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Avis de soutenance de thèse

Mlle Bassma GUERMAH

Soutiendra sa thèse pour obtenir le grade de Docteur

de l'Institut National des Postes et Télécommunications

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Sujet de thèse :

« GNSS multipath processing with new approaches based on statistical modelization and machine learning »

Devant le jury :

M. Mohamed Abdelfattah CHARIF CHEFCHAOUNI, PES, Directeur de l'INPT (Président) ;

M. Mohammed BOULMALF, PES, UIR, Rabat (Rapporteur);

M. Driss EL OUADGHIRI, PES, Université Moulay Ismail, Meknès (Rapporteur);

M. Badr ABOU EL MAJD, PH, FSR, Rabat (Rapporteur);

M. Ahmed TAMTAOUI, PES, INPT, Rabat (Examinateur);

M. Serge REBOUL, PES, ULCO, Calais, France (Examinateur);

M. Hassan EL GHAZI, PH, INPT, Rabat (Directeur de thèse);

M. Tayeb SADIKI, PH, UIR, Rabat (Co-directeur de thèse);

Abstract:

Since the middle Ages, the need of humans to identify their position in their environment has always been a necessity and a challenge. From the 1960s, the history of satellite navigation has begun with the development of the American GPS (Global Positioning System) and has since changed significantly until today with emergence and development of other positioning systems, such as the Russian system GLONASS (GLObalnaya Navigatinnaya Spoutinkovaya Sistema) and the European GALILEO system.

A GNSS-based navigation system has the ability to determine the user position (longitude, latitude, and height) anywhere and anytime in the world. However, despite tremendous advances in GNSS technology, the performances of these systems have significantly degraded in urban canyons, where several obstacles are present (Building, Trees, ground, etc.). In classical localization algorithms, the pseudo-range errors are modeled by a Gaussian distribution when the signal is received from the satellite in Line-of-sight (LOS) environment. Such assumption is very restrictive and lead to significant positioning errors in harsh environments due to Multipath effects. In urban canyons, one of the main challenges of GNSS localization is the Multipath errors. Several techniques for Multipath problem have been addressed through various approaches. For example, at the level of the three blocks of the receiver architecture (Acquisition, Tracking and PVT block) via hardware improvements (such as new antenna or others sensors like BTS, odometers and inertial measurement unit), or with signal processing and statistical analysis. The 3D models of the city and Nav2Nav cooperative positioning has also been proposed as solution for Multipath errors.

In this thesis, we developed new approaches for detecting, estimating, modeling and correcting Multipath errors, based on statistical modelization and machine learning. First, for Multipath errors estimation and modelization, we proposed new algorithms based on Map-Matching, Expectation Maximization and Variational Bayesian Learning. As a result, the Gaussian Mixture model has demonstrated its capacity to model the Multipath errors. Furthermore, the hybridization of the Particle Filter (PF) with the Variational Bayesian Inference Learning has shown its capacity to improve positioning accuracy in urban canyons. Then, we explored the potential of GSM power measurements combined with GNSS signal to estimate vehicle position in a dynamic movement. Finally, to detect the GNSS signals reception state (LOS, NLOS or Multipath), a new system based on the fusion of information provided by RHCP and LHCP antennas has proposed. The fuzzy logic and Support Vector Machines (SVM) approaches are used to define new classifiers able to detect the GNSS signal reception state. All proposed methods were extensively tested using real GPS signals. Their results were compared to the existing techniques, and their capability and effectiveness to detect, mitigate Multipath errors and improve positioning accuracy has been shown.

Keywords: GNSS, Multipath estimation, Statistical modelization, Harsh environment, Fusion of information, Gaussian mixture model, Map-Matching, Variational Bayesian Inference, Particle filter, Machine learning, GNSS signal processing, Support vector machines, Fuzzy logic, RHCP, LHCP.