RESEARCH ON THREE-DIMENSIONAL COORDINATES ACQUISITION FOR SHADOW ESTIMATION IN PHOTOVOLTAIC SYSTEM

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ABSTRACT

The amount of power generation of the PV system greatly depends on the quantity of solar radiation. When the shadow hangs to the PV system with the tree and the buildings, it has a great influence on the amount of power generation.

This research describes estimation for the shadow hangs to the PV system by using "quantity estimation system of the shadow impacts" in TUAT. This paper describes the improvement of the three-dimensional measurement in "quantity estimation system of the shadow impacts". New technique makes it possible to take pictures easily and reduces most of restrictions.

1. "Quantity estimation system of the shadow impacts"

When the shadow hangs to the PV system with the tree and the buildings, it has a great influence on the amount of power generation. Moreover, the position of shadow is changed by the altitude of the sun and the position. Therefore, it is difficult to judge the forecast of the shadow on site.

This system calculates three dimensional coordinates from easy measurement and estimates the shadow on PV system. Moreover, it estimates the amount of power generation of PV system. The easy measurement doesn't need the expensive machine parts used in a general measurement at all. Therefore, everyone can measure three dimensional coordinates at low price[1].

Figure 1 shows "quantity estimation system of the shadow impacts" flow chart. This system is composed of photogrammetry and estimation of shadow. The part of photogrammetry calculates three dimensional coordinates of the obstacles and plane. The part of estimation of shadow receives its coordinates and estimates shadow that hangs to plane from the position of the sun[2].

2. PHOTOGRAMMETRY

2.1 Stereo Photogrammetry

It is necessary to know the position of the plane, the obstacle, and the sun for estimating the shadow. There positions are calculated by the stereo photogrammetry. Figure 2 shows this principle.

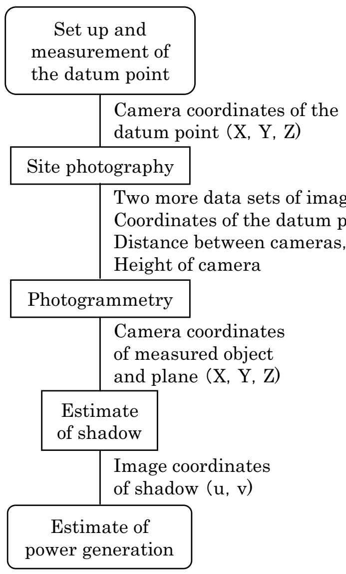

Fig. 1 Flow chart of "quantity estimation system of the shadow impacts".

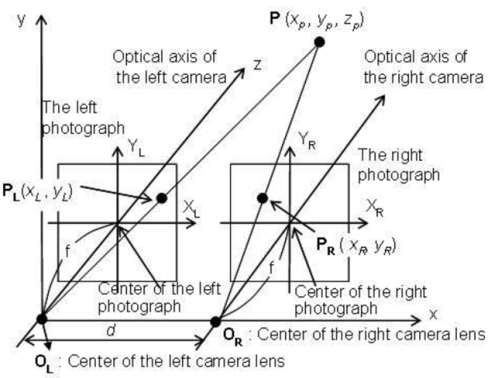

Fig. 2 Stereo photogrammetry.

The stereo photogrammetry calculates three dimensional coordinates by using trigonometric from the two more parallel images.

2.2 Correction of right camera rotation

Two more parallel photographs are needed to calculate three dimensional coordinates of plane and the obstacles. However, it is difficult to take a picture in parallel. Then, this system corrects the rotation of image and projects points of the image plane on a virtual parallel plane in the right camera. (**Fig** 3)

Figure 3 shows the rotations of the camera which are classified into three kinds[3]. These three rotations are corrected and it makes possible to use stereo photogrammetry. The photography condition becomes easy by using virtual parallel plane in the right camera.

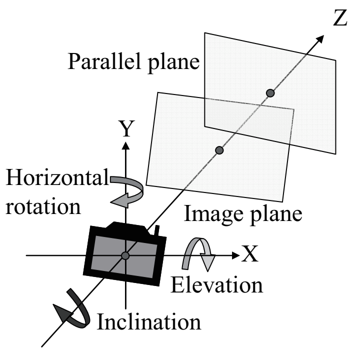

Fig. 3 Three kinds of rotation

2.3 Correction of standard camera

Three rotations of right camera can correct in this technique. However, rotations of standard camera can't correct in this technique. In addition, generally the target things become a center. Then, the technique for correcting the rotation of a standard camera was devised. Most of the restrictions are reduces by using the new technique. The new technique can correct rotations and inclination in standard camera (**Fig 4**).

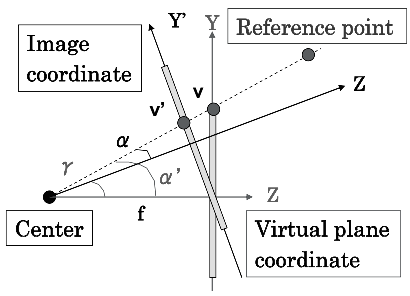

Fig 4 Correction of rotation in standard camera

The angle of elevation is calculated by using the gap of the reference point from image plane and virtual plane. Height and the depth of the reference point measured beforehand. From Fig 4, equation (1) and (2) are derived.

$$\tan\gamma = \tan(\alpha' - \alpha) \qquad (1)$$

$$\gamma = \tan^{-1}\frac{f(v - v')}{f^2 + vv'} \qquad (2)$$

Image plane coordinates is converted into virtual parallel plane coordinates by using equation (1) and (2). The restraint of photography condition is decreased by using new technique.

3. Photogrammetry experiment

We survey the three dimensional coordinates of an obstacle and plane by using new technique and the marketed digital camera, a tripod, a compass and a major. The distance from the standard camera to the reference point is measured and the distance between cameras is measured. The coordinates of specified measurement point and obstacle are calculated in "quantity estimation system of the shadow impacts".

Table 1 shows the result of measurement experiment by using traditional technique and new technique.

Table I. Result of the measurement experiment

	X[cm]	Y[cm]	Z[cm]
Actual measurement	238	267	900
Traditional technique	233	163	921
Error	−5	−104	21
This technique	233	270	921
Error	−5	3	21

As a result, accuracy of measurement using this technique was several centimeters margin of error. Especially, Y coordinates are improved.

4. CONCLUSION

The new technique makes it possible to take pictures easily and reduces most of restrictions. Therefore, everyone measure easily the coordinates of the obstacle and plane. In addition, the accuracy becomes almost the same as the traditional technique.

We will estimate the shadow by using this technique in the future.

REFERENCES

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