DEVICE-FREE WIFI SENSING FOR HUMAN ACTIVITY RECOGNITION

by
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ABSTRACT

Human activity recognition (HAR) using WiFi signals (WiFi-based HAR) has drawn considerable interest from the research community. In contrast to traditional device-based sensing techniques, WiFi-based HAR possesses several advantages, including convenience, wide availability, and privacy protection, making it an attractive sensing solution for a wide range of applications in smart home, health care, and intelligent monitoring.

Recently, applying deep learning (DL) to WiFi-based HAR has received strong research interest. Assisted by signal processing techniques, DL-based HAR methods are able to automatically extract deep features from input signals, contributing to successful recognitions. Despite its effectiveness in improving recognition performance, DL-based HAR methods suffer from several inherent drawbacks. First, feature extraction is a challenging task that always bottlenecks the recognition performance. Second, DL-based HAR requires a large number of training examples from the testing/targeted environment or/and previously seen environments (PSEs) to train the corresponding DL architectures. When the number of required samples is not sufficient, the sensing performance will drop dramatically. Third, the trained model in one environment cannot be directly applied to another environment without additional effort.

My PhD thesis aims to provide novel solutions to the above WiFi-based HAR issues. Specifically, to extract effective features, we propose two advanced methods together with leveraging the property of DL architectures to enhance the quality of input signals of DL networks and extracted repre-

sentative features. For a reliable recognition with limited training samples, we propose a novel HAR scheme by developing innovative signal processing methods and exploring the characteristics of one-shot learning to reduce the number of required training samples. The proposed HAR scheme is able to accomplish successful recognitions when both the number of PSEs and the amount of samples from the testing environment are quite limited (e.g., one PSE and at the minimum one sample for each activity from the testing environment). To achieve environmental robustness, we propose two novel signal processing algorithms and leverage the features of the matching network. The proposed models are trained once and can be directly applied to various new/testing environments for reliable recognitions without requiring an additional retraining process.

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, ZHENGUO SHI, declare that this thesis, is submitted in fulfilment of the requirements for the award of DOCTOR OF PHILOSOPHY, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Contents

List of Figures

List of Tables

List of Publications

Journal Publications

- **Zhenguo Shi**, Andrew Zhang, Richard Xu, Qingqing Cheng, Environment-Robust Device-free Human Activity Recognition with Channel-State-Information Enhancement and One-Shot Learning, in IEEE Transactions on Mobile Computing (TMC), doi: 10.1109/TMC.2020.3012433. (Corresponding to Chapter 4)

- **Zhenguo Shi**, Qingqing Cheng, Andrew Zhang, Richard Xu Environment-independent WiFi-based Human Activity Recognition using Enhanced CSI and Deep Learning under review in IEEE Internet of Things Journal (IoT). (Corresponding to Chapter 5)

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- **Zhenguo Shi**, Andrew Zhang, Richard Xu, Qingqing Cheng "Deep learning networks for human activity recognition with CSI correlation feature extraction", in IEEE International Conference on Communications, ICC 2019. (Corresponding to Chapter 4)

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- Qingqing Cheng, **Zhenguo Shi**, Diep N. Nguyen, Eryk Dutkiewicz, “An OFD-M Sensing Algorithm in Full-Duplex Systems with Self-Interference and Carrier Frequency Offset”, in IEEE Global Communications Conference (GLOBE-COM), 2019.