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Depth Camera Aided Dead-Reckoning Localization of Autonomous Mobile Robots in Unstructured GNSS-Denied Environments

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Abstract : In global navigation satellite systems (GNSS), denied settings such as indoor environments, autonomous mobile robots are often limited to dead-reckoning navigation techniques to determine their position, velocity, and attitude (PVA). Localization is typically accomplished by employing an inertial measurement unit (IMU), which, while precise in nature, accumulates errors rapidly and severely degrades the localization solution. Standard sensor fusion methods, such as Kalman filtering, aim to fuse precise IMU measurements with accurate aiding sensors to establish a precise and accurate solution. In indoor environments, where GNSS and no other a priori information is known about the environment, effective sensor fusion is difficult to achieve, as accurate aiding sensor choices are sparse. However, an opportunity arises by employing a depth camera in the indoor environment. A depth camera can capture point clouds of the surrounding floors and walls. Extracting attitude from these surfaces can serve as an accurate aiding source, which directly combats errors that arise due to gyroscope imperfections. This configuration for sensor fusion leads to a dramatic reduction of PVA error compared to traditional aiding sensor configurations. This paper provides the theoretical basis for the depth camera aiding sensor method, initial expectations of performance benefit via simulation, and hardware implementation, thus verifying its veracity. Hardware implementation is performed on the Quanser Qbot 2™ mobile robot, with a Vector-Nav VN-200™ IMU and Kinect™ camera from Microsoft.

Keywords : autonomous mobile robotics, dead reckoning, depth camera, inertial navigation, Kalman filtering, localization, sensor fusion
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