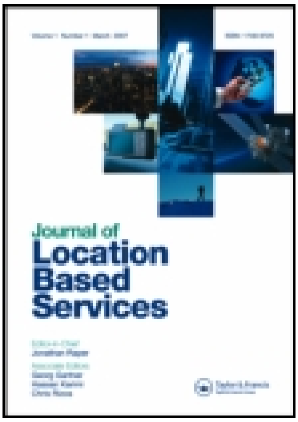


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# Indoor Positioning and Navigation. Part III: Navigation Systems

Adriano Moreira [a] & Rainer Mautz [b]

[a] Mobile and Ubiquitous Systems Group, University of Minho, Portugal

[b] Geodetic Metrology and Engineering Geodesy Group, Swiss Federal Institute of Technology, Zurich, Switzerland

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# EDITORIAL

## Indoor Positioning and Navigation. Part III: Navigation Systems

In the age of automation the ability to navigate persons and devices in indoor environments has become increasingly important for a rising number of applications. With the emergence of global satellite positioning systems, the performance of outdoor navigation has become excellent, but many mass market applications require seamless navigation capabilities in all environments. Therefore indoor navigation has become a focus of research and development during the past decade. It has by now become apparent that there is no overall solution based on a single technology, such as that provided outdoors by satellite-based navigation.

This Special Issue of the *Journal of Location Based Services* is the last of three parts where some of the best works presented at IPIN 2011 are revisited and extended. This concluding part addresses navigation systems, with three papers illustrating the state of the art in navigation approaches used in different contexts and level of accuracy. In general, indoor navigation approaches can be divided into two classes: those requiring locally deployed infrastructure (paper I) and those being infrastructure free (papers II and III).

The first paper entitled 'CLIPS – a camera and laser-based indoor positioning system', by my colleague Sebastian Tilch and myself, describes a camera-based navigation approach at millimetre-level accuracy which requires local infrastructure, even though the deployment is facilitated by projecting the reference points with lasers. All systems requiring dedicated local infrastructure become too costly when scaled to larger coverage areas.

Infrastructure free navigation approaches must rely on self-contained sensors. Self-contained sensors can be divided into two classes, as those measuring absolute quantities, e.g. magnetometers, odometers and pressure sensors or sensors capable of measuring only changes of distances or speed such as accelerometers and gyroscopes. The latter group of sensors is used in the common pedestrian dead reckoning approach that is based on an inertial navigation system (INS). Using dead reckoning, an INS-based guidance system is continually adding detected changes to its previously calculated positions. Thus, the accuracy of the propagated position depends heavily on the quality of the provided start position and direction. Most notably, owing to the double integration of noisy accelerometer measurements, INS suffers from accumulation of position deviation and magnification of the angular deviation over the travelled distance (Abbe error). If absolute position or orientation updates are obtained by another sensor source at a high rate, the INS can be used to deliver positions with much higher precision compared to geometric interpolation between supporting points. In pedestrian navigation, the accumulating positioning deviation of dead reckoning origins from two major types of deviations: the along-track deviation mainly caused by the step length imprecision and the cross-track deviation mainly caused by the imprecision of the azimuth measurement.

To bring the self-contained sensor data in relation to the environment, detailed map data can be used, known as map measurements. If available indoor maps are stored locally in the device, self-contained navigation becomes feasible. For correction of position and orientation, constraints from a map can be compared with the movement pattern to create complementary geometric information. This process is known under the term map matching and is used to correct the current position track onto a map. The map-matching approach exhibits a powerful backup strategy for correcting the position of a dead reckoning system. While car-roadmap matching is already an established tool in outdoor navigation, the less constrained movement pattern of a person requires special map-matching algorithms tailored to pedestrian navigation.

The latter two papers deal with the challenges that arise from the erratic movement pattern of pedestrians, modelling pedestrian movements from INS data and comparing it with available indoor maps. The second paper entitled 'A pedestrian navigation system using a map-based angular motion model for indoor and outdoor environments', by Susanna Kaiser and her team at the German Aerospace Center, is based on an improved particle filter that uses a probability density function and avoids binary decisions to relate the user's heading to an available floor-plan. The third paper with the title 'Accurate map-based indoor navigation on the mobile', by Jó Ágila Bitsch Link *et al.*, describes a self-contained map-based pedestrian navigation system that uses only sensors readily available in modern smartphones. The user's position is determined by novel step detectors and algorithms for path matching. Once the combination of self-contained sensors and map matching becomes applicable, it will be a big leap forward by having a truly self-contained indoor navigation capability.

We hope you have enjoyed this series of three special issues with excellent papers where the state-of-the-art in indoor positioning and navigation has been well documented.

**Guest Editors**

Adriano Moreira
*Mobile and Ubiquitous Systems Group*
*University of Minho, Portugal*
*Email: adriano.moreira@algoritmi.uminho.pt*

Rainer Mautz
*Geodetic Metrology and Engineering Geodesy Group*
*Swiss Federal Institute of Technology, Zurich, Switzerland*
*Email: mautz@geod.baug.ethz.ch*