REAL-TIME MEASUREMENT OF ALTITUDE DATA USING THE ACCELEROMETER

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ABSTRACT

In the determination of the position of the platform which collects image sensing information, the information on the height direction (altitude) is important. GPS is low in accuracy in determining altitude, though GPS is a powerful means of positioning the platform, and its use is difficult in the city region and the mountain region, where the electric wave does not reach easily. Moreover, also in the method of computing distance and an angle, respectively, using an accelerometer and a gyroscope for the inertial navigation system, and computing a 3-dimensional position, development is advancing(inertial survey). However, the accuracy of a gyroscope is low (high accuracy gyroscopes are expensive) and has caused a minus factor for utilization. From such a situation, the following two things were developed by this research: Altitude data is extracted only using an accelerometer. It is carried in vehicles etc., and altitude data is extracted. When altitude data extraction, such as the Mobile matching, becomes important by this, it is considered that it becomes a very effective thing.

1. APPARATUS USED

The accelerometer used in this research is Japan Aviation Electronics Industry, Ltd. JA-5VC1 accelerometer. The power supply of the accelerometer is Japan Aviation Electronics Industry, Ltd. PA-1001-11C1 accelero amplifier. Moreover, the 24bit A/D conversion board, which changed from analog data into digital data and was used in order to carry out calculation processing, is Interface company 98AD24N8S-79 AZI-3108. Measurement equipment attaches an accelerometer in a block so that it may become a 3 axes rectangular cross as shown in Figure1, and it is attached in the stand which prevents vibration.

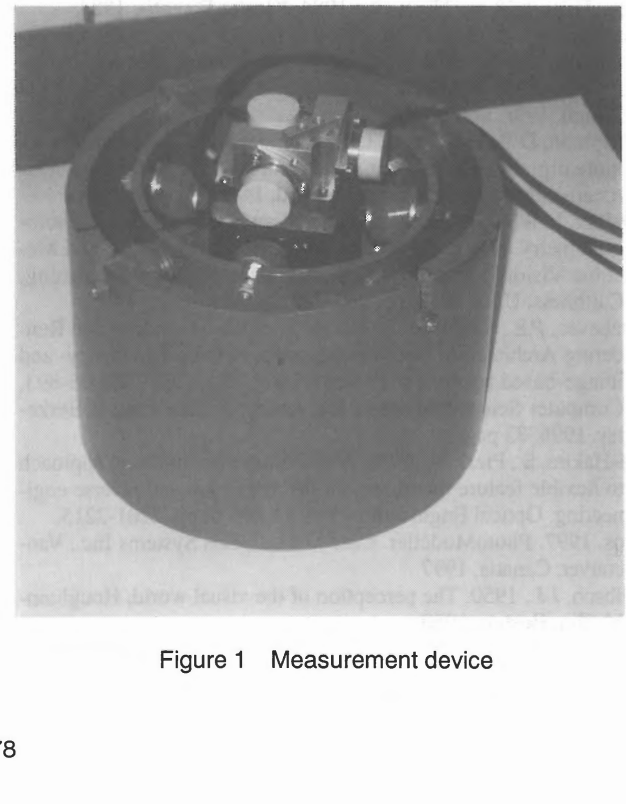

Figure 1 Measurement device

2. THE PRINCIPLE OF EXTRACTION OF ALTITUDE DATA ONLY USING THE ACCELEROMETER

What is necessary is to catch change of the acceleration of the direction of a gravity axis, in order to extract altitude data using an accelerometer. What is necessary is for that to turn the detection axis of one accelerometer in the direction of a gravity axis. Then, the change in the acceleration in the direction of the gravity axis can be seen by pulling the value of gravity in the point from the obtained value. It is assumed that the change in the distance (height) in the direction of the gravity axis by integrating the change in the acceleration at time, catching as a change in the speed in the direction of the gravity axis, and integrating again in addition at time. However, it is very difficult always to put the detection axis of the accelerometer for a constant direction. Although there is device which keeps the horizontal, called a gimbals mechanism, it is hard to create with sufficient accuracy. Then even when the direction of a detection axis is not fixed, the method obtained in the acceleration of the direction of a gravity axis is considered. When the vector of one of every three dimensions is shown, it is possible to show as coordinates by the length of three orthogonal axes. A perpendicular acceleration can be measured by installing three accelerometers as much as this to orthogonalize respectively (Figure 2).

