Basic Study on the Preparation of Topographic Maps for Landslide Areas by an Inertial Photogrammetric Camera System

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ABSTRACT

With the use of an accelerometer and a gyro that are inertial sensors, it is possible to calculate both the distance and angle. That is, if a camera is mounted with an accelerometer and a gyro, the position and gradient of the camera when it takes a photograph can be calculated. In this paper, a camera mounted with inertial sensors is defined as an inertial photogrammetric camera. In this paper, using the inertial photogrammetric camera system for terrestrial photogrammetry that was developed by the authors, the topographic maps of landslide areas were prepared. A landslide area subject to this study was about 60 meters in height, the width of its lower end was about 100 meters, and its oblique angle was about 50 degrees. While moving the cart on a river bank that was located about 120 meters away from the landslide area, the stereo photographs of the landslide area were taken. To examine the accuracy of measured results obtained by the inertial photogrammetry, a white polystyrene foam plate with a size of 80 x 80 cm was placed on several locations in the landslide area. Those locations were then measured by a Total Station and the obtained data were regarded as the true values. Based on the photographs taken, a topographic map (contour map) was prepared. The result of the research showed that the system developed in this study was effective.

1. INTRODUCTION

Distance and angle can be calculated with a gyro and an accelerometer which are inertial device. Therefore, calculation of position and inclination of camera become possible by installing the gyroscope and accelerometer in the camera. This study is the fundamental research on photogrammetory using a camera equipped with an inertial device. If the position and the inclination of camera which are exterior orientation element are obtainable without a control point, it would save much time and labor conduct the control survey and also would contribute greatly for simplifying the photogrammetory. Some studies that resemble this study are introducing a system in which a camera is mounted with GPS and a gyro. In this study, however, no GPS is used. The reason is that the use of GPS in areas where radio waves cannot reach is difficult. The main purpose of this study is to apply the system to terrestrial photogrammetry. In terrestrial photogrammetry, it is expected that the system is mainly used in areas where radio waves cannot reach. A vibration gyro, whose performance was somewhat lower but inexpensive, and a fiber optical gyro with moderate performance were used. In addition, a servo-type accelerometer was used. By installing the individual unit of the gyros and accelerometer on each of X, Y and Z axes that were orthogonal to one another, inertial equipment based on a strap-down system was prepared. A 2.11-megapixel digital camera was used for the equipment. The authors eventually would like to develop a mobile type of the inertial photogrammetric camera system which was developed in this study. In this paper, however, as the basic stage for its development, a tripod for the camera was installed on a cart with wheels and both the inertial equipment and the digital camera were mounted on the tripod. In addition, a personal computer for data collection and an electric power unit were mounted on the cart. A landslide area subject to this study was about 60 meters in height, the width of its lower end was about 100 meters, and its oblique angle was about 50 degrees. While moving the cart on a river bank that was located about 120 meters away from the landslide area, the stereo photographs of the landslide area were taken. To examine the accuracy of measured results obtained by the inertial photogrammetry, a white polystyrene foam plate with a size of 80 x 80 cm was placed on several locations in the landslide area. Those locations were then measured by a Total Station and the obtained data were regarded as the true values. Based on the photographs taken, a topographic map (contour map) was prepared.

2 COMPOSITION OF THIS SYSTEM

In the system of the photogrammetry done with an inertial device, a gyro and an accelerometer which were installed at right angles to each other were equipped with a camera in this study. Data from gyro and accelerometer is converted from analogue into digital through the A/D conversion board, and is taken into the personal computer. Then, the position and the inclination of the camera at the time of taking a picture are calculated. On the other hand, the photograph taken with the camera is measured using a digitizer, and a analysis of the photograph is performed in the position and the inclination of a camera which were obtained from the gyro and the accelerometer. Figure1 shows the coordinate system and sensor.

