Summary

In the era of Information Society, where people, objects, spaces and vehicles are rich of sensors able to acquire bites of data and to share them through an interconnected communication network to provide numerous services, it is fundamental to link these information and these sensors with their global position in the world. Location Based Services (LBSs) consist in a widespread panorama of applications, tasks, and services in which the position is the fundamental information to provide. Some examples are search and rescue operations, autonomous navigation, impaired assistance, geospatial analysis, Intelligent Transport System (ITS) and behaviour characterization. This wide panorama of applications requires robust and reliable estimation of the position, both indoor and outdoor, and in the transition between them. Since sensors performances are strictly bound to the type of environment, the research effort must be driven to the ubiquity of the solution which means integrating different sensors to reach the seamless positioning and navigation.

Nowadays, the location information is usually provided by a constellation of satellites that communicate with a receiver on the earth i.e. the Global Navigation Satellite System (GNSS). Thanks to this technology it is possible to estimate the global position, velocity and time of the receiver with high accuracy. Unfortunately, as people spend most of their time indoor and in urban areas, their positioning devices experience huge limitation. Indoor, the GNSS signals are attenuated or blocked by objects in line of sight and the positioning is highly degraded or unavailable. Moreover, urban environment presents some challenges that make GNSS vulnerable to a range of threats: multipath caused by the presence of buildings and trees, decreased satellite visibility and received signal strength, due to no open-sky condition, interferences from anthropogenic radiofrequency emissions over the GNSS bandwidths and more. Overcoming all these issues requires methods, technologies and sensors able to enhance the system performances in term of accuracy, reliability and continuity, both indoor and outdoor. For this purpose, multi-sensor integration and data fusion must be adopted to exploit the benefits of several complementary technologies and to limit their weaknesses. Moreover, the market demands for ubiquitous solutions embedded in low-cost devices. This requirement introduces further challenges related to the noise affecting low-cost sensors and to the seamlessness of the solution, i.e. the continuity of the navigation

estimation in the passage from outdoor to indoor spaces and vice versa. In this panorama, the present work aims to investigate on low-cost sensors integration for positioning and navigation in challenging environments. Based on the literature review and focusing the interest on the urban environment, the most suitable sensors have been selected, tested and validated in different scenarios. The characterization of these systems (i.e. technology, methodology, algorithms) has been used to implement an hybridized navigation solution which integrates Ultra-wideband (UWB), visual sensors, and Inertial Navigation System (INS). The results of this integration have been applied in one of the most challenging environment: an underground mine.