

## Chapter 25

# GNSS Positioning Enhancement Based on NLOS Multipath Biases Estimation Using Gaussian Mixture Noise

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### ABSTRACT

*Global navigation satellite systems (GNSS) have been widely used in many applications where positioning plays an important role. However, the performances of these applications can be degraded in urban canyons, due to Non-Line-Of-Sight (NLOS) and Multipath interference affecting GNSS signals. In order to ensure high accuracy positioning, this article proposes to model the NLOS and Multipath biases by Gaussian Mixture noise using Expectation Maximization (EM) algorithm. In this context, an approach to estimate the Multipath and NLOS biases for real time positioning is presented and statistical tests for searching the probability distribution of NLOS and Multipath biases are illustrated. Furthermore, a hybrid approach based on PF (Particle Filter) and EM algorithm for estimating user position in hard environment is presented. Using real GPS (Global Positioning System) signal, the efficiency of the proposed approach is shown, and a significant improvement of the positioning accuracy over the simple PF estimation is obtained.*

## **INTRODUCTION**

### **Context**

Commonly, A global navigation satellite system is a system, with global coverage, that uses satellites to provide autonomous geo-spatial positioning, using the GNSS signal. Unfortunately, the GNSS signal emitted by satellite can be distorted by the propagation impairments, namely: atmospheric layers, orbital error, Multipath, NLOS and Masking phenomena. Therefore, the errors caused by these phenomena lead sometimes to significant error affecting the positioning accuracy.

The orbital and atmospheric errors can be corrected by models, such as Klobuchar single-frequency model for ionospheric error (Klobuchar, 1996) and the Hopfield model for tropospheric error (Bradford, 1996) However, the Multipath and NLOS errors related to local phenomena remain not well modeled and are always the subject of studies in several laboratories around the world.

In the literature, we find many types of techniques used to enhance the localization performance in constrained environments, like Statistical filtering techniques, pseudorange selection and multi-sensor systems. In this paper, our research work aims to search the statistical model of NLOS and Multipath errors.

Practically, to estimate the user position, statistical filtering methods are used, such as Kalman Filter and Least Squared method. However, the application of these methods is restricted to White Gaussian noise model and linear systems; therefore, the Particle Filter (PF) can be adopted for this problem type.

### **Problem**

In hard environments (Multipath and NLOS phenomena are present), the statistical filtering methods used for estimating user position show important positioning errors because their Multipath/ NLOS noise model is unsuitable. Consequently, a good model for NLOS and Multipath errors in the GNSS measurement model will help to improve significantly the positioning accuracy in hard areas.

### **Contribution**

This paper aims to enhance the positioning accuracy by modeling the NLOS and Multipath biases affecting GNSS signal in hard environments. In this context, a Gaussian mixture model based on EM algorithm is used to estimate NLOS and Multipath errors. Furthermore, a hybrid PF/GMEM approach is developed to estimate user position in hard areas. Additionally, our proposed approach is compared to classical PF method with a white Gaussian model for Multipath/NLOS noise.

### **Contents**

This article is organized as follows: In section II, the urban positioning problem and some relevant works are presented. We present the GNSS measurement model, the approach for estimating NLOS and Multipath biases, the visual and statistical analysis tests for searching the NLOS and Multipath errors distribution in section III. Then, we deal with the formulation of the EM algorithm for modeling NLOS and Multipath errors in section IV. In section V, we present the hybrid PF/GMEM approach developed

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