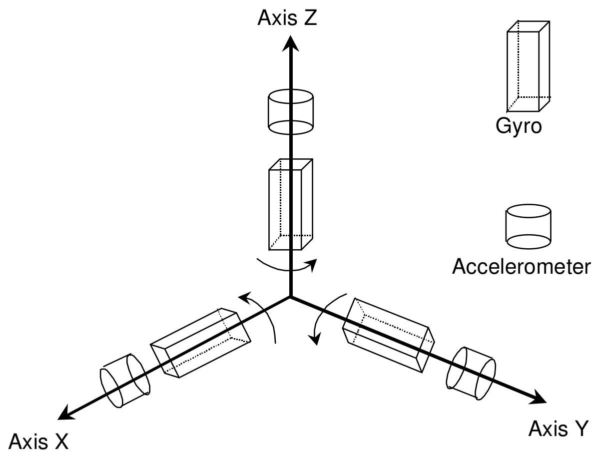

Figure1. Coordinate system and sensor

2.1 Inertial device

(1) Vibration gyro: The vibration gyro used for this measurement is the ENV-05A piezo-electric vibration gyro of Murata Mfg. Co. Ltd. which is shown in Figure 2.
(2) Fiber optical gyro: The fiber optical gyro used for this measurement is the JG-35FD fiber optical gyro of Japan Aviation Electronics Industry, Ltd. which is shown in Figure 3.
(3) Accelerometer: The accelerometer used for this measurement is the JA-5V accelerometer of Japan Aviation Electronics Industry, Ltd. which is shown in Figure 4.

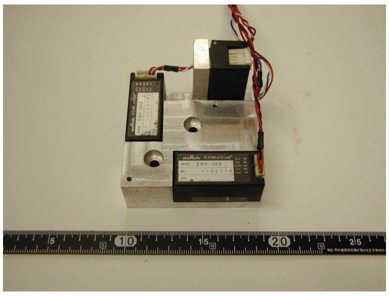

Figure 2. Vibration gyro

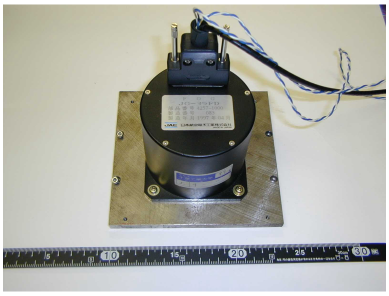

Figure 3. Fiber optical gyro

Figure 4. Accelerometer

2.2 Inertial photogrammetric camera

The experiment device equipped with the inertial device in the camera is defined in this study as an inertial photogrammetric camera. The inertial photogrammetric camera made for this study is shown in Figure 5. The camera used is a digital camera with 2.11 million pixels. The gyro and the accelerometer which are installed at right angles to each other are equipped with the camera. As a result, the three dimension position and the inclination of the camera when taking a picture are required.

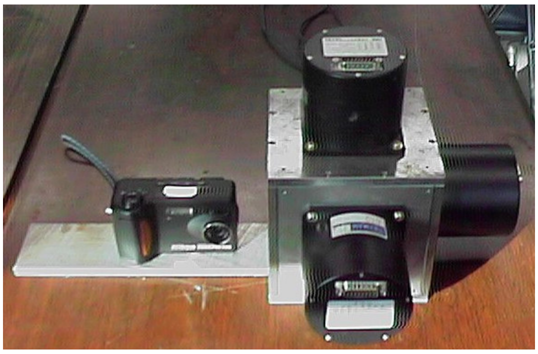

Figure 5. Inertial photogrammetric camera

2.3 Composition of experimental device

The photograph device made for this study is shown in Figure 6. Final inertia photogrammetric camera system with the aim in this study is the handy type equipment. However, since it is in the middle point of present development, the inertial sensor and digital camera are mounted on the tripod, and the tripod is put on the four-wheeled cart.Figure6 shows the inertial photogrammetric camera device. In addition, the following were also mounted on the cart Personal computer for data collection and personal computer for the image datum collection and electric power source equipment for the drive. In the experiment field, the tripod of the camera on the cart prevented the swinging of the camera, as it is lower, and the tripod of which it was tall had to be used, since the tree of which it is tall mainly exists.

