Enhancing 3D Position Accuracy of Ground Based Pseudolite System with High Altitude Platform System Using Particle Filter

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Abstract: This study aims to investigate the advantages of integrating the High Altitude Platform System (HAPS) to enhance 3D position accuracy of a ground-based pseudolite system using Particle Filters (PF). Particle Filters operate within a Bayesian framework, and their effectiveness is demonstrated through simulation experiments. The proposed architecture is designed to achieve superior 3D positioning accuracy due to vertical diversity by placing some Pseudolite at higher altitude. The simulation involved a network of 10 ground-based pseudolite stations, with an additional step of selecting and deploying 2 pseudolites at altitudes ranging from 15 to 20 km. This selection was based on sensitivity analysis of specific pseudolite-altitude combinations, aimed at improving vertical diversity beyond what is achievable only with ground-based pseudolite stations. 3D position accuracy with PF improved drastically from 81.10 m to 0.65 m.
Keywords: HAPS, Particle Filter, Pseudolite, VDOP, Position Accuracy.

Introduction: The High Altitude Platform System (HAPS) offers a compelling solution to augment the positional accuracy by leveraging a ground-based pseudolite framework. This investigation employs a hybrid configuration comprising two pseudolites placed at high-altitude platforms and eight ground-based pseudolite stations. A Particle Filter (PF) approach is utilized to estimate the 3D positional accuracy for a static user. Given the sensitivity of the system to the initial position estimate, the GPS-derived initial guess is imparted into the Particle Filter algorithm. Combination of HAPS & Ground Based provides a better architecture for overall improvement of vertical and 3D position accuracy.

Results & Discussion: Table 1 shows a comparison of position accuracy of only Ground Based Pseudolite System, HAPS and HAPS with PF. It can be observed from the table that 3D position accuracy with only Pseudolite System is significantly high (around 81 m) due to poor vertical diversity. However, when two pseudolites are placed at HAPS, VDOP significantly improves from 27.25 to 0.82. This improved VDOP due to HAPS results into a better 3D position accuracy which is 1.03 m without PF and is around 0.65 m with PF as illustrated in Figure 1.

Table 1: Comparison of Positional Accuracy of Ground Based, Combination of HAPS & Ground Based System

Systems	3D Position Error (m)	VDOP
Ground Based Pseudolite System	81.10	27.25
Pseudolites with HAPS	1.03	0.82
Pseudolites with HAPS (with PF)	0.65	0.82

Figure 1: 3D Position Error with & without PF

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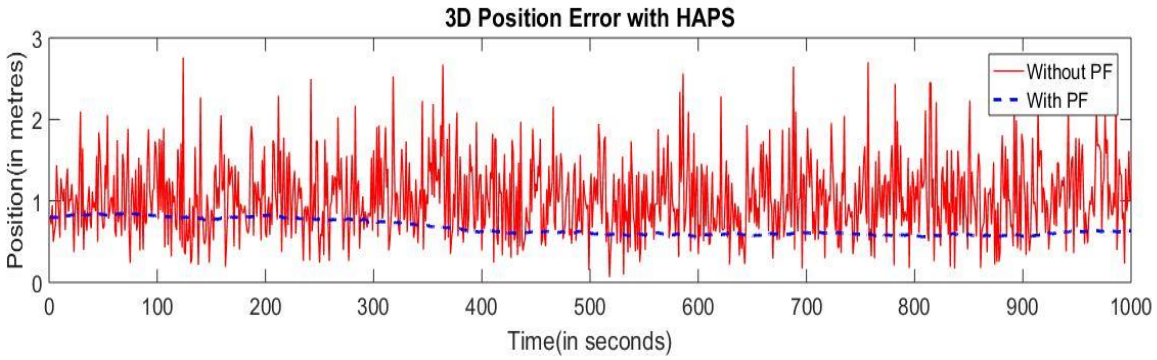

Figure 2: 3D Position Error with & without EKF

Conclusion: The proposed High Altitude Platform System (HAPS) with a ground-based pseudolite system and an integrated Particle Filter (PF) approach has been proven highly effective in enhancing the 3D positional accuracy of only ground based pseudolite system. The substantial reduction in Vertical Dilution of Precision (VDOP), achieved through vertical diversity with inclusion of HAPS results in improved pseudolite geometry and hence vertical & 3D positioning accuracy. This architecture for augmenting ground based pseudolite system is a very promising and effective solution for very accurate 3D positioning.

References:

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