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Improved Vehicle Positioning Algorithm Using Enhanced Innovation-Based Adaptive Kalman Filter

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Abstract: Accurate positioning is a key factor for enabling innovative applications to properly perform their tasks in various areas including: Intelligent Transportation Systems (ITS) and Vehicular Ad Hoc Network (VANET). Vehicle positioning accuracy depends heavily on positioning techniques and the measurements condition in its surroundings. Several approaches which can be used for improving vehicle positioning accuracy have been reported in literature. Although some positioning techniques have achieved high accuracy in a controlled environment, they suffer from dynamic measurement noises in real environments leading to low accuracy and integrity for some VANET applications. To solve this issue, some existing positioning approaches assume the availability of prior knowledge concerning measurement noises, which is not practical for VANET. The aim of this paper is to propose an algorithm for improving accuracy and integrity of positioning information under dynamic and unstable measurement conditions. To do this, a positioning algorithm has been designed based on the Innovation-based Adaptive Estimation Kalman Filter (IAE_KF) by integrating the positioning measurements with vehicle kinematic information. Following that, the IAE_KF algorithm is enhanced in terms of positioning accuracy and integrity (EIAE_KF) in order to meet VANET applications requirements. This enhancement involves two stages which are: a switching strategy between dead reckoning and the Kalman Filter based on the innovation property of the optimal filter; and the estimation of the actual noise covariance based on the Yule-Walker method. An online error estimation model is then proposed to estimate the uncertainty of the EIAE_KF algorithm to enhance the integrity of the position information. Next Generation Simulation dataset (NGSIM) which contains real world vehicle trajectories is used as ground truth for the evaluation and testing procedure. The effectiveness of the proposed algorithm is demonstrated through a comprehensive simulation study. The results show that the EIAE_KF algorithm is more effective than existing solutions in terms of enhancing positioning information accuracy and integrity so as to meet VANET applications requirements.

Keywords
VANET; ITS; Vehicle Positioning; Kalman Filter; Adaptive Filtering; Error Estimation; Innovation-Based Adaptive Filtering.

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1. Introduction
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