Positioning System for 4-Wheel Mobile Robot: Encoder, Gyro and Accelerometer Data Fusion with Error Model Method

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ABSTRACT

In this sensor fusion approach, combination of filtering encoder, gyro and accelerometer's signals was used to improve and correct the measurement of 4-wheel mobile robot's own position. The error model method was proposed for fusing encoder information with relative position measurement by gyro sensor and accelerometer's information to obtain more reliable position estimation. From this, we computed high-accuracy position estimation and had reduced the systematic and non-systematic errors during traveling and had succeeded in estimating the bias drift of gyro and accelerometer. The basic tool here is a Kalman filter supported by change detection from sensor diagnosis. Results and experience of real-time implementations are presented.

Key words: Sensor fusion; Odometry; Gyro; Accelerometer; Bias drift; Mobile robot

INTRODUCTION

Typically, mobile robot's behavior such as navigation, map building and estimation of own position is very important. There are lots of researches regarding the mobile robot (Watanabe and Yuta, 1990; Komori et al., 1992; Barshan, 1994; Cooper and Durrant-Whyte, 1994; Komoriya and Oyama, 1994; Maeyama et al., 1994; Tonouchi et al., 1994; Borenstein et al., 1996; Maeyama et al., 1996; Borenstein and Feng, 1997; Maeyama et al., 1997; Abott and Powell, 1999; Becker and Simon, 2000; Hashimoto et al., 2000). Basically, the method of estimation for a wheel-type mobile robot's position employs the rotation encoder (also called odometry system) of a wheel, etc. However, in outdoor environment, the estimated position by encoder has an unpredictable error caused by traveling over an unexpected small object or a bump under the wheels. When this happens, the accuracy of the estimated robot's position becomes worse instantaneously. Despite these limitations, most researchers agree that encoder is an important part of a robot's navigation system and that navigation tasks will be simplified if encoder accuracy can be improved. Since a gyro sensor and accelerometer (acceleration sensor) can measure directions and acceleration of a robot, unrelated to the condition of a road surface, they are very effective in position estimation. When we have the informations from different sources, the problem rises here is how to use them with fusion method (Ishikawa and Yamasaki, 1994; Luo, 1994; Toshiharu and Ishikawa, 1994; Becker and Simon, 2000). In this paper, we propose a method for fusing encoder information with relative position measurements by gyro sensor and accelerometer's information to obtain