Utilizing Wireless Positioning as a Tracking Data Source

Spiros Athanasiou[1], Panos Georgantas[2], George Gerakakis[2], and Dieter Pfoser[1]

[1] Institute for the Management of Information Systems
"Athena" Research Center
G. Mpakou 17, 11524Athens, Greece
{spathan,pfoser}@imis.athena-innovation.gr
[2] School of Electrical and Computer Engineering
National Technical University of Athens
Greece, 15780
{pgeor,ggera}@dblab.ece.ntua.gr

Abstract. Tracking data has become a valuable resource for establishing speed profiles for road networks, i.e., travel-time maps. While methods to derive travel time maps from GPS tracking data sources, such as floating car data (FCD), are available, the critical aspect in this process is to obtain amounts of data that fully cover all geographic areas of interest. In this work, we introduce Wireless Positioning Systems (WPS) based on 802.11 networks (WiFi), as an additional technology to extend the number of available tracking data sources. Featuring increased ubiquity but lower accuracy than GPS, this technology has the potential to produce travel time maps comparable to GPS data sources. Specifically, we adapt and apply readily available algorithms for (a) WPS (centroid and fingerprinting) to derive position estimates, and (b) map matching to derive travel times. Further, we introduce map matching as a means to improve WPS accuracy. We present an extensive experimental evaluation on real data comparing our approach to GPS-based techniques. We demonstrate that the exploitation of WPS tracking data sources is feasible with existing tools and techniques.

Keywords: wireless positioning, map matching, tracking, FCD.

1 Introduction

Incorporating travel times into road network information, i.e., travel time maps, is an important prerequisite for a large number of spatiotemporal tasks. Examples include shortest path computation, traffic avoidance, emergency response, etc. Solutions typically rely on collected floating car data (FCD) that sample the overall traffic conditions [16, 5] in a given region. FCD capture temporal variations in achievable vehicle speeds throughout the road network. For example, speeds during the rush-hour are considerably lower than during night traffic. Then, in a post-processing step termed map-matching [4, 19], tracking data is accurately related to the road network and travel times are extracted. It is critical that *large amounts* of FCD are available for long periods of time and geography, so that the extracted speed profiles are accurate. Currently, all methods use GPS for tracking the position of vehicles.

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1.1 The Case for GPS vs. WPS

While GPS is the most popular positioning technique, it has several drawbacks. First, it requires the use of specific hardware limiting the number of vehicles or users that can collect and provide tracking data. Second, there are occasions where GPS is inadequate (e.g., limited coverage, interference of high frequency electronic equipment). This is especially true for “urban canyons”, i.e., areas in urban environments where line-of-sight with the GPS satellites is obscured, leading to inaccurate readings or no coverage at all. As demonstrated by LaMarca et al. [11], the average availability of GPS in an urban environment is only 4.5% during a user’s daily schedule. In contrast, wireless networks, such as WiFi and GSM, are available on average 94.5% and 99.6% respectively. Third, the addition of extra integrated or autonomous GPS modules lead to increased power consumption, and thus limit the user’s mobility or application of GPS.

These drawbacks of GPS have led to the rise of Wireless Positioning Systems (WPS), where the user location is estimated with the help of other, readily available wireless networks. As a technology, WPS delivers less accurate results (e.g., ~40m for WiFi/outdoors), but provides greater coverage characteristics (e.g., above 90% of a user’s time). Further, WPS can be integrated in practically any computing device that incorporates a wireless network interface, and with a negligible burden on the interface’s power consumption. So while WPS is less accurate than GPS, for typical everyday applications it can efficiently augment or even replace GPS.

Lately, WPS capable devices and applications are becoming a common place for end users, with examples like the iPhone, Android, Google Gears, Mozilla Firefox 3.1, etc. In addition, the integration of WPS in GPS and WiFi chipsets (e.g., SiRF, Broadcom, Texas Instruments) will result in a state where practically all mobile devices will have WPS capabilities. This argument is a fact, rather than a prediction, with great implications on spatiotemporal data management in general. In combination with the emerging usage of geolocation Web APIs (e.g., W3C Geolocation) we anticipate that in the near future there will be an abundance of readily available WPS positioning data.

Consequently, the technical advance of WPS is leading to new challenges and potential gains for numerous applications, where the scale and amount of positioning data will require corresponding advances in algorithmic solutions. Further, repurposing this sort of data by accommodating their particularities (e.g., varying levels of accuracy, ubiquitous coverage, etc.) in order to extract hidden knowledge, will be another area of great interest.

Our work is therefore extremely relevant in this newly established context, and applied to the specific issue of creating travel time maps. Currently, the creation of travel time maps from actual travel data is based solely on FCD. While this guarantees the use of position readings of high accuracy, it also limits the availability of such data for extended periods of time and geography. However, by successfully exploiting WPS, we would have access to data (a) whose size is several orders of magnitude greater, (b) temporally span bigger periods, and (c) extend to larger geographic areas. One could argue that WPS is only feasible in urban areas. While this observation is true, it actually strengthens our argument; urban areas are *exactly* where travel time maps are valuable resources for routing solutions.