Fusing Information from Multiple Navigation Systems Using Upper Bounds on their Spatial Separations

Isaac Skog, John-Olof Nilsson, Dave Zachariah, and Peter Händel
Signal Processing Lab, ACCESS Linnaeus Centre
KTH Royal Institute of Technology
Stockholm, Sweden

ABSTRACT

It is generally believed that successful robust and infrastructure-free indoor pedestrian navigation will be based on a multitude of navigation technologies with complementary characteristics. Unfortunately, such complementary technologies are generally based on different physical properties and therefore the most favorable locations on the body of the different subsystems differ. For example, a zero-velocity-update-aided inertial navigation system is favorably mounted on the foot of the user and a vision based system is favorably mounted on the head or shoulder of the user. Unfortunately, if the navigation subsystems are not collocated, they will track different parts of the body of the user. This poses a major obstacle for the integration of different navigation technologies.

The human body is a non-rigid body and therefore the relative poses of its parts are not fixed and one cannot directly relate the navigation solution of one subsystem to another. However, the mounting points give upper limits on the spatially separations of the different subsystems. Consequently, in this paper we propose a general method for combining the information from several non-collocated navigation systems for which there are upper bounds on their maximum spatial separation. The method has wide applicability in system integration for multi-sensor pedestrian navigation systems and, to our knowledge, the general principle of exploiting an upper bound on the separation between navigation points has not previously been discussed in the literature.

In the paper, the problem of fusing the information from the different navigation subsystem is first posed as a non-linear inequality constraint filtering problem. A method is proposed to solve the filtering problem using sub-space projection and convex optimization. Approximations and analytical expressions for the related filter updates are derived and, finally, the applicability and value of the resulting filtering is demonstrated on real data from two foot-mounted zero-velocity-update-aided inertial navigation systems.

KEYWORDS: Constrained filtering, sensor fusion, convex optimization, inertial navigation, zero-velocity-update