Lab program 2
Pedestrian Dead Reckoning

Navigation Systems, WS 2018/19

Navigation Systems VU – Administration

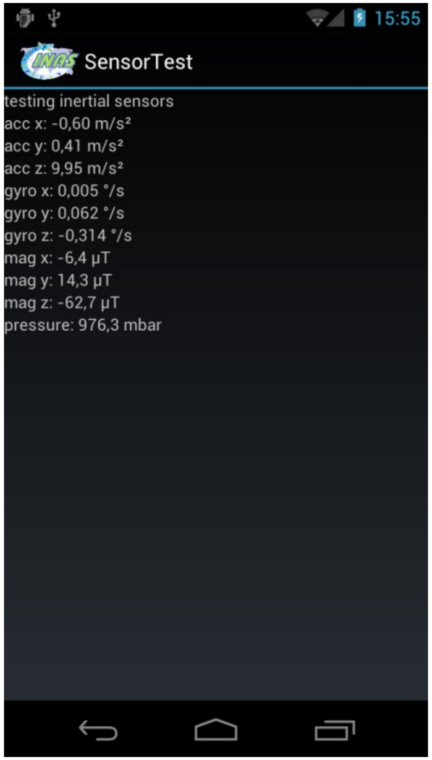
- Lecture
- 2 labs in total
  - Routing
  - Pedestrian navigation
- Assessment: 2/3 lecture (exam), 1/3 lab

Pedestrian Navigation – Introduction

- Absolute and relative positioning
- Relative: Pedestrian Dead Reckoning (PDR)
  - Inertial-based
  - Step-based
    - Step detection
    - Step length
    - Direction estimation

Pedestrian Navigation – Introduction to lab

- Step-based PDR
- Smartphone data dump of inertial sensors
  - $f_x^2 + f_y^2 + f_z^2 = g^2$
  - $\omega_{il}^{l} = \begin{bmatrix} \omega_e \cos\varphi \\ 0 \\ -\omega_e \sin\varphi \end{bmatrix}, \dot{\varphi} = \dot{\lambda} = 0$



Basic formulas

- Step detection: Peak detection
  - $acc_{total} = \sqrt{acc_x^2 + acc_y^2 + acc_z^2}$
- Step length estimation
  - Step length models
  - e.g. $step = 0.6\,m$

Basic formulas

- Direction estimation
  - Magnetic orientation

roll $r = tan^{-1}\left(\frac{-a_y}{-a_z}\right)$ pitch $p = tan^{-1}\left(\frac{a_x}{\sqrt{a_y^2+a_z^2}}\right)$

yaw $y_{mag} = tan^{-1}\left(\frac{-m_y\, cos(r)+m_z\, sin(r)}{m_x\, cos(p)+m_y\, sin(p)\, sin(r)+m_z\, sin(p)\, cos(r)}\right)$

- Step counting
  - $N_{t+1} = N_t + StepLength_t \cdot \cos(heading)$
  - $E_{t+1} = E_t + StepLength_t \cdot \sin(heading)$

Spherical approximation

- PDR: relative position (x,y) in [m]
- Geographic coordinates φ, λ needed for visualization
  - Coordinate transformation

