

INDORA

Track 2 (on-site Non Camera based Positioning)

Starting with a few bachelor and master theses at P. J. Šafárik University, a few constraints had been specified leading to an approach that require no additional infrastructure and utilize low cost smartphones with built-in sensors held in user hand. The core part of the method is grid-based bayesian filtering described in IPIN 2016 conference paper [1].

Records from smartphone sensors are acquired and applied in these partial problems:

- Step detection - accelerometer
- Heading estimation - device orientation (magnetometer, gyroscope)
- Floor detection - barometer, accelerometer

If step detector is not available as a software sensor by the platform, the steps are obtained using a step detection method. Four phases of the step are identified to detect a step resulting to the reliable technique in long-term walk. Step heading is obtained from the device rotation vector. Some basic filtering methods are applied to reduce outliers and to stabilize the walking direction.

Step length estimation has essential impact on the localization accuracy. Step length is unknown and may vary for a single user during the walk. Therefore a default value is selected and may be corrected - increased or decreased if a specific situation occurs. Stabilized walk is denoted when at least a given number of consecutive steps is within a small interval. Incorrect step length estimation results to a large gap between two consecutive steps in case of a significant turn (typically 90-degrees) executed after stabilized walk or with multiple consecutive steps denoting the same position.

As in many Pedestrian Dead-Reckoning solutions, a **map model** is essential for the localization accuracy. The walls are annotated on the map using external tool and zones (corridors, rooms) are split to form convex polygons. Map is automatically tessellated into square grid indicating reachable and unreachable grid cells. This model is used when step is detected to discard invalid movement in terms of the map model, i.e. steps through the walls. It may be advantageous to limit the freedom of movement in corridors with typical two opposed walk directions by artificially reducing the corridor width by denoting the other positions as accessible with less probability or inaccessible at all.

Advanced point-mass filtering method [2] is applied to estimate the current user location. Point-mass approach is based on an approximation of the continuous state space by a grid of isolated points. Values of conditional probability density functions are computed only at these

grid points. Multigrid implementation is eligible to approximate multimodal pdf anticipated in indoor environment. The method incorporates efficient partial methods, e.g. boundary-based grid design or thrifty convolution which supports real-time position estimations. Two-dimensional grids represent positions in a building on a single floor. Particularly barometer measurements are utilized to detect movement between floors.

Simulation performed by Šimandl et al. [2] show the better quality estimation of the advanced point-mass method compared to the particle filter. For a low-dimensional problem (such as our implementation of indoor localization method) it has comparable computational demands as the particle filter. To reduce these demands an efficient implementation of the applied methods is required, e.g. precomputed values for convolution or introducing a threshold below which negligible values are reset to zeros.

An initial absolute position is determined manually (or in real scenario using QR codes) and a new current position is estimated when a step is detected. Relative position computation leads to inaccuracies which are reduced due to the building structure. Another source of location information is provided by WiFi measurements. **WiFi fingerprinting** method updates the grid belief values and produce referring absolute position estimation which is desired especially in larger spaces without walls, e.g. shopping mall lobby.

References:

- [1] Galčík, F. and Opiela, M., 2016, October. Grid-based indoor localization using smartphones. In Indoor Positioning and Indoor Navigation (IPIN), 2016 International Conference on (pp. 1-8). IEEE.
- [2] Šimandl, M., Královec, J. and Söderström, T., 2006. Advanced point-mass method for nonlinear state estimation. Automatica, 42(7), pp.1133-1145.