$$G+V=\sqrt{a^2+b^2+c^2} \quad (2.1)$$

G: Gravity acceleration
V: Vertical acceleration
a,b,c: Acceleration of each axis

The acceleration in the direction of the gravity axis is obtained by the expression above as the combined power of three accelerometers. Because gravity only works when the device is geostationary, the combined power of three accelerometers will measure gravity. Moreover, when the device moves in the direction of the gravity axis, the acceleration which the gravity acceleration plus moves is detected. However, in movements other than the direction of the gravity axis, the combined power of a horizontal acceleration and the acceleration in the direction of the gravity axis is detected, and the error is caused in the level survey. Then this research examined how to remove horizontal acceleration. By this method, it compares with the method of an inertial survey of the former using the gyroscope and the accelerometer. It is not necessary to think the rotation of device and the state of the device of initial movement (horizontal and direction etc. of progress); therefore the device may be simplified (the gyroscope is not needed) and the data analysis can be simplified. In addition, when asking high precision by the conventional inertial survey, since a gyroscope is very expensive, it is connected also with curtailment of cost.

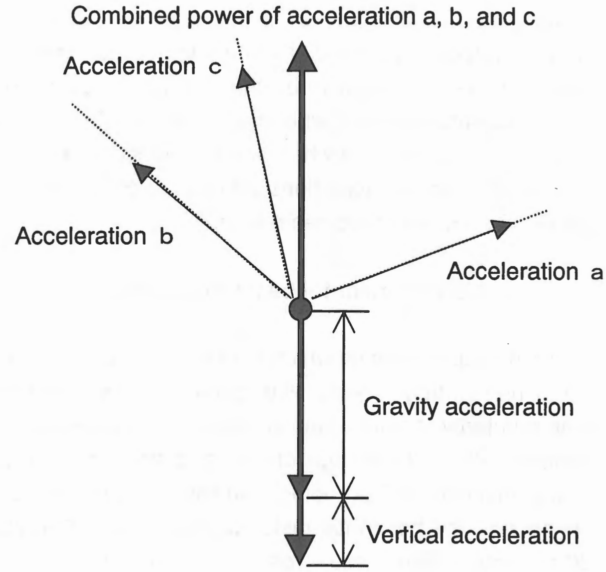

Figure 2 Combined power of three axes

3. BASIC EXPERIMENT

3-1. Perpendicular basic experiment

The experiment device was installed in the elevator in the fourth Chiba Institute of Technology building (RC9 story) to experiment on the movement only in a perpendicular direction, and the distances measured with the calculated moved distance and a steel tape measure were compared. The experiment horizontally installs the level stand, and the measurement device is installed on it. Two cases were studied: the case where maintained the level mostly and it moves, and the case where device is leaned by hand during movement. Measurement performed movement of the first-third floor, the first-fifth floor, the first-seventh floor, and the first-ninth floor on the sampling frequency of 100Hz. Analysis computed the combined power of the acceleration of the direction of three axes, and what had been integrated twice at time was assumed to be height. Figure 3 shows the result.

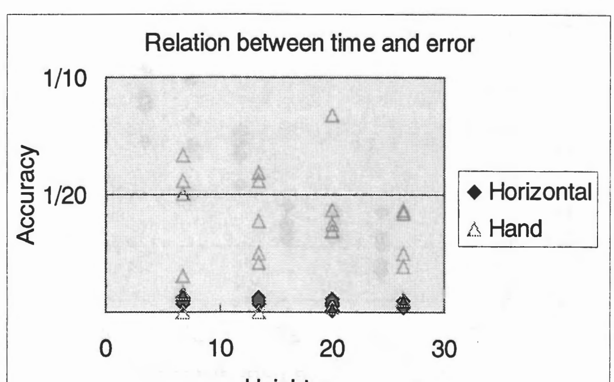

Figure 3 Experiment result

As a result, the measurement of the height of accuracy about 1/200 is possible for a perpendicular movement. However, accuracy is very bad when leaning by hand. The cause of this is thought to be that for the acceleration to work horizontally in time when the device is lifted from the level stand, putting, and when had the device by the hand, and to calculate accelerations other than the direction of the gravity axis as combined power.

3-2. Horizontal basic experiment

To do the experiment by which the height (error) calculated when horizontally moving was confirmed, by movement time regularity, distance was changed and it moved on the almost horizontal passage of the third floor of the fourth Chiba Institute of Technology building (Figure 4). Each distance of the horizontal distance 10m, 15m, 20m, 25m, 30m, and 35m was measured at 30 seconds. Measurement was performed on the sampling frequency of 50Hz. Figure 5 shows the result.

