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Fusing wheel and visual odometry with inertial measurements: An extended Kalman filter for unmanned ground vehicles in GPS-denied environments

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Localization is a central component of a robotic system as many other technologies providing autonomy rely upon it, such as planning, control, mapping, etc. Smooth and accurate real-time pose estimation is thus a key enabler and many algorithms exist to provide that capability. One of the most successful and widespread approach is the Extended Kalman Filter (EKF), which can fuse asynchronous, time-delayed measurements from heterogeneous sensors. It is commonly used in Inertial Navigation Systems (INS) for combining GPS and IMU measurements. In order to estimate the position and orientation of an unmanned ground vehicle as it travels through an unknown, unstructured, GPS-denied environment, we leveraged the EKF framework to fuse the information provided by the vehicle's onboard gyroscopes, accelerometers, wheel encoders and cameras. Our implementation is customized for ground vehicles, where the non-holonomic kinematics makes the lateral motion difficult to observe. We use angular rate measurements provided by the IMU's gyroscopes together with the forward linear velocity measurement provided by the wheel encoders to predict the vehicle's motion at a high rate. We then use Visual Odometry (VO) as a relative pose measurement together with accelerometer measurements provided by the IMU to update and correct those predictions over time. Our pose estimation system was demonstrated on a real unmanned ground vehicle, a modified military Humvee, in both short and long-drive scenarios and achieved a performance of less than one percent error over distance travelled with accumulated yaw drift being the major source of localization error.

Biography

Olivier A Toupet has completed his MS in Aeronautics and Astronautics from MIT in 2006. He is currently a Research Technologist in the Robotic Mobility group at NASA JPL, where he develops advanced autonomy for robotic systems. He is also a Rover Planner for the MSL flight mission, where he drives the Curiosity rover and operates its robotic arm on Mars.

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