Utilizing pulsed pseudolites and high-sensitivity GPS for ubiquitous outdoor/indoor satellite navigation

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ABSTRACT

This paper presents a ubiquitous outdoor/indoor GNSS navigation platform that utilizes GPS and pulsed pseudolite (PL) signals for seamless positioning. Pseudolites, i.e. pseudo-satellites transmitting GNSS-like (Global Navigation Satellite System) signals, provide a means for bridging the gap between outdoors and indoors when GNSS positioning is concerned. The same receiver technology can be utilized both for acquiring live GNSS signals as well as the PL signals. However, if not properly designed with respect to timing, identification, and signal power, PL signals can introduce severe interference without improving the positioning availability.

In October 2011, a recommendation was comprised by the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT) describing a regulatory framework for authorisation regime of indoor GNSS pseudolites in the band 1559-1610 MHz. The recommendation states, among others, that the GNSS PL equivalent isotropically radiated power should be limited to -50 dBm in general cases; that the operation of indoor GNSS pseudolites should be limited to the band 1559-1610 MHz; and the indoor GNSS pseudolites should use dedicated codes only as reserved by the corresponding GNSS operators. The recommendation opens up new possibilities for the technology development and implementation of indoor pseudolite-based positioning.

A pulsing scheme of the pseudolite signal successfully reduces interference problems: the pseudolite signal is efficiently transmitted only at particular time instants. In this paper, with the ECC recommendation in mind, pulsed pseudolites are strategically placed indoors at known locations at the ends of office building corridors to assist high-sensitivity GPS positioning. A particle filter is implemented to fuse the proximity information of the pseudolites at known locations and the high-sensitivity satellite navigation positioning result. The implemented scenario resembles the Indoor MEssaging System (IMES) in which location information is transmitted to suitable GNSS receivers, since here proximity sensing and known PL

location are utilized. In addition to the positions derived from pseudolite proximity and GPS, floormap-information is integrated to the result to further improve the obtainable accuracy. The location obtained from GPS is restricted to the corridor location, based on sensing the proximity of the pseudolite. Accuracy of around 5 meters is expected to be achieved in a typical glass, concrete, and steel office building with pseudolite-proximity (6 pseudolites are installed in a 3-storey building), floormap, and high-sensitivity indoor GPS signals fused together. Pseudolites provide a convenient navigation aid indoors for a GNSS receiver without the need for using additional hardware.

KEYWORDS: Indoor navigation, pulsed pseudolites, particle filter, proximity sensing, high-sensitivity GPS