Figure 4 Experiment place

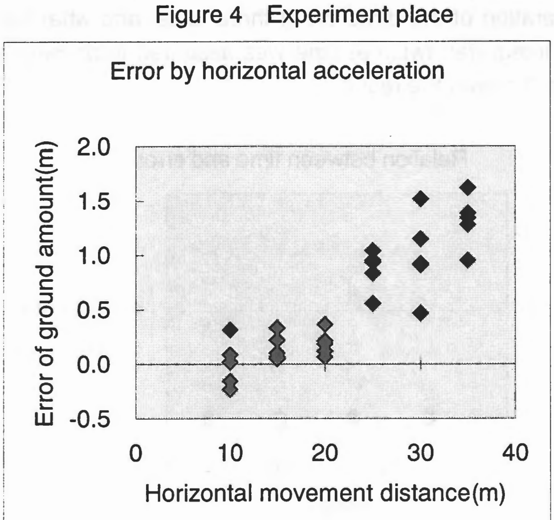

Figure 5 Experiment result

An experiment result shows that the large error has come out of a quicker motion. As a result, the influence of the horizontal acceleration is understood. How this horizontal acceleration is processed because the horizontal acceleration greatly influences in the measurement which uses the combined power of three axes becomes a problem.

4. APPLICATION TO FIELD EXPERIMENT

4-1. Ideal model

The influence of the horizontal acceleration is considered. The horizontal acceleration is included in the combined power of three accelerometers as shown in Figure 6. To examine the influence of the horizontal acceleration, the following models were examined theoretically.

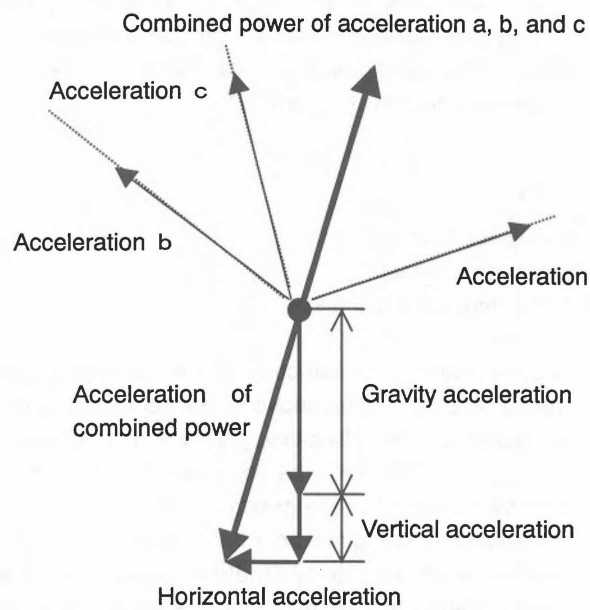

Figure 6 Influence of horizontal acceleration

<The conditions of a model>
It goes straight on a horizontal plane, and it is accelerated to 40km/h (11m/s) at 8 seconds. It runs 40km/h for 85 seconds, and it stops at 5 seconds. The gravity acceleration is assumed to be 9.8m/s^2. On the basis of this, it verifies by actual motion (Figure 7～10).

4-2. Comparison with Ideal model

It experimented by considering application in an actual geographical feature from the result of a perpendicular basic experiment and a horizontal basic experiment, and carrying measurement device in a car.

