Graz University of Technology

Institute of Geodesy
Working Group Navigation

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Navigation Systems
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2nd Lab Program
Pedestrian Navigation

Objective

This program deals with one subtask of Pedestrian Navigation: Pedestrian Dead Reckoning. For positioning within a navigation system, it is most suitable to use an absolute positioning solution as well as a relative positioning solution to estimate the current position continuously.

A relative position solution, specifically designed for the gait pattern of pedestrians, is called Pedestrian Dead Reckoning (PDR). Beginning at a given start point, an indoor pedestrian trajectory has to be computed. The provided data source is the inertial data from a smartphone, collected while walking within the building Steyrergasse 30 in Graz while holding the smartphone in walking direction. Due to the large sensor errors within smartphone sensors, the approach of a step-based PDR has to be computed.

The result should be a visualization of the pedestrian trajectory starting at the given starting point, moving along the hallways and stopping at the end of the time series.

Data source

The data given is a time series of roughly 3 minutes and taken directly from smartphone sensor readings. The smartphone was hand-held by the pedestrian in walking direction while walking within a building hallway. The inertial data provided are accelerations in three orthogonal axes as well as magnetometer measurements in three orthogonal axes. Furthermore, barometric measurements are given. The data is provided in the text file *data.txt* which has the following structure:

time [ms]	acc_x[m/s²]	acc_y[m/s²]	acc_z[m/s²]	mag_x [µT]	mag_y[µT]	mag_z [µT]	$baro$ [hPa]

Where the time is given in [ms], the accelerations are given in [m/s²] in three axes, the magnetometer measurements are given in [µT] in three axes and the pressure is given in [hPa].

The starting point for the trajectory is approximately given with:

$$\varphi = 47.06427\,°,\ \lambda = 15.45313\,°$$

For visualization indoors, the provided Matlab file *plot_google_map_15.m* may be used, although an own visualization may be created. After successfully plotting the pedestrian trajectory in φ, λ [°], the Matlab (2015) function *plot_google_map_15* will deliver a google maps visualization, if an internet connection is available. The building layout for this laboratory is incorporated within google maps.

Algorithm

The algorithm of a step-based PDR is divided into three steps:

- Step detection
- Step length estimation
- Direction estimation

For step detection algorithms, the peaks correlated to the human gait cycle have to be detected. Therefore, the total acceleration is used most often with $acc_{total} = \sqrt{acc_x^2 + acc_y^2 + acc_z^2}$. Within a clear acceleration signal, the gait peaks equal the steps and may be detected with simple thresholds within a segmentation process.

After detecting a step, the step length of this detected step has to be computed. Therefore, empirical models are available where the most basic model is the assumption of a fixed step length of e.g. 0.6 m, depending on the user. Your step length estimation should also consider varying step lengths depending on whether the user is walking stairs or along the hallway.

For the direction estimation, the magnetometer data may be used. The magnetometer measurements in three axes can be levelled purely with the acceleration measurements, see lecture notes. After that, a magnetic heading can be calculated which may be used directly as step direction. Consider the magnetic variations within a building structure. Due to magnetic variations, the direction derived from the magnetometer measurements will vary systematically as well as randomly.

For each step of the PDR, the step detection, the step length estimation and the direction estimation, thresholds have to be set, step length models have to be defined and possibly a heading filtering has to be conducted. Analyse and explain all chosen models and assumptions within your work.

For visualization of your results, a spherical approximation of the trajectory (for calculating φ, λ [°] coordinates out of the x,y [m] of the PDR) is valid and generally acceptable for indoors dimensions of a *building scale*. Therefore you might as well use $R = 6378137\,m$. However, the use of basic mapping equations is even more appropriate.

Deliverables

- Analysis of given data.
- Visualization of the step detection and step direction estimation.
- Visualization of the estimated heights.
- Explanation of the chosen step length estimation.
- Visualization of the derived trajectory indoors.
- Short technical paper of your work (2 pages) in English (according to IEEE format):
  - Use the provided template or visit ieee.org for word or Latex templates
  - Follow the IEEE two-column template and include at least abstract, introduction, methodology, preliminary results, conclusion and your used references.
  - Summarize your solutions and results as specified above with your interpretation
- Source code of developed software (no printouts)

The technical paper and the source code have to be uploaded to the TeachCenter by January 25th 2019, 08:00 a.m. with the correct file denotation “Matriculation#_lab2.zip”. The interview will take place on Feburary 1st, 2019. You can register for a time slot for the interview in the TeachCenter.

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