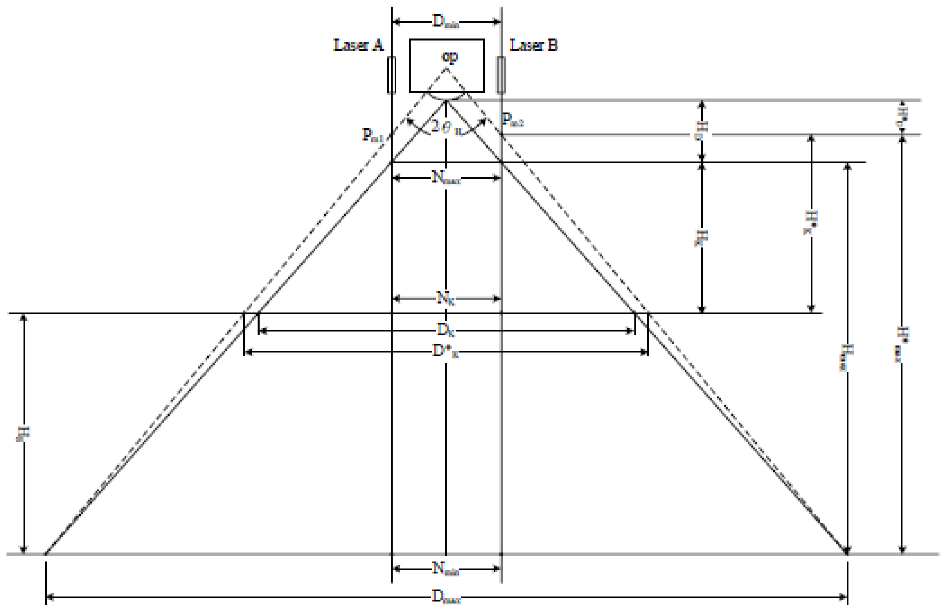

Fig. 4 Schematic diagram illustrate parallel measuring method

Previous researches have measuring inaccuracy caused by the invalid measuring area between H^*_{max} and H_{max} because the intrinsic parameters, view angle, and optical origin of the camera are not considered during the measurement. With the view angle of $2\theta_H$ in Fig. 4, the valid range for measurement is the area between two dotted lines as shown in Fig. 4. As a result, (3.3) can be modified as follows:

$$H_k^* = \frac{H_D^* \times D_k^*}{D_{min}} - H_D^* \qquad (3.4)$$

Although the parallel measuring method has achieved a more satisfactory measuring performance in comparison to the triangular measuring method, there are still rooms for improvements by taking account of the optical origin of the camera and H^*_D so as to obtain more accurate measuring results. In this paper, we have improved the IBDMS for a lower error rate and easier implement by using any cameras.

4. Conclusion

The proposed methods for distance measurement are Stereoscopic, Triangular and Parallel. Stereoscopic is passive method based upon the pictures taken from two horizontally displaced cameras. Although the method is based on relatively simple algorithm, the calculated distance is still quite accurate. Better results are obtained with wider base (distance between the cameras). Whereas Triangular and Parallel measuring method used Laser to determine distance which provide more accurate result as compare to passive.

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