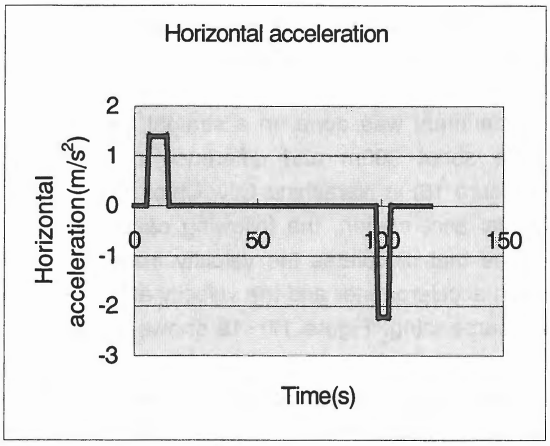

Figure 7 Horizontal acceleration model

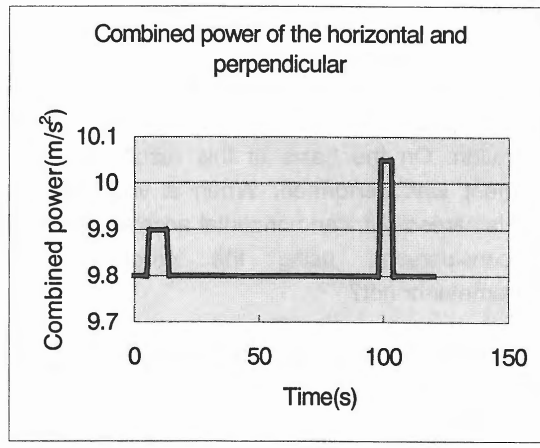

Figure 9 Combined power model

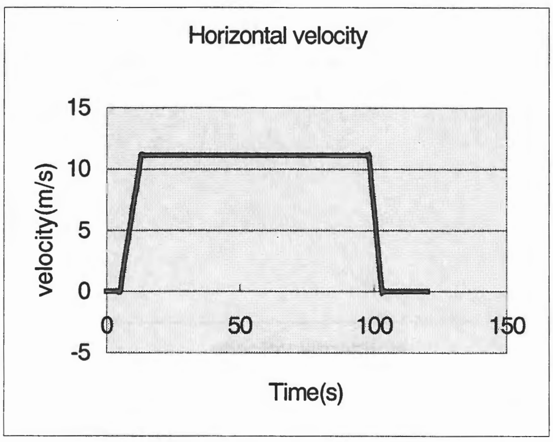

Figure 8 Horizontal velocity model

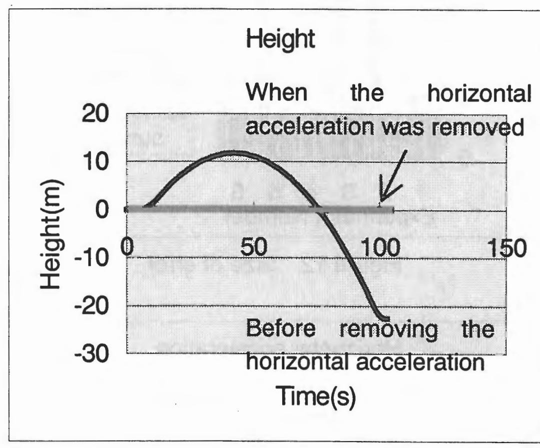

Figure 10 Height model

One piece is perpendicularly turned among three acceleration meters, and one more piece is turned in the advance direction, and it is carried in vehicles on a straight line road of the distance about 500m and difference of height about 0.5m in the vicinity of Akanehama, Narashino City, Chiba Pref. (Figure 11).

The motion like an acceleration → fixed velocity (45 km/h)→ deceleration

The velocity of the wheel was recorded in the video at the same time as the person in the passenger's seat read the speed meter of the vehicle by eyes. Moreover, the experiments were measured at the same time at the inertial survey, and compared. As for the horizontal acceleration, two cases were thought. The case where one watched the meter of the car, and presumed the speed (presumed horizontal acceleration). The case where another one calculates the velocity from the progress direction accelerometer and the velocity at a fixed velocity to the same thing. Figure 12～15 show the experiment result.

Figure 11 Experiment place

From the result of the experiment, both the case of using the presumed acceleration and the assumption of the accelerometer in the direction of progress a standard were able to consider the influence of a rough, horizontal acceleration. On the basis of this result, the following experiment was performed. When a very complicated motion is carried out, can horizontal acceleration be taken into consideration using the progress direction accelerometer or not?

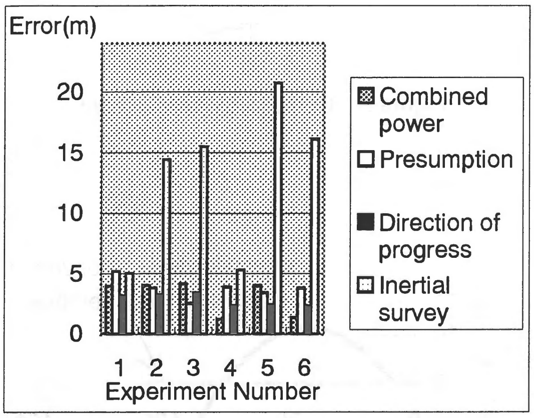

Figure 12 Size of error

4-3. Analysis to complex movement on road with inclination

The experiment was done on a straight line road of the distance about 500m and difference of height about 9.6m(Figure 16) in Narashino City, Chiba Pref. As for the horizontal acceleration, the following case was thought. The case that calculates the velocity from the progress direction accelerometer and the velocity at a fixed velocity to the same thing. Figure 17～19 shows the experiment result.

