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

Nearchos Paspallis, *Assistant Prof. in Computing, UCLan Cyprus*

Marios Raspopoulos, *Assistant Prof. in Electrical and Electronic Engineering, UCLan Cyprus*

uclan
University of Central Lancashire
— **CYPRUS** —

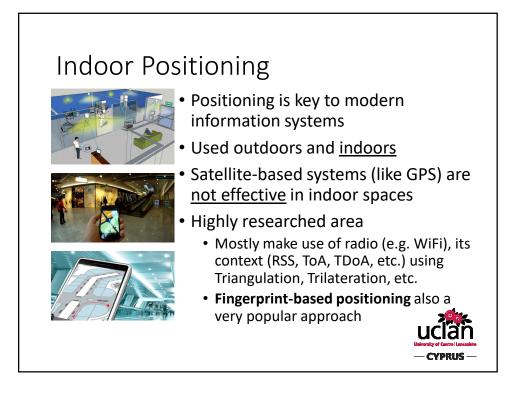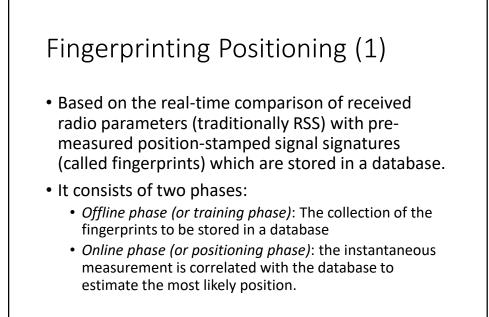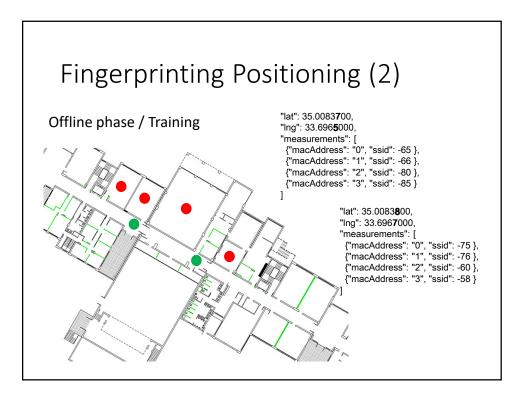25th International Conference on Information Systems Development (ISD 2016)

Outline

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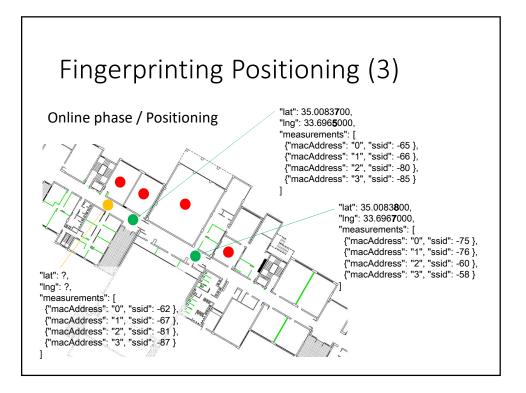- Evaluation
- Conclusions & Future Work

Scope

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

Indoor Positioning

- Positioning is key to modern information systems
- Used outdoors and <u>indoors</u>
- Satellite-based systems (like GPS) are <u>not effective</u> 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

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.

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 }
]

Fingerprinting Positioning (3)

Online phase / Positioning

"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 }
]

"lat": ?,
"lng": ?,
"measurements": [
 {"macAddress": "0", "ssid": -62 },
 {"macAddress": "1", "ssid": -67 },
 {"macAddress": "2", "ssid": -81 },
 {"macAddress": "3", "ssid": -87 }
]

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).*

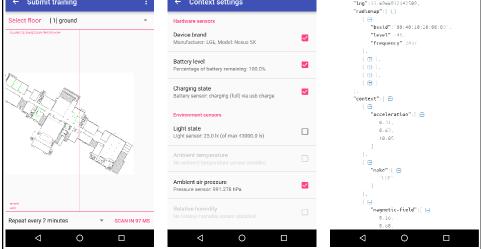# Platform Design and Implementation

- Main features
  - Add or edit locations (e.g. CNTI)
  - Add or edit floors (possibly different floorplan)
  - Take context-aware fingerprint measurements
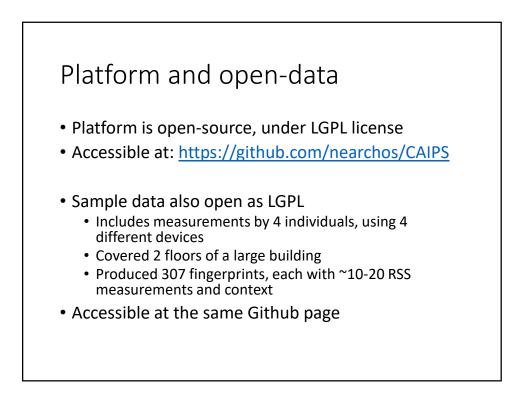 - Export collected data as JSON-formatted data

- 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)

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
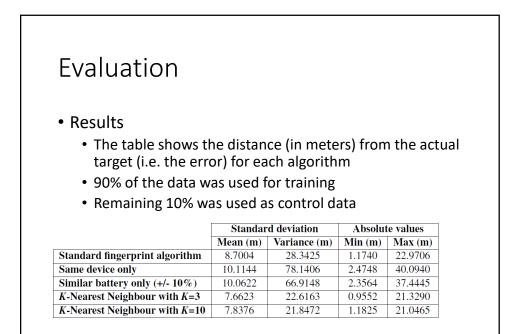- Accessible at the same Github page

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

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

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)

Questions?

- Thank you!