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A constrain approach for UWB and PDR fusion

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ABSTRACT

Pedestrian Dead-Reckoning (PDR) and Radio Frequency (RF) ranging/positioning are complementary techniques for position estimation. The fact that they estimate two different points on the body has been studied in GPS/IMU systems using "lever arm" vector compensation, but the direct fusion of RF positioning in the head/hand and inertial navigation in the foot with constant vector compensation might incorporate errors in the estimation. This is because the compensation vector changes with time for a pedestrian, and requires the establishment of a high covariance in the measurements to account for this change. We propose to treat the time varying compensation with an upper bound in the distance between the estimated positions of both sensors.

It is possible to treat the bound as a quadratic inequality constrain that limits the probability distribution of the difference of the positions. The simplest bound for the difference of the positions is a maximal distance of 2 m between the positions, a spherical limit. For a pedestrian, it is possible to establish a smaller limit removing the mean of the height and establishing a lower maximal distance in the Z axis, this non-symmetrical limit establishes an ellipsoid with a smaller volume as the bound and improves the fusion. Tracking the evolution of this distribution of probabilities involves solving a multidimensional integral and we propose the use of a particle filter to obtain the mean and covariance of the difference of the positions and the relationship with the rest of the states.

We have tested the algorithm by processing data from an Ultra Wide Band (UWB) positioning sensor from Ubisense together with a Microstrain 3DM-GX3-35 IMU, both placed on the helmet of a person, and a foot-mounted IMU, ADIS16367 from Analog Devices. Our results show that the system is able to estimate the position of a person with a smaller error growth of a dead reckoning system and provide a better position estimate between measurements of the UWB system.

KEYWORDS: Pedestrian Dead-Reckoning, Ultra Wide Band, nonlinear constrains, sensor fusion, zero-velocity detection.