Poster Abstract: E-Loc: Indoor Localization through Building Electric Wiring

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ABSTRACT

E-Loc is an indoor localization system, which, through using existing indoor electric wiring, detects occupants' location. While many indoor localization technologies require intensive infrastructural supports, *E-Loc* obtain locations by injecting a signal into the protected earth line of existing residential power network. Caused by human body inside a room, the electromagnetic character changes can be detected to deduce a resident's location. We evaluate our system through experiments inside multiple rooms and our system is able to reach meter-level accuracy.

CCS CONCEPTS

•**Human-centered computing** →**Ubiquitous and mobile computing systems and tools;** •**Information systems** →*Geographic information systems;* •**Computer systems organization** →Sensor networks;

KEYWORDS

indoor localization, electric wiring, socket

ACM Reference format:
Tian Zhou, Yue Zhang, Xinlei Chen, Pei Zhang, and Lin Zhang. 2017. Poster Abstract: E-Loc: Indoor Localization through Building Electric Wiring. In *Proceedings of The 16th ACM/IEEE International Conference on Information Processing in Sensor Networks, Pittsburgh, PA USA, April 2017 (IPSN 2017),* 2 pages.
DOI: http://dx.doi.org/10.1145/3055031.3055064

1 INTRODUCTION

Occupant localization plays an important role in many pervasive smart space applications from residential to commercial spaces. For instance, a smart space might utilize location information of the occupants and their motion to determine space utilization for layout and management decisions.

Various methods have been explored for unobtrusive localization of occupants including cameras [1], passive infrared motion (PIR) sensors [2], radio frequency (RF) sensors [3] and vibration sensors [4, 5]. But these methods either require infrastructure support, or carrying device for localization. Additional infrastructure often leads to increased deployment and maintenance costs. On the other hand, wearable sensors are often forgotten or require additional user maintenance for long term tracking.

This paper proposes *E-Loc* , an indoor localization method through the use of existing in-home electric wiring. The *E-Loc* injects periodic signals into the earth line of existing electric wiring. Through sensing at different locations on the same earth line, the system captures the electric signal variations, due to users at different locations. Finally, through characterizing the "degree of change" measurements, location of human body can be detected.

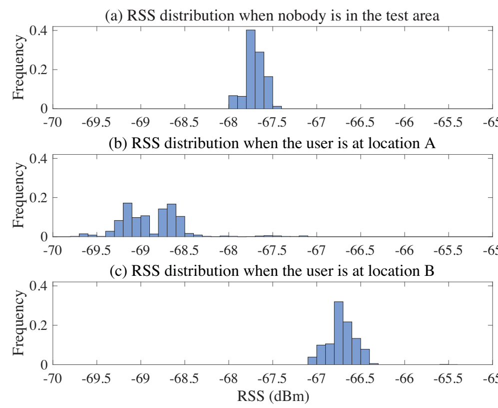

Figure 1: Example of influence of human presence on signal RSS from one power socket. (a) shows the signal when nobody is present. (b) shows the signal when a user is at one location, and (c) shows the user at a different location. Each histogram is calculated on a half-hour continuous collection of data.

2 SYSTEM OVERVIEW

Figure 2 shows the overview of *E-Loc* . First a signal is injected in the building wiring. Then the power spectrum surrounding the frequency of the injected signal are collected at different sockets. Noise removed before the received signal strength (RSS) peak energy is extracted as a feature. Finally support vector machine (SVM) classifier is used to classify the location.

Human antenna effect: The *E-Loc* system operates by treating the human body as an electrical conductor that will affect the

IPSN 2017, Pittsburgh, PA USA

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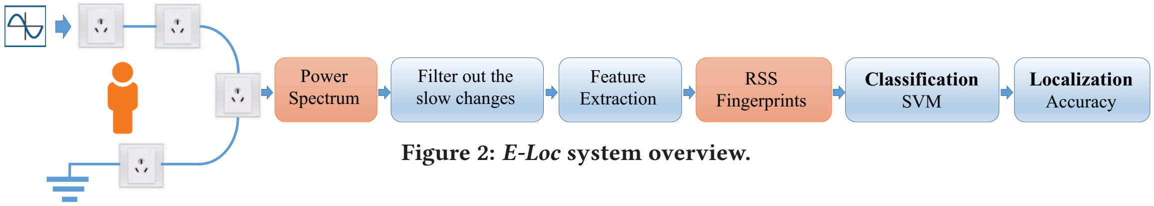

