AUTONOMOUS MOBILE ROBOT INDOOR NAVIGATION USING MULTI-SENSOR INTEGRATION

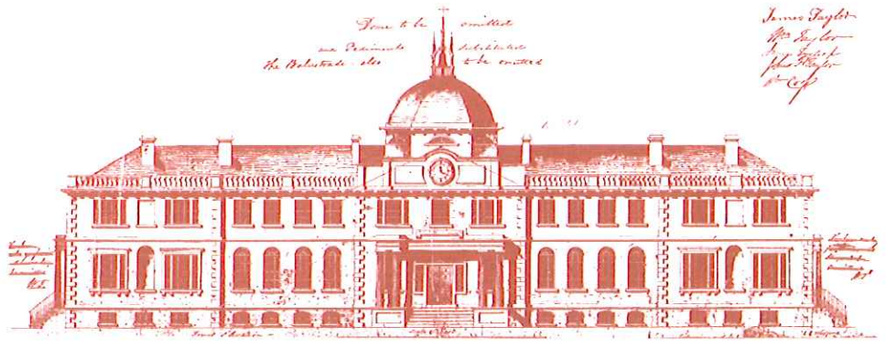
Abstract

Currently, most of the autonomous mobile robot indoor navigation systems are unable to provide absolute state information and rely on expensive sensors. The goal of this research is to develop a low cost, high accuracy, autonomous mobile robot indoor navigation system. The robot starts from an unknown location in a corridor environment and arrives at a selected target point with certain accuracy by following the center line or virtually any lane of the corridors. The core of this autonomous navigation system is in the development of reliable indoor orientation and position estimation algorithms.

Integrating MEMS inertial and magnetic sensors improves overall performance of orientation estimation. However, challenges exist in dealing with the large sensor errors of gyros and the large measurement noises of accelerometers and magnetometers. A quaternion based Kalman filter has been developed which applies tightly coupled and closed-loop integration strategies. It incorporates an online sensor calibration procedure for modeling time-varying sensor biases of the accelerometers and magnetometers, and a mechanism for adapting the measurement noise in the presence of motion and magnetic disturbances. In static mode, the integration algorithm can provide an estimation accuracy of less than 1° when there is no magnetic anomaly. Even with the existence of significant magnetic disturbances, the orientation estimation error is reduced from up to 131.6° to 4.7°. In kinematic mode, the solutions show as much as 40% error reduction compared to those without applying the integration strategy.

A novel indoor positioning system based on radio frequency identification technology has been developed, which can deal with complicated indoor radio signal environments due to multipath, non-line-of-sight, and signal interference. A regularized particle filter has been built by employing a non-parametric, probabilistic observation model. An effective online measurement quality control algorithm has been developed, which can identify and reject non-line-of-sight and/or multipath corrupted measurements. The developed indoor positioning system achieved a mean positioning error of 1.64 m, which is about 49% or more improvement in accuracy compared to other conventional methods such as the geometry-based approach applied in RADAR.

To successfully guide a robot to a target position, a sonic-vision system that can profile the local environment has been developed and two intelligent controllers have been designed. An efficient autonomous navigation algorithm has been developed, which choreographs all sub-system components comprising the orientation estimation module, the positioning module, the sonic-vision, and the intelligent controllers. The results showed that the robot is able to autonomously navigate to a pre-specified target point with a mean offset of 2.38 m. The average cross-track error was about 0.1 m which indicates the controllers' autonomous capability in tracking and guidance. Overall results have confirmed the significant performance improvements of the developed orientation and position estimation methods, the benefits of applying them for indoor navigation, and the effectiveness of the autonomous navigation algorithm.



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UNIVERSITY OF NEW BRUNSWICK

SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Hui Tang

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Hui Tang

Graduate Academic Unit

Geodesy & Geomatics Engineering

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December 16, 2013

1:00 p.m.

ADI Studio (Room HC-25)
Head Hall

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Examining Board:

Dr. Donghyun Kim (Geodesy & Geomatics Eng.)	Supervisor
Dr. Richard Langley (Geodesy & Geomatics Eng.)	
Dr. Peter Dare (Geodesy & Geomatics Eng.)	
Dr. Howard Li (Elect. & Comp. Eng.)	Chairperson

External Examiner:
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Universities attended:

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Publications:

Tang H. and D. Kim (2013). "A probabilistic approach to RFID mobile robot positioning." *IEEE Transactions on Signal Processing* (submitted).

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