GNSS, RFID and INS Integration for Pedestrian Navigation

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ABSTRACT

The development of pedestrian navigation and guidance services are challenging research topics and have been investigated by several researchers worldwide. Most of the developed systems thereby rely on the use of satellite positioning (GNSS), sometimes also in combination with other sensors and positioning methods. In our approach at the Vienna University of Technolgy GPS positioning was first combined with dead reckoning (DR) sensors to be able to provide a continuous position determination in urban environments where satellite signals are frequently blocked by buildings and other obstructions. It could be shown that this integration works well in outdoor environment. Positioning accuracies on the few metre level could be achieved. If the pedestrian, however, enters a building or if GPS is not available for long periods of time in the outdoor environment, the accumulation of errors of the DR only positioning leeds to large positioning errors. An update using an absolute positioning determination method is then required. Therefore in our approach the use of alternative location techniques was investigated such as the use of WiFi (or WLAN) and RFID (Radio Frequency Identification). The advantage of WiFi positioning is that already available infrastructure can be used if a WiFi has been deployed in a building or at public spaces. On the other hand, RFID can also provide a low cost solution for indoor and outdoor urban positioning. Both methods have been investigated and it could be seen that RFID has several advantages for pedestrian navigation. Therefore this technolgy is investigated more in detail in the research project "Ubiquitous Cartography for Pedestrian Navigation (UCPNAVI)".

In RFID positioning the location estimation is based on RSSI (received signal strength indication) which is a measurement of the power present in a received radio signal. The receiver can compute its position using various methods based on RSSI. Totally, three different methods have been employed, i.e., cell-based positioning, trilateration using ranges to the surrounding RFID tags deduced from received signal strength measurements and RFID location fingerprinting. This technolgies can be employed depending on the density of the RFID transponders (so-called tags) in the surrounding environment. The conducted experiments showed that these approaches are suitable to navigate the user with different positioning accuracies, i.e., lower positioning accuracies in outdoor environment using cell-based positioning and higher positioning accuracies in indoor environment with trilateration and fingerprinting. The positioning is restricted, however, to areas where at least one RFID signal can be detected. If there is lack of coverage of signals of the RFID tags, the RFID reader will lose its orientation. In order to overcome these shortages we propose to integrate a low-cost Inertial navigation system (INS) in addition.

INS obtain measurements for the rate of turn using a gyroscope and acceleration using an accelerometer. These measurements need to be integrated over time to obtain orientation changes and velocity measurements. Then the current position could be derived by means of integrating the obtained orientation changes and velocity measurements over time if the start position is given for the integration. In this way the trajectory of the user in the lack of the coverage between two RFID tags can be calculated. Inside of the signal coverage the position determined by RFID can be regularly corrected. However, the INS components produce small measurement errors that accumulate over time and cause drift errors. Therefore the sensor is accurate over short time intervals. In this regard, the INS needs position determined by RFID or GPS as a start point for the integration and for regular updates. This means that the RFID or GNSS and the INS would be fused with each other, in order to position more accurately.

This paper deals with the integration and fusion of RFID, GNSS and INS for pedestrian navigation. After a description of the principles and methods of positioning using active RFID the determination of pedestrian trajectories using INS and RFID is described briefly. The approach is verfied by field tests and first test results are presented.