By this experiment, in the movement on the field without a slope, the progress direction accelerometer can be used. However, if the progress direction accelerometer is used in the movement on face of a large slope, the device will incline, and it will be influenced by gravity acceleration. And it will be large error. Therefore, the sensor of the velocity of the car etc. which accurately detects the speed is necessary to improve accuracy.

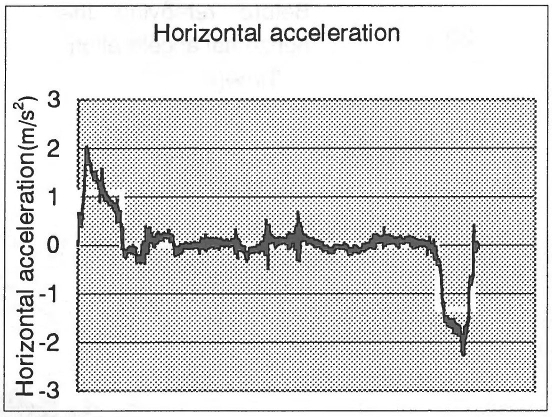

Figure 13 Horizontal acceleration

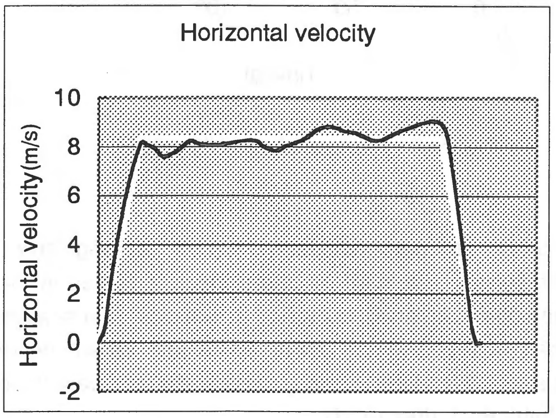

Figure 14 Horizontal velocity

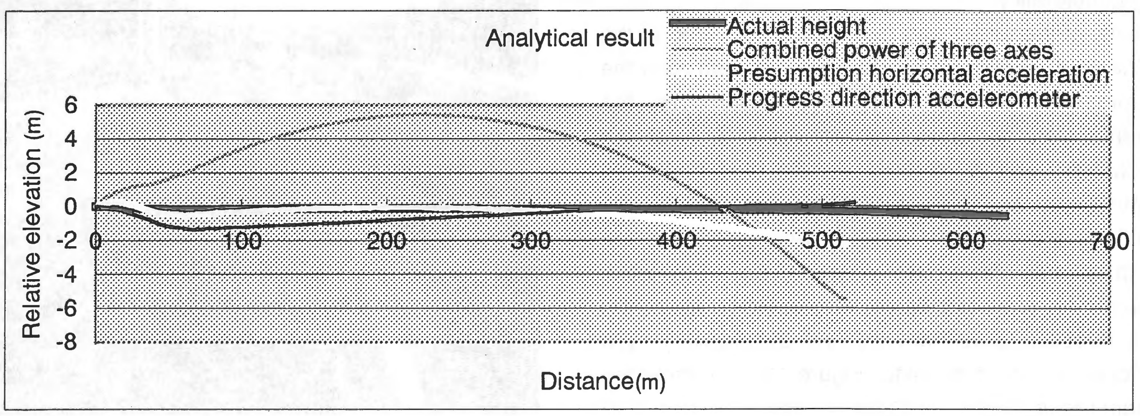

Figure 15 Experiment result

Figure 16 Experiment place

5. Conclusion

In one acceleration meter, because a large scale device which kept the horizontal, that is, the gimbals mechanism was necessary, it thought about an irrelevant device to the inclination of the device with three acceleration meters. This method is the installation of the accelerometer on three orthogonal axes, and it is the one measured based on the combined power of three axes. When the movement of the perpendicular was measured based on this device, a tentative result was obtained. Application in actual geographical feature was performed on the basis of the result there. As a result, it has been understood that the horizontal acceleration when horizontally moving influences the error. Then, the speed meter of the car was used to measure the horizontal acceleration. As a result, because the road inclination was comparatively small, it was able to be confirmed that accuracy in a perpendicular direction improved more than the inertial survey by this method on a general road.

