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Preliminary Study on Measurement of Global Coordinates from a Close Range Using an Attitude Heading Reference System (AHRS)

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***Abstract*— In this study, a conceptual measurement model for a targeting global coordinate from an original points was investigated using a laser sensor and AHRS. The target coordinate was estimated from the current global coordinate, distance and Euler angle. The global model is generally nonlinear, thus equal search was applied for the estimation. The method will be convenient to obtain positions of buildings, stadiums and land.**

I. Introduction

Global coordinates are widely used in various commercial areas such as mobile phones, autonomous driving and logistics. Recent global navigation satellite system (GNSS) provides precise positional information in centimeter level. Thus, global coordinates of targeting points in a stadium, outdoor concert and building can be estimated using a laser, tilt and GNSS sensors. GNSS sensors are commonly combined with an attitude heading reference system (AHRS) which is composed of an inertial measurement unit (IMU), and gravity sensor. This study theoretically investigated an estimation method of a global coordinate targeted by a laser sensor.

II. Methods

The measurement of a target coordinate in a short distance is shown in Figure 1. A laser sensor on a stage aims at a point on a wall and measures the distance. The global coordinate and the Euler angles of the laser sensor are obtained using the GNSS and IMU sensors respectively. The relative distance (d_x, d_y, d_z) can be calculated from the outputs of the laser and IMU sensors. Then, height of the targeting point is simply obtained by the height of the GNSS and the d_z. However, latitude and longitude must be estimated using a sphere and WGS84 models. These models calculates distance between two global coordinates. The relation between the relative distance and the target coordinate can be described explicitly as follows [1].

$$(\Delta\phi, \Delta\psi) = (\phi_1 - \phi_2, \psi_1 - \psi_2) \quad (1)$$

$$\omega = 2\sin^{-1}\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + cos(\phi_1)cos(\psi_2)\sin^2\left(\frac{\Delta\psi}{2}\right)} \quad (2)$$

$$d = \sqrt{d_x^2 + d_y^2} = 2R_{earth}\omega \quad (3)$$

The WGS84 model considers the elliptical shape of the earth, thus is more complex owing to the major and minor axes [2]. The general relation between the models and sensors can be written as follows.

$$(\phi_2, \psi_2) = f(d_x, d_y, \phi_1, \psi_1) \quad (4)$$

As shown in equations (1) – (3), it is difficult to solve the equations analytically, thus equal search was applied. The equal search is normally exact and convergent but computation cost is expensive. However, the computation boundary is limited into the laser measurement range, thus the equal search is exceptionally available in this case.

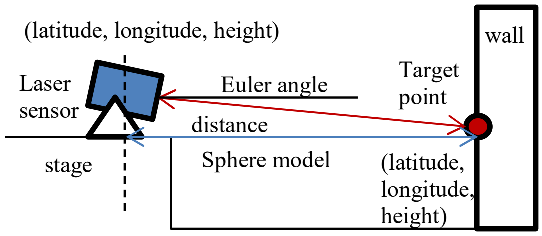

Figure 1. Conceptual diagram of global coordinate measurement.

III. Results & Discussion

The global coordinate of the laser sensor was virtually defined on our office using the Google map. Ten global coordinates was also obtained around the office, (37.2930, 126.8408), for the verification. The distance was obtained from the Great Circle Calculator of the NHC. The maximum distance error of the proposed method was 8.5 and 82 µm for the sphere and WGS84 models, respectively. When calculating the target coordinate using the distances, the error was below the accuracy of commercial GNSS sensors. The processing time was under 1.6 and 0.7 sec for the sphere and WGS84 models respectively. We are currently integrating the laser, GNSS and IMU sensors into a sensor module on which the proposed method will be embedded.

IV. Conclusion

A method to measure a global coordinate from a close range using a laser, GNSS and IMU was proposed. The method was composed of sensor outputs, geometrical relations and equal search. The proposed method was simulated using the Google map and was verified using the Great Circle Calculator. The simulated performance showed the possibility to construct a sensor module.

References

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