Figure 2: *E-Loc* system overview.

electromagnetic (EM) waves[6]. Thus, by injecting a signal into the earth line of the existing electrical wire, the signal is affected by the human body. This small change is affected by a number of factors: 1) the location of the human body, 2) the location of the electrical wiring and path inside the walls and floors, and 3) the electrical coupling of the earth line and the true earth. Since we can assume that the location of the human body changes at much higher rates than the rest of the environment, we can measure these changes to deduce the location of the human.

Indoor Electric Wiring: Our system utilizes existing indoor electric wiring as a poor transmitting antenna to emit small amount of EM waves into the surrounding environment. Due to the pervasiveness of the electrical systems this enables *E-Loc* to be deployed in many environments. And *E-Loc* inject the signal into the earth line to improve safety. This further limits the effective range of the signals and complies with regulations. The human body antenna, when present, will affect the propagation pattern of injected signal in the electric wiring as shown in Figure 1. The presence and location changes of a person in an indoor environment can affect RSS distribution to decrease, increase, or remain constant due to multipath effect.

Once the signals are collected at the electrical outlets, the slowly varying environmental changes are first filtered out of the raw data. Then the peak RSS is used as a feature for SVM classifier to classify the locations.

3 EVALUATION & RESULTS

Real-world experiments are conducted at the top floor of Tsinghua Rohm building. The covered area includes a conference room, an office room and the corridor. We artificially divide the space into 1.2m × 1.2m grids for our experiment. The number of cells where a user can be present is 46 (i.e. cells that are not occupied by large benches, tables, walls, etc.). The deployment of the injector is placed in the corner of the room, and the receivers (five power spectrum analyzers) are placed at the other sockets (5 in total). A 70 MHz and 10 dBm sine wave (determined experimentally) is injected into the electric wire.

In our experiments, we asked one occupant to move along the spaces and the data is logged. In order to fully test the robustness of our system, the occupant is asked to move around within each testing grid for 60 seconds. Finally, we perform 10-fold cross-validation to identify each occupied cell. The results are shown in Figure 3. Using the peak value of RSS at 70MHz, the average accuracy with SVM is 90.76%. However, according to this figure, the misclassification rate of the cells near the injector or the receiver is higher than that of the other cells. This is because when the user is close to the receiver, the user is considered to be in the near-field region of the transmitting antenna. The tiny movements of the human body can lead to large changes in RSS. As a result, the diversity of RSS in

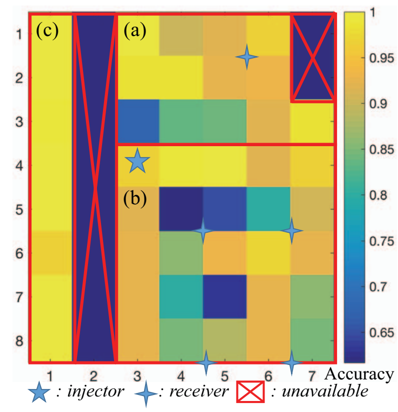

Figure 3: Classification accuracy of each cell are plotted on the map of (a) office, (b) conference room and (c) the corridor. Red lines shows the walls.

these cells leads to lower classification accuracy compared to other regions.

4 CONCLUSIONS & FUTURE WORK

In this work, we show the initial results of locating a person by measuring the signal variation along the earth wire in existing electric wires in a building. Through real world experiments, we show that our system achieves 91% localization accuracy with 1.2 meter resolution. Using existing electrical wires enable future smart space location sensing of humans without wearable and minimal additional infrastructure hardware.

ACKNOWLEDGMENTS

The work is supported by the Shenzhen Municipal Development and Reform Commission under Grant No.: SDRC [2015]1872.

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