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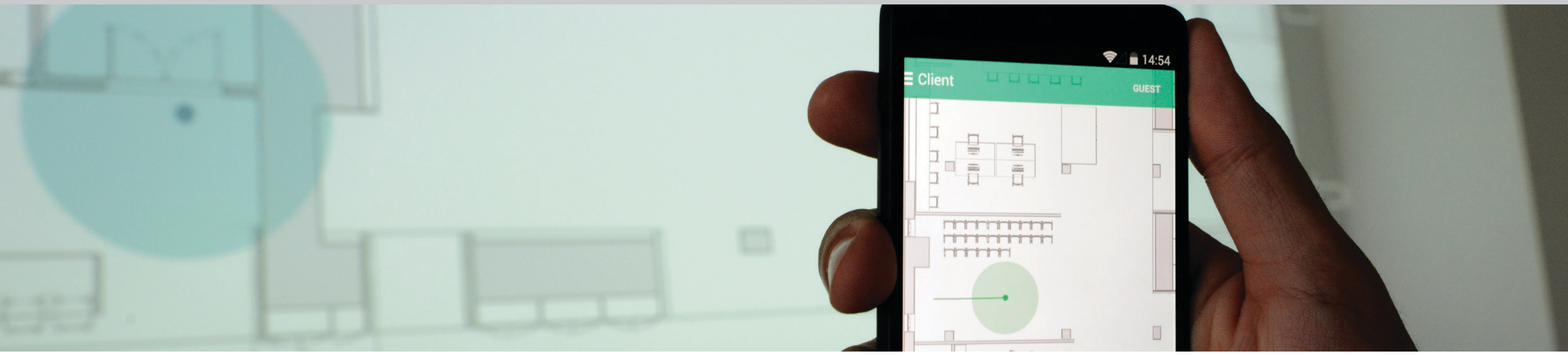

CROWD4PIL - HUMAN CROWDSOURCING DATA FOR INDOOR LOCATION APPLIED TO AMBIENT ASSISTED LIVING SCENARIOS

Automatic construction of floorplans and environmental fingerprints

Motivation

In recent years, the popularity of mobile devices is accelerating the demand for more accurate location information. Indoor maps are a prerequisite of indoor location based applications. However, indoor maps are sometimes inaccessible or non-existent for most indoor environments. The absence of indoor maps and the high cost of manually constructing them produce a need for an inexpensive and efficient way to dynamically construct indoor maps. Furthermore, fingerprinting-based solutions require an initial data collection of building fingerprints which increases the implementation costs, possibly hindering the system to be deployed in large buildings. Lastly, the vulnerability of external environment changes poses a challenge for updating fingerprints within a reasonable time frame and might deteriorate the system's accuracy.

In this context, crowdsourcing stands as the only viable solution for collecting the large amount of data required to support infrastructure free indoor location systems. Innovative use cases depending on locate people inside buildings are eagerly waiting for a technology to provide them this information. For example, in the scope of Ambient Assisted Living, knowing the location of an elderly will help on quickly recognizing where an accident happened. Moreover, in the field of consumer behavior, these systems will allow the development of new sales techniques, gathering consumer needs and market offerings.

Proposed Approach

The purpose of the developed algorithm is to use data collected by the users' smartphone sensors to obtain buildings' floorplans, creating at the same time environment fingerprints that will be used by the localization and navigation system.

The core idea behind the proposed algorithm is the aggregation of data recorded on