- $dx = R \cdot d\varphi$
- $dy = R \cdot cos\varphi \cdot d\lambda$

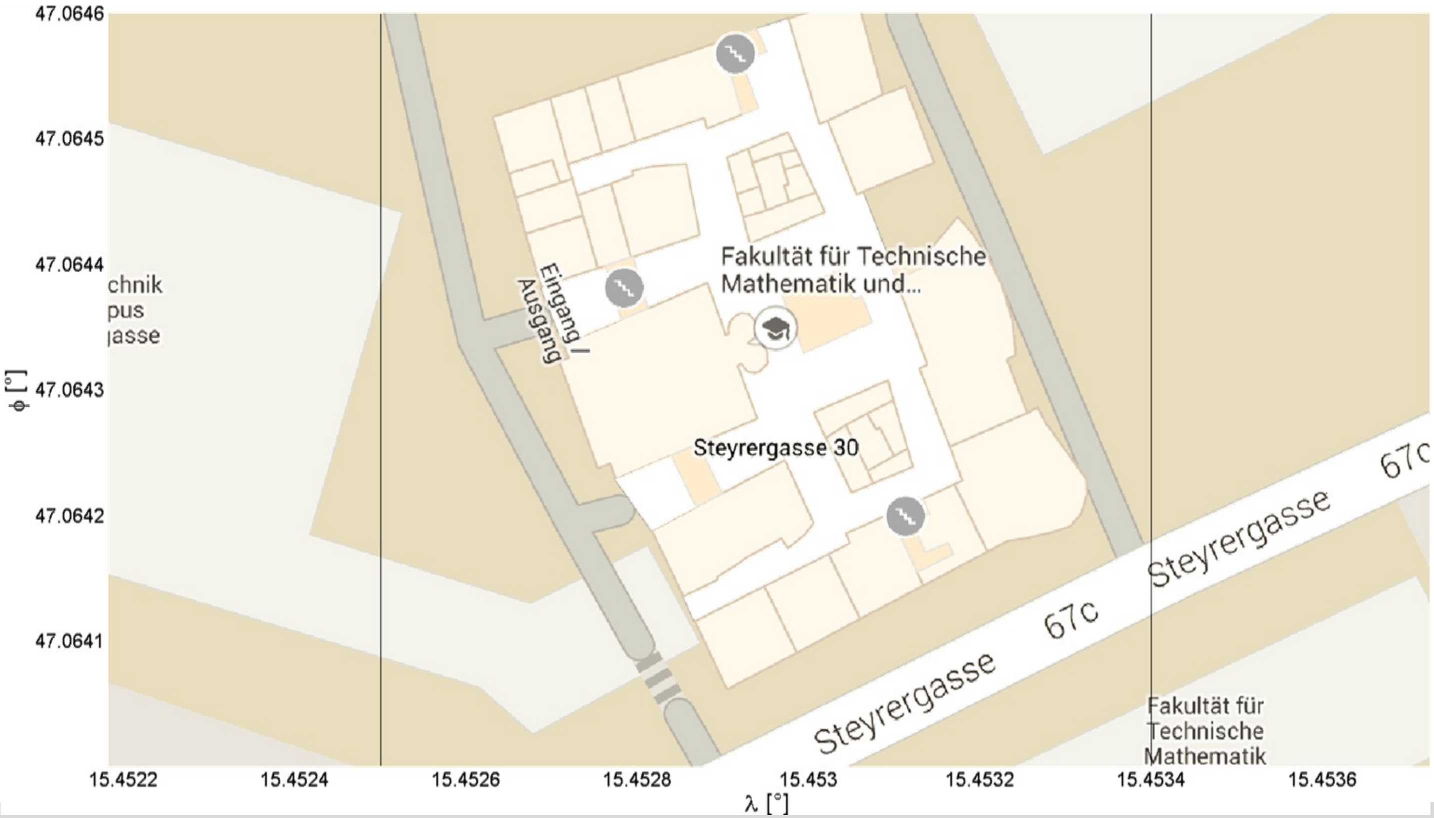
- Inverse spherical approximation from [x,y] to [φ, λ]

Height

- Barometer
- $h = \frac{288{,}15\ K}{0{,}0065 \frac{K}{m}} \cdot (1 - \left(\frac{p(h)}{1013.25\ hPa}\right)^{\frac{1}{5{,}255}})$
- Filtering + outlier detection
- Stairs → adapt step length

Visualization

- e.g. google API, Matlab function, etc.
- Matlab: plot_google_map_15('APIKey','AIzaSyCyJuOW-15fzA0HWpu4IceIihrfJsVgZvY');



Objectives

- Basic step detection
- Creation of step length model
- Magnetic orientation
- Dead reckoning calculation
- Visualization

Further considerations

- Walking backwards
- Walking stairs
- Magnetic deviations in buildings
  - Filtering?
- Accuracy
  - How long is unsupported positioning possible?

Short paper

- IEEE format
- 2 pages
- English
- Minimal requirements
  - Abstract
  - Introduction
  - Methodology
  - Results
  - Conclusion

Pedestrian Navigation

Navigation Systems VU, WS 2018/19, laboratory # 2

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***Abstract*—Pedestrians spend 80% of their time in indoor environments. Given that a vast majority of pedestrians own a smartphone, it would be convenient if an indoor positioning solution purely based on smartphone sensors existed. This paper focuses on one possible approach, namely Pedestrian Dead Reckoning based on inertial sensors from a smartphone.**

Keywords—smartphone; inertial sensors; dead reckoning; navigation;

I. Introduction

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II. Methodology Approach

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References

[1] G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. *(references)*
[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.
[3] I.S. Jacobs and C.P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.
[4]

TeachCenter

- Group choice (2 students per group)
- Upload source code and short paper
  - January 25th, 2019
- Chose time slot for interview

Interview

- 1st February 2019
- Time slots: 5 min

- Evaluation interview
  - Problem statement / understanding
  - Technical rigour / methodology
  - Interpretation of results