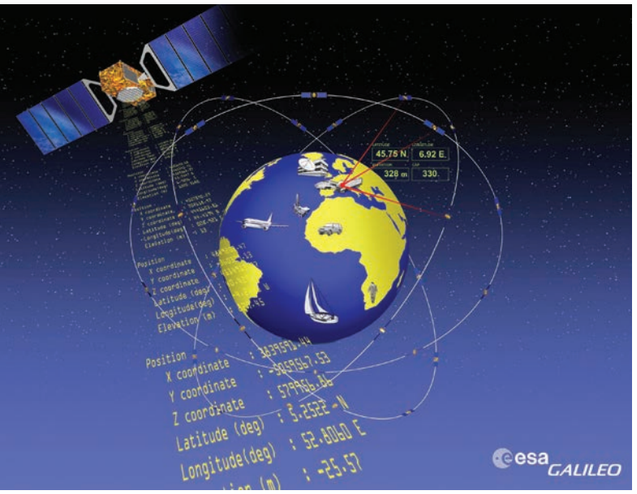
Advanced Receivers and Navigation Algorithms for GPS/Galileo Signals

Navigation and location using Global Navigation Satellite Systems (GNSS), such as GPS and Glonass, are finding ever increasing applications in civilian activities. The purpose of the current project is to study, implement and evaluate new algorithms for fast acquisition, tracking and multipath mitigation in GNSS receivers. Coordinated positioning between GNSS receivers is also considered.



Main Project Team

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Funding Agencies

Fundação para a Ciência e Tecnologia (FCT)	73.800€
Start Date	01-09-2007
Ending Date	01-03-2011

Indicators

Journal Papers	6
Conference Papers	24
Concluded PhD	1
Concluded MSc	7

Two Main Publications

F. D. Nunes, J. M. N. Leitão, F. M. G. Sousa, **"Nonlinear Filtering in GNSS Pseudorange Dynamics Estimation Combining Code Delay and Carrier Phase"**, IEEE Journal of Selected Topics in Signal Processing, vol. 3, no. 4, pp. 639-650, August 2009.

Nuria B.-Delgado, F. D. Nunes, **"Multipath Estimation in Multicorrelator GNSS Receivers using the Maximum Likelihood Principle"**, IEEE Transactions on Aerospace and Electronic Systems, vol. 48, no. 4, pp. 3222-3233, October 2012.

PROJECT WEBPAGE URL

http://www.it.pt/project_detail_p.asp?ID=843

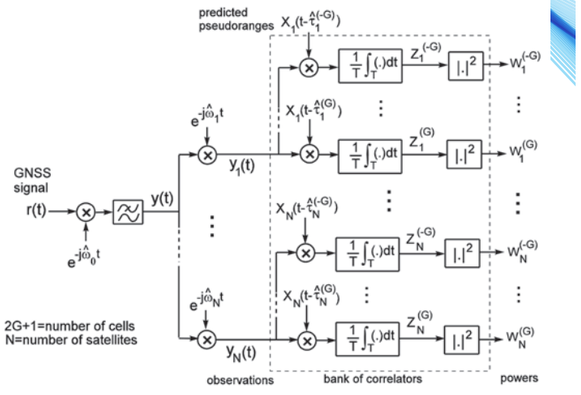

Fig. 1 Pre-processing part of the proposed low-complexity VDLL architecture

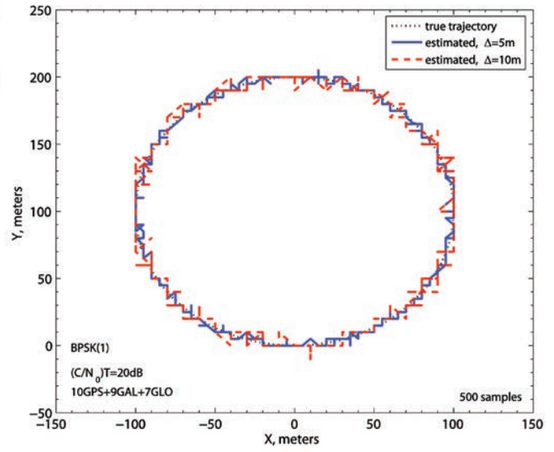

Fig. 2 Circular trajectory estimation with 500 samples, different cell sizes, and BPSK(1) modulation

GENERAL MOTIVATION AND OBJECTIVES

Signal design in modern GNSS is fairly innovative; new modulation schemes were introduced aiming to increase the code tracking accuracy. Besides, data-free (or pilot) signals are available permitting longer coherent integration intervals. To fully exploit their potentialities, the new signals require more sophisticated receivers in terms of bandwidth and signal processing capability.

The project objectives are to study and develop: a) Algorithms and methods for fast acquisition of GNSS signals; b) Open-loop tracking architectures alternative to the conventional DLL+PLL, based on stochastic nonlinear filtering; c) Advanced structures and algorithms for multipath mitigation; d) Coordinated positioning techniques; e) Communication channel models relevant in navigation.

CHALLENGE

New receiving structures are usually derived from the early-late discriminator, for code tracking, and the phase-locked loop, for carrier tracking. However, innovative architectures avoiding the drawbacks of traditional solutions are highly desirable.

MAIN WORK DESCRIPTION

The project is divided into the following 5 scientific tasks.

1) Channel modelling: Encompasses improvements in the area of satellite selection. Methods were developed using the Convex Hull approach as a computationally efficient alternative to the conventional brute-force algorithms.

2) Code/frequency acquisition: The near-far mitigation techniques aim at acquiring and tracking very weak GNSS signals which are masked by strong signals when conventional acquisition techniques are employed.

3) Code/frequency tracking: Alternative architectures to the conventional scalar PLL/DLL receiver were developed. The usual alternative is a vector (VDLL) architecture which may be relatively complicated. We devised equivalent tracking structures with smaller complexity based on estimation of 3D cells (Figs. 1 and 2).

4) Multipath mitigation: Algorithms for multipath mitigation are usually based on the narrow correlator, and double-delta or other gating functions techniques. However, for close-in multipath these methods are inefficient and ML algorithms have to be employed, at the cost of a high computational effort. Alternative algorithms with smaller computational complexities have been investigated.

5) Assisted-GNSS and coordinated positioning: Aimed the development of navigation algorithms for coordinated positioning applications and the support of their implementation on portable units. Several algorithms were proposed for coordinated positioning, heading estimation, and road constrained positioning.

TECHNICAL ACHIEVEMENTS

1) Architecture for code delay and Doppler phase merging in GNSS receivers with the goal of achieving very small tracking errors;

2) Multipath estimators for multicorrelator GNSS receivers using the ML approach;

3) Near-far mitigation algorithm for GNSS receivers suitable for indoor reception;

4) Algorithms for dynamic GNSS satellite selection in multi-constellation scenarios based on Convex Geometry;

5) Vector delay locked loop (VDLL) architecture for indoor environments;

6) Several algorithms for coordinated positioning, heading estimation, and road constrained positioning; 7) Application of Importance Sampling techniques in carrier phase tracking problems.