An Open Platform for Studying and Testing Context-Aware Indoor Positioning Algorithms

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Outline

- Scope
- Indoor Positioning Systems
- Fingerprint-based Positioning
- Platform Design and Implementation
- Evaluation
- Conclusions & Future Work

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Scope

- Work in Progress
- What is the problem?
- Main goal: Develop an open platform for studying and analyzing indoor positioning algorithms
- The novelty relates to the collection and use of additional context data to enhance localization accuracy
- Fingerprint-based
- Currently implemented on Android

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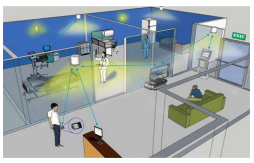
Indoor Positioning



- Positioning is key to modern information systems
- Used outdoors and indoors
- Satellite-based systems (like GPS) are not effective in indoor spaces
- Highly researched area
  - Mostly make use of radio (e.g. WiFi), its context (RSS, ToA, TDoA, etc.) using Triangulation, Trilateration, etc.
  - **Fingerprint-based positioning** also a very popular approach

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Fingerprinting Positioning (1)

- Based on the real-time comparison of received radio parameters (traditionally RSS) with pre-measured position-stamped signal signatures (called fingerprints) which are stored in a database.
- It consists of two phases:
  - *Offline phase (or training phase)*: The collection of the fingerprints to be stored in a database
  - *Online phase (or positioning phase)*: the instantaneous measurement is correlated with the database to estimate the most likely position.

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Fingerprinting Positioning (2)

Offline phase / Training

"lat": 35.0083700,
"lng": 33.6965000,
"measurements": [
{"macAddress": "0", "ssid": -65 },
{"macAddress": "1", "ssid": -66 },
{"macAddress": "2", "ssid": -80 },
{"macAddress": "3", "ssid": -85 }
]

"lat": 35.0083800,
"lng": 33.6967000,
"measurements": [
{"macAddress": "0", "ssid": -75 },
{"macAddress": "1", "ssid": -76 },
{"macAddress": "2", "ssid": -60 },
{"macAddress": "3", "ssid": -58 }
]

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Fingerprinting Positioning (3)

Online phase / Positioning

Related Work – Open Platforms for Positioning

- *SmartCampusAAU* [1] is a similar open platform that facilitates the easy creation of positioning systems.
- Includes an App and a back-end and enables both device- and infrastructure-based indoor positioning
- Allows researchers to publicly share their positioning data based on crowdsourcing techniques.
- We take this concept one step further by enriching the database with various kinds of other context (non-radio based) which potentially can lead to the creation of more accurate positioning systems.

[1] *Hansen, R., Thomsen, B., Thomsen L. L., Adamsen, F. S., SmartCampusAAU – An Open Platform Enabling Indoor Positioning and Navigation," 2013 IEEE 14th International Conference on Mobile Data Management, Milan, pp. 33-38 (2013).*

Platform Design and Implementation

- Main features
  - Add or edit locations (e.g. CNTI)
  - Add or edit floors (possibly different floorplan)
  - Take context-aware fingerprint measurements
  - Export collected data as JSON-formatted data
- Automatic context collection includes
  - Device brand and model
  - Battery charge level and status (charging, etc.)
  - Environment state (light, temperature, pressure, humidity)
  - Location and motion sensors (location, acceleration, magnetic field, gravity, gyroscope, rotation vector)

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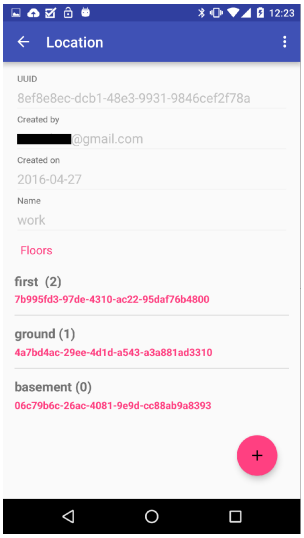
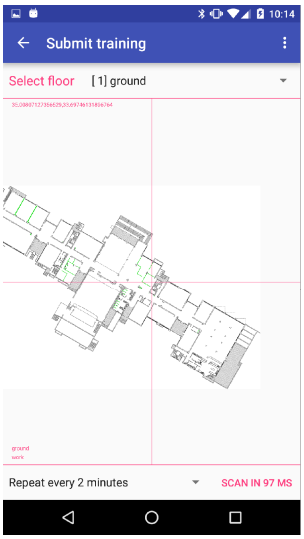
Platform Design and Implementation



Platform Design and Implementation



Platform and open-data

- Platform is open-source, under LGPL license
- Accessible at: https://github.com/nearchos/CAIPS

- Sample data also open as LGPL
  - Includes measurements by 4 individuals, using 4 different devices
  - Covered 2 floors of a large building
  - Produced 307 fingerprints, each with ~10-20 RSS measurements and context
- Accessible at the same Github page

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Evaluation

- Aims
  - Assess the quality of the collected data
  - Compare the performance of popular fingerprint algorithms
- Assessed algorithms
  - Standard fingerprinting (Euclidean distance of all samples)
    - Same device only
    - Similar battery (+/- 10%) only
  - *K*-Nearest Neighbor
    - With *K*=3 and *K*=10

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Evaluation

- Results
  - The table shows the distance (in meters) from the actual target (i.e. the error) for each algorithm
  - 90% of the data was used for training
  - Remaining 10% was used as control data

	Standard deviation		Absolute values	
	Mean (m)	Variance (m)	Min (m)	Max (m)
Standard fingerprint algorithm	8.7004	28.3425	1.1740	22.9706
Same device only	10.1144	78.1406	2.4748	40.0940
Similar battery only (+/- 10%)	10.0622	66.9148	2.3564	37.4445
***K*-Nearest Neighbour with *K*=3**	7.6623	22.6163	0.9552	21.3290
***K*-Nearest Neighbour with *K*=10**	7.8376	21.8472	1.1825	21.0465

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Conclusions

- Developed a novel, open platform for studying and evaluating context-aware, indoor positioning algorithms
  - Initial results indicate that context might be able to help improve the performance and accuracy of indoor positioning
- Future work
  - Continue development on CAIS platform
  - Collect a more extensive, open set of data (context-enriched fingerprints)
  - Further assess existing algorithms and propose new ones (exploiting the extra context data)

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Questions?

- Thank you!

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