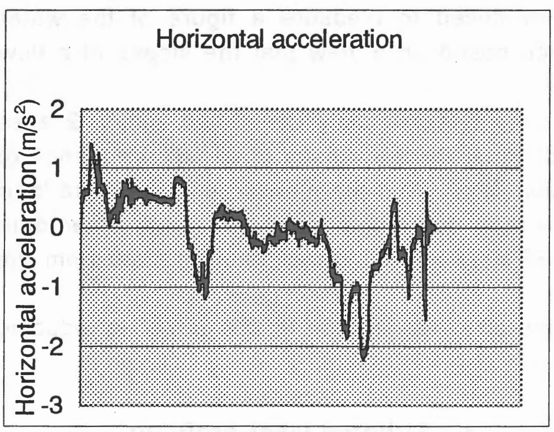

Figure 17 Horizontal acceleration

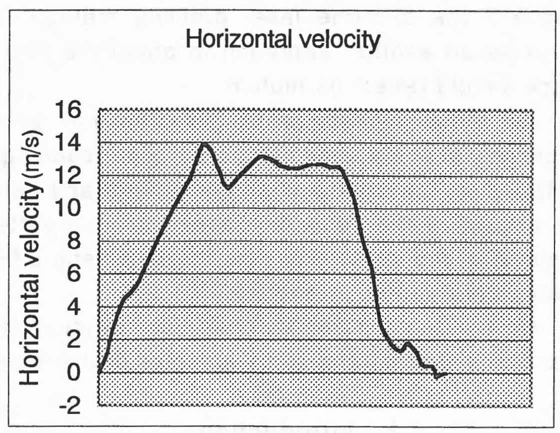

Figure 18 Horizontal velocity

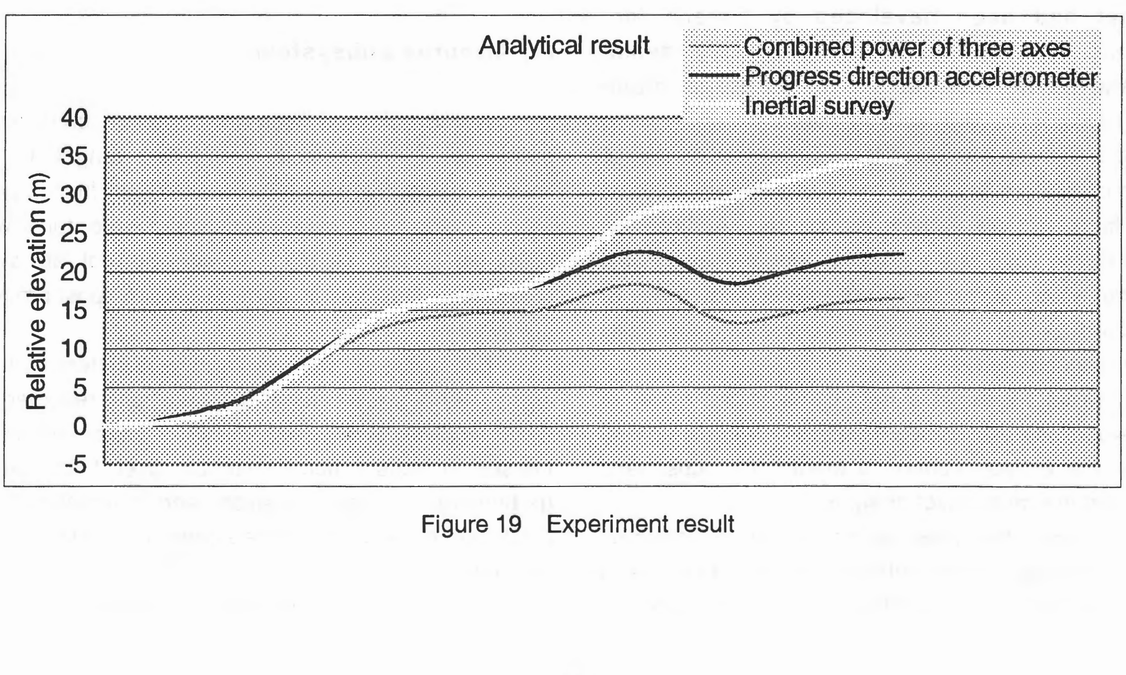

Figure 19 Experiment result