Figure6. Four-wheeled cart type

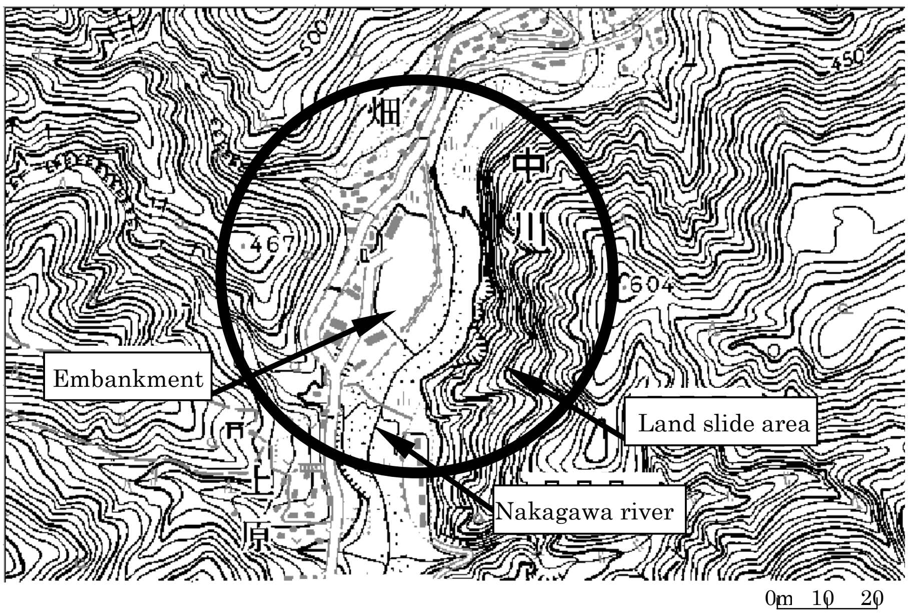

Figure7. Map of the experiment field

Figure8. Aspect of experiment

3.PREPARATION OF TOPOGRAPHIC MAP FOR LANDSLIDE AREA

The landslide area was measured using the inertial photogrammetric camera system. The place as an object is the steep landslide area shown in Figure7. The landslide area and the river are located between the center part enclosed with the circle on the map of Figure7 and there is an embankment. The landslide area has a height of about 60 meters and a width of about 100 meters at the lower end of landslide area, and the inclination angle is about 50 degrees.

3.1 Experiment field and aspect of experiment

White board of 80 cm×80cm size was installed in several pieces in the landslide area in order to examine the accuracy of measurement result got by the inertial photogrammetry, It was measured by the Total Station and was made to be a true value. The photographing was carried out by the transfer of the camera in respect to the embankment in the opposite shore which separated about 120 meters from landslide area, as it is shown in Figure7. The upper embankment contained a rugged dirt lane which caused the mounted camera on the cart to shake a lot while being tlansferd. The aspect of the experiment is shown in Figure8.

3.2 photographing

The cart was made to move to B point, C point, D point, after the photographing was carried out at photographing start point A, as is shown in Figure9, The photographing was almost perpendicularly carried out for the landslide area. Figure10 shows the stereo photograph taken a picture with A point and C point.

