DOCTORAL THESIS

Towards Low-cost and Real-time Mobile Sensing

LI, Hao

Date of Award:
2021

Abstract

With the increasing popularity of sensor-equipped smartphones, mobile sensing nowadays emerges as a promising direction. Mobile sensing applications analyze the collected signal data from the surroundings and thus understand the physical environment. Various applications have been developed through this new paradigm, such as mobile location estimation, audio recognition, and augmented reality. However, many practical issues need to be addressed when deploying mobile sensing applications in real-world scenarios. In this thesis, we investigate three practical problems related to mobile sensing applications and design customized frameworks and methods to provide low-cost and real-time mobile sensing services, particularly in the area of mobile location sensing.

First, we investigate the high data collection cost problem in WiFi fingerprint-based mobile location sensing. We propose a general framework with a low-cost offline data collection while maintaining high localization accuracy. In particular, we reduce the number of reference points to obtain a sparse fingerprint. Our framework adopts the clustering method to reduce the adverse effects when applying regression-based approaches on the sparse fingerprint. The proposed framework can provide high localization accuracy through extensive experiments on the campus.

Second, we study the heterogeneous mobile devices problem in passive mobile location sensing systems. We propose a customized localization approach that automatically infers a signal-strength-to-distance function for every device on the fly and simultaneously estimates its location with the Expectation-Maximization algorithm.

A real-world pilot test at an exhibition center is conducted, and heterogeneous mobile devices can be localized and tracked accurately.

Third, we present a mobile deep learning inference framework to schedule multiple DNN jobs with real-time requirements for deep mobile sensing tasks. Considering characteristics of DNN workloads and mobile hardware, we design the framework with mobile GPU/CPU collaboration by DNN partitioning and CPU offloading. The proposed framework can better utilize all computational resources on mobile phones. We evaluate our system on the mobile platform by extending TensorFlow Lite. The evaluation results indicate that our framework can support real-time deep mobile sensing tasks.

Keywords: Mobile Sensing, Location Estimation, WiFi Signal Strength, Real-time Scheduling, Deep Learning Inference

Table of Contents

List of Tables

List of Figures