# Deeply Coupled GPS/INS Integration in Pedestrian Navigation Systems in Weak Signal Conditions

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## ABSTRACT

This paper describes non-coherent deeply coupled GPS/INS integration in a pedestrian navigation system using step length updates to improve position accuracy and availability in weak signal conditions. A pedestrian navigation system consists of several sensors to compute a position of a person to guide for example rescue missions. The system presented in this paper consists of a torso mounted IMU and is used for step detection and step length and heading estimation. Additionally a barometer, magnetometer and a GPS sensor for absolute positioning are used. Since pedestrian navigation systems often are used in challenging environments like urban canyons or indoors, the use of GPS signals is often restricted. We will show that by using a deeply coupled GPS/INS integration system, tracking of GPS signals under weak signal conditions is possible and a seamless transition between in and outdoor situations is achieved. By applying the information of a position displacement between two steps from the step length and heading estimation GPS tracking and position accuracy can be increased.

For an optimal performance the system uses a deeply acquisition and re-acquisition routine. Therefore additional satellites can be used which could not have been acquired before, due to low signal to noise ratios. By carefully weighting the GPS measurements accordingly to their cn0 and having a larger set of satellites available, position accuracy is increased compared to a non-vector tracking approach. The sensor fusion itself is realized in an error state space kalman filter and the step length update is performed using a state cloning technique preserving realistic position uncertainties in the filter.

With this approach tracking and acquisition of GPS signals inside buildings with cn0 below 20dBHz is possible. In this paper we will show that using deep integration in GPS signal tracking including step length estimations increases position accuracy of a pedestrian navigation system and availability of GPS position updates

**KEYWORDS**: Deeply Coupled GPS/INS, weak signal conditions