High Speed Motion Tracking with Magnetometer in Nonuniform Magnetic Field

Authors : Jeronimo Cox, Tomonari Furukawa

Abstract : Magnetometers have become more popular in inertial measurement units (IMU) for their ability to correct estimations using the earth's magnetic field. Accelerometer and gyroscope-based packages fail with dead-reckoning errors accumulated over time. Localization in robotic applications with magnetometer-inclusive IMUs has become popular as a way to track the odometry of slower-speed robots. With high-speed motions, the accumulated error increases over smaller periods of time, making them difficult to track with IMU. Tracking a high-speed motion is especially difficult with limited observability. Visual obstruction of motion leaves motion-tracking cameras unusable. When motions are too dynamic for estimation techniques reliant on the observability of the gravity vector, the use of magnetometers is further justified. As available magnetometer calibration methods are limited with the assumption that background magnetic fields are uniform, estimation in nonuniform magnetic fields is problematic. Hard iron distortion is a distortion of the magnetic field by other objects that produce magnetic fields. This kind of distortion is often observed as the offset from the origin of the center of data points when a magnetometer is rotated. The magnitude of hard iron distortion is dependent on proximity to distortion sources. Soft iron distortion is more related to the scaling of the axes of magnetometer sensors. Hard iron distortion is more of a contributor to the error of attitude estimation with magnetometers. Indoor environments or spaces inside ferrite-based structures, such as building reinforcements or a vehicle, often cause distortions with proximity. As positions correlate to areas of distortion, methods of magnetometer localization include the production of spatial mapping of magnetic field and collection of distortion signatures to better aid location tracking. The goal of this paper is to compare magnetometer methods that don't need pre-productions of magnetic field maps. Mapping the magnetic field in some spaces can be costly and inefficient. Dynamic measurement fusion is used to track the motion of a multi-link system with us. Conventional calibration by data collection of rotation at a static point, real-time estimation of calibration parameters each time step, and using two magnetometers for determining local hard iron distortion are compared to confirm the robustness and accuracy of each technique. With opposite-facing magnetometers, hard iron distortion can be accounted for regardless of position, Rather than assuming that hard iron distortion is constant regardless of positional change. The motion measured is a repeatable planar motion of a two-link system connected by revolute joints. The links are translated on a moving base to impulse rotation of the links. Equipping the joints with absolute encoders and recording the motion with cameras to enable ground truth comparison to each of the magnetometer methods. While the two-magnetometer method accounts for local hard iron distortion, the method fails where the magnetic field direction in space is inconsistent.

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