(SD2019-307) Autonomous Millimeter Accurate Mapping of WiFi Infrastructure AND Reverse Localization of COTS WiFi Access Points

Tech ID: 32534 / UC Case 2021-Z08-1

BACKGROUND

Indoor localization has been studied for nearly two decades fueled by wide interest in indoor navigation, achieving the necessary decimeter-level accuracy. However, there are no real-world deployments of WiFi-based user localization algorithms, primarily because these algorithms are infrastructure dependent and therefore assume the location of the Access Points, their antenna geometries, and deployment orientations in the physical map. In the real world, such detailed knowledge of the location attributes of the access point is seldom available, thereby making WiFi localization hard to deploy.

Location services, fundamentally, rely on two components: a mapping system and a positioning system. The mapping system provides context, and the positioning system identifies the position within the map. Outdoor location services have thrived over the last couple of decades because of wellestablished platforms for both these components (e.g. Google Maps for mapping, and GPS for positioning). In contrast, indoor location services haven't caught up because of the lack of reliable mapping and positioning frameworks (and lack of integration between the two). SLAM methods construct maps that aren't tagged with locations. Wi-Fi positioning lacks maps, and is also prone to environmental errors.
In contrast, indoor navigation even with significant interest from industry and academia lacks further behind. We cannot use our smartphone to navigate to a conference room in a new building or to find a product of interest in a shopping mall. The primary reason for the poor indoor navigation system is the unavailability of indoor localization augmented maps and floor plans. On one hand, Google and a few other providers make indoor floor plans for airports, malls, and famous buildings, those floor-plans have to be created manually and often need to updated as floor plans change and they lack details such as the position of furniture and other obstacles. On the other hand, besides mapping, ability to position users' location on these indoor maps is necessary for indoor navigation

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have invented a platform that can map indoor environments and collect location labeled Wi-Fi Channel State Information (CSI). Dubbed 'MapFind' this technology enables easy deployments of indoor positioning systems by automatically constructing maps of the environment and by enabling quick testing of localization algorithms. The inventors demonstrated the efficacy of this platform by collecting 150,000 data points in a 1000 square feet space, and leveraged this labeled data to train a deep learning based WiFi localization model, 'DeepLoc', that outperforms state-of-the-art methods in Wi-Fi positioning by a factor of 2.

MapFind may open up opportunities for other researchers to create large labeled datasets for indoor positioning and allow for novel machine learning based approaches to localization. Furthermore, the inventors envision that the datasets thus collected will slowly evolve into a standardized repository that will enable standardized evaluation of new localization algorithms.

Existing art misses the link between the context based maps and the WiFi localization. Our invention bridges this gap. The current state of the art indoor localization algorithms are limited to testing across few 100s of data points and thus disabling them from the vast knowledge of Deep Learning models. While our invention enables the collection of millions of data points automatically, thus enabling us to develop Deep Learning based indoor WiFi localization models.

CONTACT
Skip Cynar
scynar@ucsd.edu
tel: 858-822-2672.

OTHER INFORMATION

CATEGORIZED AS

- Communications
  - Wireless
- Sensors & Instrumentation
  - Position sensors

RELATED CASES

2021-Z08-1

The system operates in two stages: mapping and localization. During the mapping phase, MapFind robot, equipped with a Wi-Fi device to collect wireless channel information, performs an autonomous walk through the space to map the environment. Simultaneously, the Wi-Fi device on MapFind collects the CSI for Wi-Fi packets heard from all the access points in the environment. At the end of its walk, the platform generates a map of the environment, and a log of the CSI-data collected at different locations. The CSI-data is labeled with the ground truth values of the platform locations.

DeepLoc uses the CSI-log generated by MapFind to train a deep learning model. This model, once trained, can be used by users to locate themselves using their Wi-Fi enabled devices (like smartphones). The users can also access the maps of the building by making calls to a centralized server.

Researchers from UC San Diego have for the first time, established the accuracy requirements for the location attributes of access points (AP) to achieve decimeter level user localization accuracy. Surprisingly, these requirements for antenna geometries and deployment orientation are very stringent, which is hard to achieve with manual effort. To ease the deployment of real-world WiFi localization, the researchers developed LocAP, which is an autonomous system to physically map the environment and accurately LOCate the attributes of existing wireless infrastructure in the physical space down to the required stringent accuracy of 3 mm antenna separation and 3 degree deployment orientation median errors, whereas state-of-the-art algorithm reports 150 mm and 25 degrees respectively.

APPLICATIONS

Using the mapping and reverse localization information, this invention can provide accurate indoor localization and navigation for large indoor environments. These accurate access points (AP) location attributes aids many of the networking issues like user location based smart hand-off, network load balancing utilizing both AP locations and client locations and other networking services based on AP and client locations. Further, with the emergence of 5G and 11ad/ax wireless protocols, where directional beams become more and more important, these angle of arrival estimates that are provided by LocAP, can be further used to perform smart-beamforming at both the client and the AP side.

ADVANTAGES

STATE OF DEVELOPMENT

INTELLECTUAL PROPERTY INFO

Patent-pending technology. UC San Diego is seeking partners to commercialize this technology.

RELATED MATERIALS

- Seetharaman, A. (2019). Reverse Localization of Wi-Fi Access Points. UC San Diego. ProQuest ID: Seetharaman_ucsd_0033M_18158. Merritt ID: ark:/13030/m5cp22mb. - 03/01/2021
- Roshan Ayyalasomayajula, Aditya Arun, Chenfeng Wu, Shrivatsan Rajagopalan, Shreya Ganesaraman, Aravind Seetharaman, Ish Kumar Jain, and Dinesh Bharadia. "LocAP: Autonomous Millimeter Accurate Mapping of WiFi Infrastructure". Proceedings of the 17th USENIX Symposium on Networked Systems Design and Implementation (NSDI '20) - 02/27/2020
- Related/detailed presentation on YouTube - https://www.usenix.org/conference/nsdi20/presentation/ayyalasomayajula - 02/27/2020

University of California, San Diego
Office of Innovation and Commercialization
9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910
Tel: 858.534.5815
innovation@ucsd.edu
https://innovation.ucsd.edu
Fax: 858.534.7345