NOTICE OF THESIS PROPOSAL PRESENTATION

Geodesy and Geomatics Engineering

Doctor of Philosophy

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Friday, December 4, 2009
Head Hall – Room E-11 @ 1:30 pm

Supervisor:	Dr. Dongyun Kim, Geodesy and Geomatics Eng.
Supervisory Committee:	Dr. Richard Langley, Geodesy and Geomatics Eng.
	Dr. Peter Dare, Geodesy and Geomatics Eng.
Chair:	Dr. John Hughes Clarke, Geodesy and Geomatics Eng.

Autonomous Indoor Navigation Using RFID, IMU and Other Navigational Sensors

ABSTRACT

For autonomous navigation in an indoor environment, a mobile robot should be able to figure out its own position and orientation with respect to a reference frame. For position and velocity determination, the Global Positioning System (GPS) is the most worldwide method. However, it is restricted typically to outdoor applications because GPS signals available in an indoor environment are normally too weak to track. A few high-sensitive GPS receivers can track weak signals in a building. However, GPS receivers often have increased errors in an indoor environment due to signal blockage and multipath interference.

For absolute position determination of a mobile robot in an indoor environment, radio frequency identification (RFID) is a promising technology. Some research has been done using RFID technique to realize indoor positioning based on trilateration. For an indoor environment with severe multipath and some other site specific effects, it is difficult to model the relationship between signal strength measurement and range. Probabilistic localization method naturally takes the variation into account, which would give accurate estimation of location. Instead of using the conventional estimation filter such as an extended Kalman filter (EKF) and an unscented Kalman filter (UKF), I propose to employ a particle filter (PF) to deal with the non-Gaussian problem typically in indoor environments.

Positioning using only RFID technique can only provide meter-level accuracy, which cannot satisfy high accuracy applications. In this research, I propose to integrate an inertial navigation system (INS) and an RFID system, as well as two optical encoders to develop a positioning system with high accuracy. An INS is a self-contained navigation unit that provides attitude, velocity and position information through direct measurements from the inertial measurement unit (IMU) or by integration, which has short-term accuracy and can operate continuously in indoor environments. Integration by taking advantages from both sides would give better solutions. The significant challenges in integrating a low-cost MEMS IMU with an RFID system arise from dealing with quickly drifting IMU estimates, corrupted RFID data in a dynamic indoor environment, and no RFID measurement update for the worst case.

The accuracy of an inertial navigation solution degrades with time as the inertial sensor errors are integrated through the navigation equations, especially for a low-cost Micro-Electro-Mechanical-System (MEMS) IMU. To solve the divergence problem, I propose to integrate a tri-axis gyro, a tri-axis accelerometer as well as a tri-axis magnetometer to update the drifting attitude estimate. Tilt angle correction from accelerometers and heading compensation from magnetometers, which show long-term accuracy, are able to update the gyros' drifting attitude solutions. Special attention should be paid to non-gravitational acceleration when applying the tilt angle correction from accelerometers, and the distorted magnetic measurements. Velocity and relative displacement information provided by the optical encoder can be used to update the drifting accelerometer estimates. On the other hand, the accurate attitude deduced through the above pre-filtering stage, and velocity from the optical encoder can be used to improve the RFID positioning accuracy and efficiency.

The field tests will be carried out in our indoor navigation lab of dimension 6m×15m. Four or more long range active RFID tags will be attached on the wall, and a mobile robot equipped with an RFID reader, and an MEMS IMU as well as two optical encoders, will be tested along a pre-defined trajectory to validate my navigation method.

It is believed that with such a multi-sensor integration strategy, centimeter level positioning accuracy and $1° \sim 2°$ attitude results can be delivered for mobile robot in real-time.

Faculty Members and Graduate Students are invited to attend the 20 minute presentation