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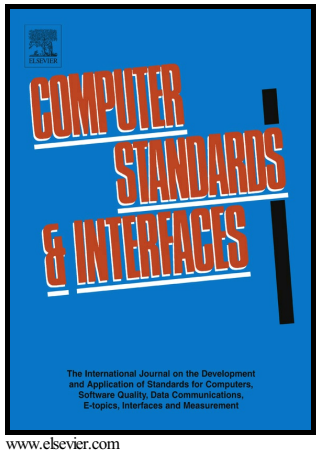

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Abstract

In this paper, we propose a remote measurement system consisting of a single point laser distance sensor and an IMU (Inertial Measurement Unit). The movement of the system is estimated using a strapdown inertial navigation algorithm. This movement information is combined with the distance sensor to obtain remote point position. The distance sensor is a time-of-flight range finder and can measure distances up to 40 m. Using the estimated remote point position, length between remote points is computed. Also, a plane to plane (such as wall to wall) distance is estimated. The maximum root mean square of the error (RMSE) for the length, height, angle are 2.93 cm, 2.23 cm and 0.58 deg, respectively.

Keywords: Remote measurement, LIDAR, inertial sensor, IMU, hand-held device

1. Introduction

LIDAR (Light Detection and Ranging) is now commonly used in mapping by attaching the LIDAR in an airplane [1, 2, 3], a robot [4, 5, 6] or a vehicle [7, 8, 9]. LIDAR is also commonly used as a measurement system. There are many accurate measurement devices based on the LIDAR measurement system, such as LM-100 [10], 414D [11], D110 and D2 [12]. These devices are normally used as length measurement systems and can be used with an extra package to obtain more measurement functions. Although this system can give high accuracy, it is not flexible due to the auxiliary package. For example, professional measurement functions, such as point-to-point, smart angle and area measurement functions, are added in S910 [12]. However, this device must be used with a complicated auxiliary package consisting of a Leica FTA360-S tripod adapter and a Leica TRI 70 tripod and then rotated around a fixed center during measurement.

The LIDAR measurement system could become flexible by replacing the complicated auxiliary package with a motion sensor. Since a system consisting of a LIDAR and a motion sensor can be easily used as a handheld device, the measurement system becomes more convenient. In this paper, we apply a simple system consisting of a single point laser distance sensor (1-D LIDAR) and an IMU (three-axis accelerators and three-axis gyroscopes) to remote length measurement problems with reasonable accuracy. Since an IMU provides the pose of the system and the distance sensor obtains the distance to target points, the system provides 3-D coordinates of the target points with respect to a local coordinate system in which the z-axis is pointing upward. Using the 3-D coordinates, we can compute information (such as length, height, angle, area and distance) on the target objects. Recently, IMU had been embedded in smart phones. This system can be constructed by simply attaching a distance sensor to a smart phone.

Many research approaches related to the remote measurement problem are proposed. In [13], authors proposed a distance estimation system using an IMU and a mono camera. In this research, two images of the

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