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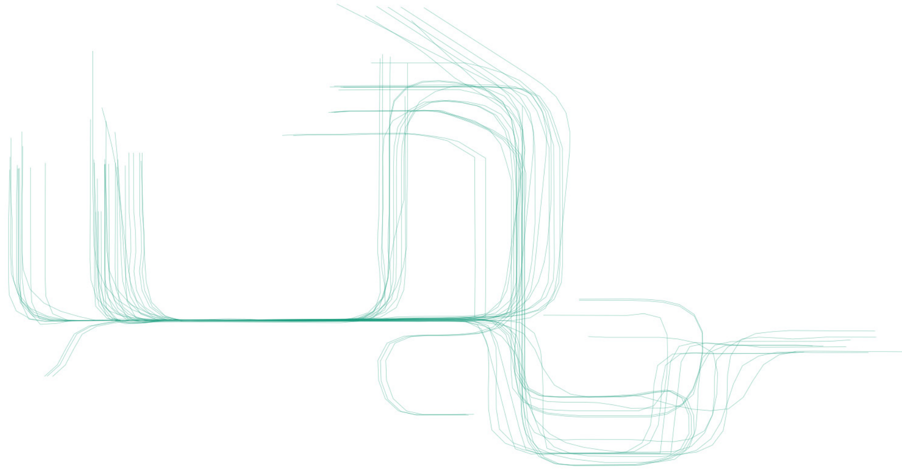

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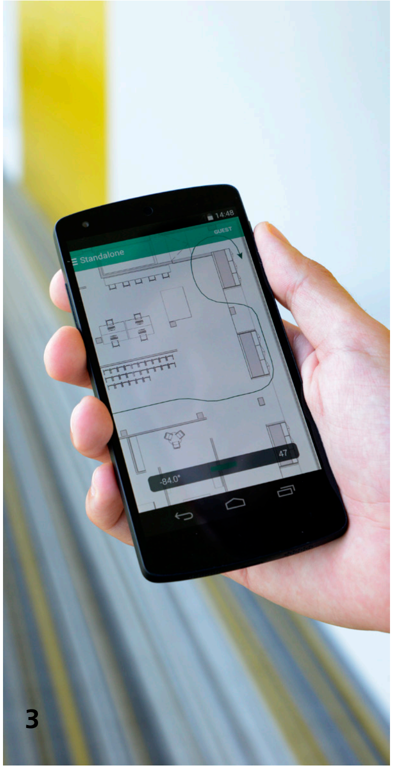

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multiple trajectories by multiple users. The reconstruction of each of these trajectories relies on dead reckoning algorithms that use inertial sensors to quantify the amount and direction of movement. At the same time, readings from magnetometer and Wi-Fi radio are also used to detect unique sensing data signatures. Therefore, the proposed solution combines dead reckoning techniques with trajectory clustering based on Wi-Fi data and geomagnetic matching.

After user trajectory estimation using dead reckoning techniques, an unsupervised machine learning technique is applied, where Wi-Fi radio data is clustered, allowing the system to divide and group the estimated trajectories into smaller areas that correspond to the same area of the building. This means that trajectory sections made by different users that belong to the same cluster, were acquired in the same building area.

Using the heading estimation, the users' trajectories are segmented by straight line sections within the same cluster. Since the system does not rely on any user input, and the north estimation might be wrong due to magnetic interferences, all the obtained sections are compared to each other, independently of their direction, to identify which ones were obtained in the same physical space. This identification is possible due to the same magnetic interferences, since they are caused by specific building characteristics, such as construction materials or metallic handrails. This way, some locations can be easily identified by their unique magnetic behaviour.

After the geomagnetic matches are identified, all the reconstructed trajectories are matched in the same referential to obtain the walkable areas of the indoor map, as seen in Fig. 2. Considering that the individual mobile trajectories are highly noisy due to error accumulation, the obtained map is filtered into a simpler shape and all trajectories are merged to obtain the final accurate trajectory estimation and consequently the building's fingerprints.

Ongoing and Future Work

Currently, the algorithm is almost ready to test phase, to understand if the system is accurate enough and how many acquisitions are needed to start it.

Considering that this solution is meant to be deployed in any desired building, without any specific implementation and maintenance effort, the algorithm must be adapted to receive new acquisitions over time, to process them and to update the map and the fingerprints if the building's characteristics changes.

Nevertheless, the quality of the map can be improved if new sources of information are added, as the barometer to identify floor changes or the microphone to identify sound patterns of the building.

The algorithm developed on this work overcomes the need of the building's floorplan or fingerprints beforehand, both disadvantages of most existing indoor location solutions.

1 *Magnetic and Wi-Fi radio fingerprints, respectively.*

2 *Users' trajectories matching.*

3 *Indoor positioning system running.*