Paper/Presentation Title:

Unconstrained indoors localization scheme based on Cooperative Smartphones networking with onboards inertial, Bluetooth, WiFi and GNSS devices

List all authors (with organizational affiliations) in the order they will appear on the paper:

Halgurd S. Maghdid, DPhil Student, The University of Buckingham, UK
Ihsan Alshahib Lami, Reader, The University of Buckingham, UK

Uniqness of this scheme:

1. New Indoors localization scheme that do not require dedicated infrastructure and capitalizing on the cooperation of Smartphones in the vicinity to hybridize information from their onboard devices such as inertial sensors, Bluetooth and WiFi transceivers and GNSS receivers.
2. New fusing of various localization algorithms to provide low cost, on the go, accurate measurements to within 3 meters indoors. This scheme can be deployed on any Smartphone via a simple App.

Abstract:

WiFi, Bluetooth or inertial-sensors based positioning systems have been proven to somewhat provide alternative solutions in GNSS-signal-denied areas to define Smartphones (SPs) location. However, limited coverage of WiFi access-points (WAPs)/Bluetooth-anchors, no information of WAPs physical positions within a building, no access to API functions of important device data onboard SPs, no WAPs localization protocol extensions, no synchronization between WAPs are some of the main challenges to designing a spontaneous autonomous positioning solution with reliable accuracy at reasonable cost. Existing localization techniques, such RSSI/fingerprinting techniques, do provide good performance (despite non-uniform shadowing problem) but at the expense of pre-installing dedicated infrastructure and therefore limited in application. Other Trilateration/ranging-based approaches suffer from jitters, instability, coverage and dilution of precision issues. Finally, dead-reckoning (DR) techniques, especially when using low-cost inertial sensors such as accelerometer and gyroscope onboard SPs, are highly smooth and stable, but their performance degrades quickly over time due to the accumulated measurement noise of sensors causing cumulative positioning error.

Using relative-ranging between cooperative network of SPs that are GNSS enabled, especially when the majority of the SPs are outdoors, and combining this with uncertainty calculations from onboard DR measurements is the proposal of this paper, and can improve location accuracy significantly, especially when indoors. In a previous publication [1], we have proven that a smart indoors Smartphone localization scheme (SILS) whereby participating SPs in the outdoors and indoors vicinity, form a Bluetooth network, and together with WAPs, can provide a localization accuracy to within 2.5 meters at 3 walls deep indoors. The aim of this new scheme is to introduce DR to our SILS so to improve localization accuracy when deep indoors. This means that, in deep indoors, we can utilize only available sensors on SPs, when communication with WAPs or Bluetooth-anchors is deemed unreliable or unavailable, to offer reasonably accurate localization performance. Like SILS, we believe that this new scheme is a good candidate for being deployed on SPs being low cost and on low on battery power consumption.

This new scheme can be implemented as an App and when invoked will render the SP as cooperative for being located and for helping in locating other SPs, and can do so anywhere anytime. This scheme performs range measurements (using TOA) and DR measurements of the networked SPs by exploiting the advantages of each of these techniques while compensating for their limitations. It starts by constructing a smart Bluetooth network of any cluster of cooperative SPs in the same geographical area. To achieve this, this scheme will perform the following three functions:

(1) Calibrate inertial sensors of all SPs. Indoors SP's use live GNSS information available from networked outdoors SPs. The calibration process is to estimate gyroscope bias and drift error for indoors SPs by using outdoors SPs heading and positions.

(2) Exchange a database of all SPs location as well as indoors SPs sensor bias and drift.

(3) Calculate location of indoor-SPs based on hybridization of GNSS, Bluetooth and inertial sensors measurements. These measurements include:

a. Bluetooth to Bluetooth relative-ranges of all participating SPs based on hop-synchronization and Master-Slave role switching to minimize the pseudo-ranges error,

b. Using GNSS fixed location of outdoors-SPs as reference positions, as well as

c. Fusing the measured relative-ranges between outdoors and indoors SPs and DR measurements (distance-displacement and heading) of indoors SPs by using Kalman filter. To do this, we use a step-counting method to estimate distance-displacement and we use quaternion-based method to estimate indoors SPs heading. The filter, at the first step, predicts a state of XY-coordinates and heading based on DR measurements. In the next step the filter updates the predicted state by using: 1) the difference of estimated relative-ranges and calculated Euclidean distance between SP-to-SP positions, 2) estimated heading bias & drift, 3) and change of the heading between any two states.

Results obtained from actual trials & simulations (using OPNET) of this scheme (based on Android-SPs network implementations for various indoors scenarios) show that around 3-meters accuracy can be achieved when locating SPs at various deep indoors situations even when WAPs or Bluetooth-anchors signal is considered not able to be used.

References

[1] Ihsan A. Lami, Halgurd S. Maghdid, Torben Kuseler, "SILS: A Smart Indoors Localization Scheme Based on on-the-go Cooperative Smartphones Networks Using Onboard Bluetooth, WiFi and GNSS". Proceedings of the 27th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2014), Tampa, Florida , September 8 - 12, 2014.