# Capturing Transitions Between Users' Semantically Meaningful Places Using Mobile Devices

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## ABSTRACT

Due to their ubiquity and ever-increasing technical capabilities, mobile devices are often used as data collection tools by researchers in multiple fields, notably HCI and Ubicomp. Although the data gathered by mobile devices can be generated from sources such as the device users, it is difficult for researchers to capture ground truth and verify data integrity beyond controlled laboratory studies. This lack of knowledge about data integrity may, in turn, affect the quality of higher-level inferences made using the data. In this paper, we report on the experience and results of a hybrid laboratory/field study in which we use mobile devices to infer the moment at which users transition between self-defined semantically meaningful personal places. The results show that filtered device motion does appear to reflect these moments of transition well, but the nature of the research question makes verification difficult in a field study.

## Categories and Subject Descriptors

C.3 [**Special-purpose and Application-based Systems**]: Real-time and embedded systems

## Keywords

mobile data collection, context inference, context transition, ground truth, field study

## 1. INTRODUCTION

The mobile device is evolving into an important tool for context aware systems. As devices such as smartphones become ever more sophisticated, with increased capabilities for sensing and computing, their utility for context awareness increases. Indeed, the mobile device offers unique data to context aware systems due to its ubiquity across diverse environments and its proximity to its users. It is a powerful enabler for sensing and computation in the real world.

As such, mobile devices are extremely useful tools for data collection in user studies. They allow researchers to gather data from users in an unobtrusive manner, which enables the capture of rich data that otherwise cannot be obtained without great effort. This is particularly apparent at the HCI level in mobile context aware computing. One notable example is semantic place recognition, where the goal of the system is to learn and recognise users' *subjective* and semantically meaningful personal places [5, 10] rather than the *objective* and absolute locations associated with location-based services (cf. [4]). The subjective element of place recognition adds complexity to sensing and inference and, as such, verification of data integrity is non-trivial.

In this paper, we focus on capturing the moments of transition between users' semantically meaningful places using mobile device motion data. Transition events are useful as they can – if captured – act as triggers for resource-intensive sensors or user notifications [6, 15]. Existing mobile place recognition systems use motion as simple triggers for higher-level sensing, but none have systematically analysed how mobile device motion relates to transitions between places.

We contribute a systematic analysis of a semantic place transition detection system using mobile device motion. More specifically, we analyse two factors – moving average time windows and weighting methods – and show that they have significant effects on place transition detection performance. We first review work related to semantic place recognition with mobile devices, before describing our approach to place transition detection with mobile device motion. We then outline the design of a hybrid laboratory/field study that captures users' natural transitions between places in addition to high-precision ground truth, before reporting the results of our analysis.

## 2. BACKGROUND AND RELATED WORK

In this section we provide some background to mobile semantic place recognition and contrast our contribution against relevant work in the field. The problem of semantic place recognition has received attention from researchers in recent years due to the ubiquity of mobile devices that can enable recognition in the field. There are generally two approaches to recognition: geometric-based, where spatial coordinates are used for clustering into places; and fingerprint-based, where the signatures of signals in the environment are used to identify place 'zones'.

Notable geometric-based systems include: Askbrook and Starner's GPS-based work [1], which clusters GPS coordinates *post hoc* to learn users' significant locations; Kang *et al.* [7], who use a time-based approach to cluster GPS coordinates and extract places in an *ad hoc* manner; and Liao *et*


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