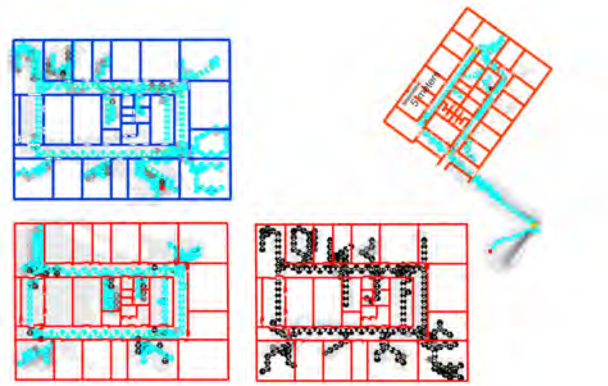
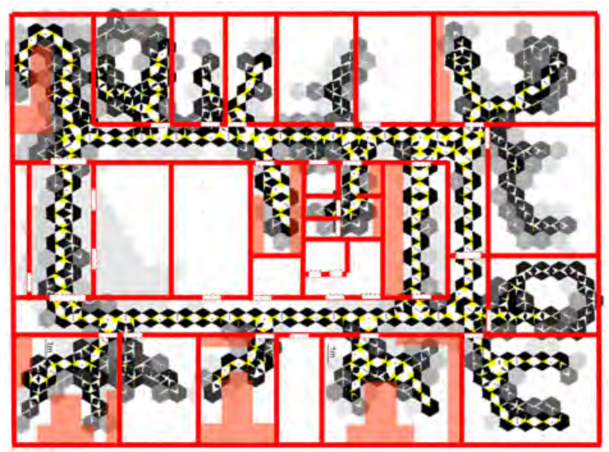


An example of four maps that result from four different walks in an office environment. (Scaled, rotated, and shifted to fit the known layout.)



Iterative, Turbo-FeetSLAM: processing four data sets within the same building leads to much more encompassing maps. One can see how furniture is reflected by the map. (Scaled, rotated, and shifted to fit the known layout; resulting scale error roughly 0.5%).

DLR at a glance

DLR is Germany’s national research center for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Transportation and Energy is integrated into national and international cooperative ventures. As Germany´s space administration, DLR has been given responsibility for the forward planning and the implementation of the German space program by the German federal government as well as for the international representation of German interests. Furthermore, Germany’s largest project-management agency is also part of DLR.

Approximately 6.700 people are employed at thirteen locations in Germany: Koeln (headquarters), Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also operates offices in Brussels, Paris, and Washington D.C.

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Information

FootSLAM
Learning Building Maps using Inertial Sensors for Pedestrians

Institute of Communications and Navigation

DLR

FootSLAM

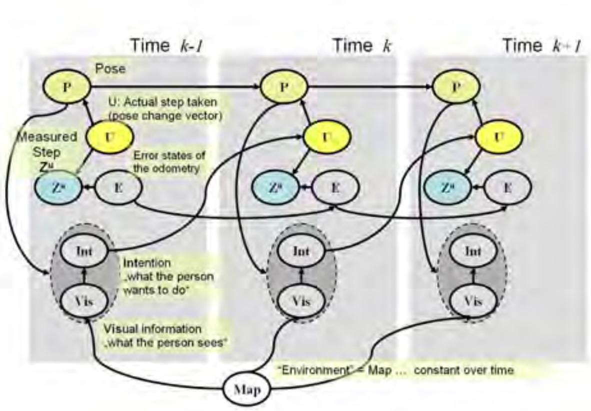
Pedestrian indoor navigation based on inertial measurements is known to be subject to unlimited position error growth caused by unknown sensor offsets, paired with double integration and increasing attitude error. In 2008 we showed that this error growth can be limited by utilizing movement constraints originating from known map information.

DLR´s Institute of Communications and Navigation has recently pioneered a new Bayesian estimation approach for Simultaneous Localization and Mapping for pedestrians - “FootSLAM” - based on human odometry using low cost foot mounted inertial sensors. The algorithm does not require any other sensor, such as cameras or laser scanners. This is unique because it allows the automatic generation of maps that are vital for indoor positioning.

When somebody walks within a constrained area such as a building, then even noisy and drift-prone odometry (step) measurements can give us information about features like turns, doors, and walls, which we can use to build a form of map of the explored area, especially when these features are revisited over time. The 2D maps obtained even for just 10 minutes of walking converge to a good approximation of the true layout and allow later positioning to within 1-3 meters accuracy. GNSS anchor points from outside the building provide absolute reference and orientation within a global coordinate system.

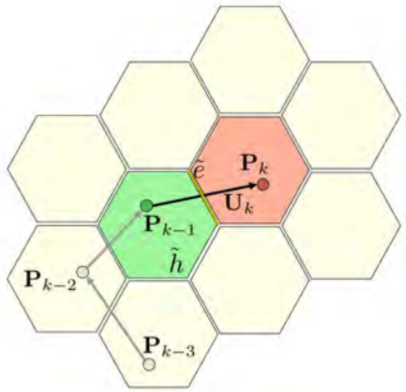
Our vision is one where ordinary people will be part of a continuous and collective mapping process of public areas. Data collected from inertial and other sensors can be processed anonymously to generate and update high quality SLAM maps; upon which we can all draw when we need to navigate. A further important application area can be rapid collaborative mapping of buildings in emergency situations or in security related missions.

URL:http://www.kn-s.dlr.de/indoornav/footslam_video.html



*Dynamic Bayesian Network (DBN) for FootSLAM showing three time slices and all involved state (random) variables. The map can include any features and information to let the pedestrian choose their Intention Int. The human’s pose consists of heading and location, the unknown step is the pose change **U** and its perturbed measurement is $\boldsymbol{Z}^u$. The hidden odometry errors are encoded in state variable **E**. This DBN is the basis for the formal derivation of the Bayesian filtering algorithm. The proposal function is chosen so that every particle explores a unique odometry error sequence.*

In our implementation of FootSLAM we adopt a 2D hexagonal grid for the Map which represents transition probabilities across edges of hexagons. Hexagons typically have a radius of 1/2 meter. The mapping part in the Rao-Blackwellized Particle Filter keeps track of the number of times an edge is crossed for each particle. The conditional probability distribution of the edge crossing probability of the Map follows a Beta distribution assuming a conjugate Beta prior. The prior can thus comprise counts from other walks, allowing collaborative mapping.



A portion of the hexagon grid and step transition $\boldsymbol{U}_k$ from time k to k-1. We assume that the step probability is conditionally independent of the pose history prior to $\boldsymbol{P}_{k-1}$ given knowledge of the Map (1st order Markov process). When inferring the Map we use only counts for that hexagon and that edge: Possible dependencies on counts of other hexagons or edges nearby are ignored.