Chapter 3
WiFi Fingerprint Localization for Emergency Response:
Harvesting Environmental Dynamics for a Rapid Setup

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ABSTRACT

As a key enabler for diversified location-based services (LBSs) of pervasive computing, indoor WiFi fingerprint localization remains a hot topic for decades. For most of previous research, maintaining a stable Radio Frequency (RF) environment constitutes one implicit but basic assumption. However, there is little room for such assumption in real-world scenarios, especially for the emergency response. Therefore, we propose a novel solution (HED) for rapidly setting up an indoor localization system by harvesting from the bursting number of available wireless resources. Via extensive real-world experiments lasting for over 6 months, we show the superiority of our HED algorithm in terms of accuracy, complexity and stability over two state-of-the-art solutions that are also designed to resist the dynamics, i.e., FreeLoc and LCS (Longest Common Subsequences). Moreover, experimental results not only confirm the benefits brought by environmental dynamics, but also provide valuable investigations and hand-on experiences on the real-world localization system.

INTRODUCTION

Disasters can be classified into two categories, natural and man-made. Examples of the former include earthquakes (Suzuki et al., 2007), hurricanes (Subramanian et al., 2011), volcanic eruption (Tan et al., 2010), etc; while terrorism attacks (Goldman, 2011) fall into the latter.

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In both natural and man-made disasters, emergency response always plays an important role. To this end, location constitutes one of the most critical contexts of the emergency response and disaster monitoring (Makki et al., 2015). For instance, in various emergency applications such as medicare (Alemdar & Ersoy, 2010), and home surveillance (He et al., 2011} demands the location-awareness.

Therefore, in this chapter, we focus on the indoor localization issue in emergency to provide an accurate localization system with fast setups, which is particularly important considering the time urgency in disasters.

Indoor localization remains a great challenge due to unique features such as the inoperative GPS, irregular signal propagation and environmental dynamics (Harle, 2013). During the last few decades, tremendous research efforts have been dedicated to addressing this localization issue. The information sources of these indoor localization techniques are diversified and mainly related to hardware devices, such as infrared (Lee et al., 2006), ultrasound (Hazas & Hopper, 2006), Bluetooth (Feldmann et al., 2003), radio-frequency identification (RFID) (Saad & Nakad, 2011) and WLAN (Bunato & Battiti, 2005).

WLAN is the most promising network access solution for the indoor environment. Therefore, nowadays WiFi signal literately can be accessed from anywhere at any time, making it a perfect source for the continuous indoor localization. Thus WiFi fingerprint localization has gradually become the mainstream solution. In general, it consists of two phases: training and serving. In the training phase, it leverages existing wireless access points (APs) and uses off-the-shelf equipments to collect signals from different APs to form the training database, i.e., the location-related fingerprints. In the serving phase, when it receives from a user a query message including unknown fingerprints, it will launch the localization algorithm to obtain the matched record within the database and return the corresponding locations to the user (Li et al., 2014).

Therefore, a key assumption to the performance is the RF environmental similarity between the training phase and serving phase. That assumption is backed up by several landmark APs manually deployed in the controlled environment (Sun et al., 2005). To the best of our knowledge, it is an implicit but fundamental assumption for most of current solutions. Thus, it is understandable that environmental dynamics are treated as a threat for the traditional approaches.

However, there exist strong concerns about whether this assumption holds in reality, especially in emergency, since the landmark APs used in the training phase could be sabotaged in disasters. This chapter provides a different angle of view on the indoor localization issue to handle such dilemma. Previous approaches may treat the environmental dynamics as a major threat hampering the system efficiency, and try to avoid such situation by using self-deployed APs to create a stable RF environment. We argue that certain environmental dynamic is not a curse but rather bless. However, before harvesting from the bursting number of available wireless resources, in-depth understandings on the dynamics are essentials. In this way, we could quickly establish an indoor localization system relying on what we have right now, not what we used to have.

To this end, we present an empirical study with extensive real-world experiments to investigate the impact of environmental dynamics on the overall localization performance. More specifically, we conduct a series of comparative experiments in both short-term (**STS**) and long-term (**LTS**) scenarios under different AP settings.

- **AP Setting:** What we used to have (Pre-Deployed APs) verse what we have right now (all surrounding APs, All-AP in short hereinafter). For the AP setting, on one hand, we can deploy a limited number of APs inside the experimental site, whose layout needs to be optimized under the

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