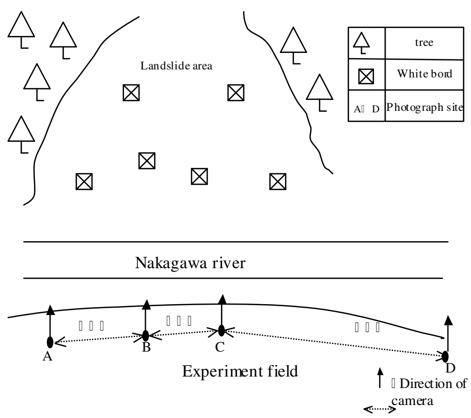

Figure9. Photography

Stereo photograph(left side)

Stereo photograph(right side)

Figure10. Photographed stereo photograph

3.3 Preparation of the topographic map

The photograph was expanded to the A4 size, and printed on printing paper. Coordinates of the measurement point on the photograph were measured by the digitizer, and the topographic map was made based on the data. The measurement point on the photograph were white boards set up beforehand on the landslide area, a scattered rock, etc. and those three dimension positions were calculated. The topographic map made by the inertia photogrammetric camera is shown in Figure11, and the topographic map described on the basis of the data of the Total Station is shown in Figure12. The contour line was depicted using Arc/view which was the software of GIS. The contour line intervals drawn in the topographic

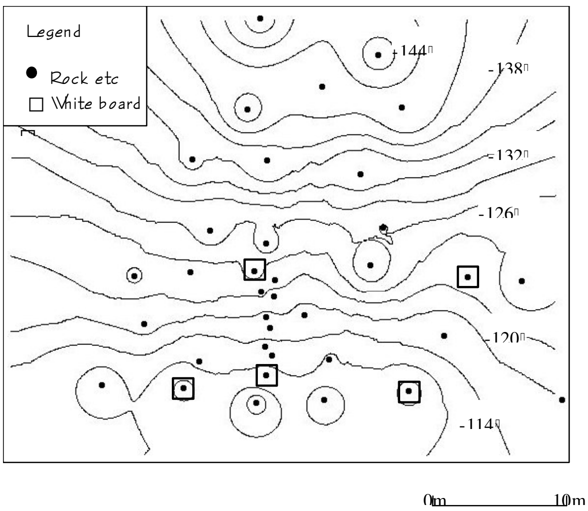

Figure11. Contour map(Inertial photogrametric camera)

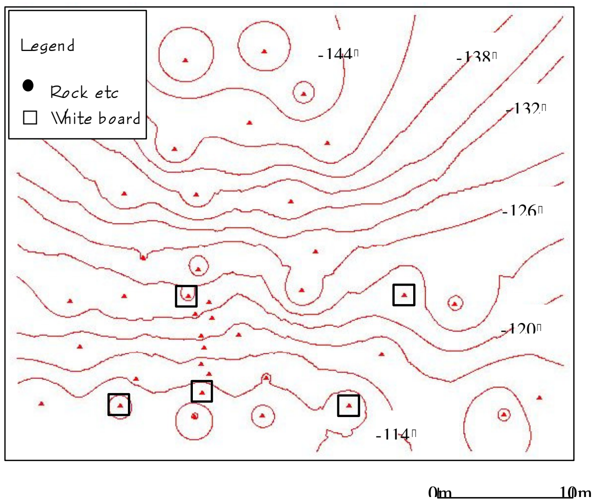

Figure12. Contour map(Total Station)

4. CONCLUSION

This study aimed at the development of photogrammetry which does not need a control point. This method, was carried out using a new aspect in the use of the accelerometer and the gyro, besides the method by the GPS and the gyro that is generally the main current of the present research. The following are the conclusions drawn:

(1) The contour map drawn using the system developed in this study was found to be almost identical to that drawn using a Total Station, indicating that the system developed in this study was very useful.

(2) A cart with wheels was used as part of the equipment. However, because the size of the wheels was small, the moving cart significantly jolted over the roughness of the terrain where it passed, which was undesirable. Therefore, it is necessary to modify the design of the cart (platform) so that it jolts less.

(3) The inertial photogrammetry system can be used for many applications other than surveying landslide areas. For this purpose, it is necessary to improve its measuring accuracy and modify its existing design in order mainly to enhance its user-friendliness.

(4) Many useful data essential for the advancement and development of an inertial photogrammetry system have been collected.

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