An Enhanced Mobile Device-Based Navigation Model: Ubiquitous Computing

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An Enhanced Mobile Device-Based Navigation Model:
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ABSTRACT

This article formulated, simulated and evaluated an enhanced model for a non-linear/non-Gaussian integrated Global Positioning System (GPS) and Inertial Navigation System (INS) mobile-based device navigation system using the Particle Filter (PF). This was with a view to enhancing the accuracy and minimize the delay experienced in the existing system which relies on linear data. An android driven Infinix X5 mobile device with GPS and INS-based sensors was used to implement the model formulated, standard Bayesian estimators were used to generate non-linear datasets with Gaussian/non-Gaussian white noises for mobile device based INS/GPS sensors. A mathematical model was formulated using Sampling Importance-weight Resampling (SIR) algorithm of the PF. The conceptual model was developed using Simulink and the design specification was done using Unified Modeling Language (UML). The model was simulated with MATLAB and the simulation results obtained were evaluated using standard metrics, and benchmarked with existing model. The overall results showed that the proposed model performed better than existing ones in term of accuracy. However, the model did not impact on delay reduction.

KEYWORDS

GPS, INS, Kalman Filter, Navigation, Particle, Re-Sampling, SIR

1. INTRODUCTION

Rapid evolvement in the field of mobile computing has massive potentials for providing dynamic multimedia information to people on the move. These context-aware models make use of background data, like that of location, display medium and the profile of users to provide some tailored functionalities to the users (Keith et al., 2000). This contextual information can, however, be presented on mobile phone-based maps. Maps, are very important for governmental, socio-economic and military purposes for planning, construction (Ronen et al., 2009), surveillance, navigation-finding for locations, and waypoints. The determination of the location to navigate to base on related geo-parameters for mobile users using maps requires the knowledge of navigation. Navigation is the process of determining the parameters of an itinerary which include acceleration, velocity, and the

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position of the center of mass of the moving object (Vasko et al., 2005). There are mobile phone-based navigation models that are designed to guide users from the current locations to their expected destinations. Such systems have often depended heavily on Global Positioning System (GPS), strong Internet connection, Bluetooth, Wireless Fidelity (WiFi), Infrared connections or a stand-alone Inertial Navigation System (INS).

Mobile-based device navigation uses pervasive information system mechanisms, which are ubiquitous, this, is largely because the massive potentials of mobile devices are responsible for making available multimedia information that is dynamic to those on the move Keith et al. (2000). Today, since these devices have become smaller and more portable, the demand for computing and networking solutions by users has also increased steadily (Sharma et al., 2011), especially for aiding navigation. Navigation, however, depends on geo-location. Geo-location is the process of estimating the location of an unknown source or transmitter using a collection of measurements obtained from sensors or receivers (Vasko et al., 2005). This implies that in order to use geo-location, sensors must be able to locate the origin of signals, and when the position of the source is unknown, localization techniques must be employed. In geo-location, a group of sensors or receivers can estimate the location of an unknown source or transmitter using position and Radio Frequency (RF) information. Several different techniques are commonly used for RF geo-location. The techniques include; Time Difference of Arrival (TDOA), Time of Arrival (TOA), Angle of Arrival (AOA), and Received Signal Strength (RSS). The TDOA, AOA, and TOA estimation procedures generally require a larger number of operations due to their mathematical complexity and may be more hardware intensive than RSS measurements (King, 2013).

As White et al. (2000) observed, there are three different ways to determine a user's location or measure a mobile device's position on a plane. The first is to use some form of Dead Reckoning (DR), in which a user's speed of movement, direction of movement and so on. is continuously used to update his/her location (Collier, 2011). INS is one of the most widely used DR systems. This is because they can provide continuous position, velocity, and also orientation estimates, which are accurate for a short term, but are subject to drift due to sensor noise. The second is to use some form of ground-based beacon that broadcasts its location to nearby users. The third is to use some form of radio/satellite positioning system that transmits information that a Personal Navigation Assistant (PNA) can use to determine a user's location. A PNA is a portable electronic product which combines a GPS and navigation function. This last approach is by far the most popular; and a lot of PNAs use the GPS to determine users' location. Although, many outdoor solutions are based on GPS or Assisted GPS (AGPS); they suffer remarkable drop-outs in urban canyons and in obstructed environment. This makes a standalone navigation system with GPS problematic. This calls for the integration of sensors for optimal mobile navigation experience, which is the focus of this study.

Studies from Wan et al. (2011) and Johnson et al. (2012) have further shown that GPS suffers short-term accuracy failure aside multipath problem and that INS performs poorly at the long term. WiFi and other wireless devices suffer attenuation and signal fluctuations (Jaime et al., 2009). These systems by their nature and design result in application delay and reduced accuracy. In this research, the short-term accuracy problem of GPS is addressed by combining it with INS. This integration cancels the long-term accuracy problem of INS. Furthermore, PF algorithm is applied to enhance accuracy since it results in a high response time of the application. Several INS/GPS integration methods have been proposed in the literature, from loosely-coupled to tightly-coupled implementations (Zhou et al., 2010). This work introduces improvements on loosely-coupled schemes based on low-cost Micro-ElectroMechanical System (MEMS) devices. The next section of this paper discusses related models while section three presents our proposed model. Section four describes the experiment for this work; the result analysis is presented in section five while section six concludes the paper.