

Chapter 81

Privacy–Preserving Spatial Trajectory Prediction Based on a Novel Matrix Representation

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ABSTRACT

Since the introduction of iPhone in 2007, smartphones have become very popular (e.g., the number of worldwide smartphone sales has surpassed the number of PC sales in 2011). The feature of high mobility and small size of smartphones has created many applications that are not possible or inconvenient for PCs and servers, even laptops. Location-based services (LBS), one of mobile applications, have attracted a great attention recently. This research proposes a location-based service, which predicts a spatial trajectory based on the current and previous trajectories by using a novel matrix representation. Spatial trajectory prediction can be used in a variety of purposes such as travel recommendations and traffic control and planning, but at the same time, just like most location-based services, the user privacy concern is a major issue. Without rigorous privacy protection, users would be reluctant to use the service. The proposed method is simple but effective and user privacy is rigorously preserved at the same time because the trajectory prediction is performed at the user-side. Additionally, this research is not only useful but also pedagogical because it involves a variety of topics like (i) mobile computing, (ii) mobile security, and (iii) human behavior recognition.

1. INTRODUCTION

Spatial trajectory prediction is a popular and useful location-based service. It can be applied to a variety of subjects such as traffic control and planning and travel recommendations. This research proposes a novel trajectory prediction based on the previous trajectories because human travel patterns normally have an inertia feature, e.g., people are attracted by interesting locations or landmarks such as parks

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and malls. The proposed method is simple and effective by using an innovative matrix representation. Trajectory processing then becomes matrix processing, which is well documented and includes plenty of tools and software. At the same time, user privacy is rigorously preserved because the simplicity of the proposed method allows the prediction to be carried out on the client, instead of the server. This section introduces the importance of the location-based services, the problems the trajectory prediction faces, the objectives and concerns of this research, the proposed method, and the organization of this article.

1. **Location-Based Service (LBS) Forecasts:** The worldwide PC and mobile phone sales are given in the Table 1 according to various market research reports (BNET, 2004; Canalys, 2007 & 2010; CNET, 2006a & 2006b; Gartner, 2005-2014; GsmServer, 2004; IDC, 2008). The number of smart-phones shipped worldwide has passed the number of PCs and servers shipped in 2011 and the gap between them is expected to keep bigger. The emerging smartphones have created many kinds of applications that are not possible or inconvenient for PCs and servers, even notebooks. One of the best-seller applications is location-based services according to the following market research:
 - a. Fleishman Hillard (2012) reports 80% of smartphone owners have location-based services and half of them use services that provide offers, promotions, and sales based on their current locations.
 - b. The most convenient mobile shopping experience is price comparison and product research according to JiWire (2011, October 14).
 - c. The number of location-based services users was increased from 12.3 million in 2009 to 33.2 million in 2010 (170% increase) in the US based on SNL Kagan (Cohen, 2011, January 20).

This research proposes a kind of location-based research, privacy-preserving spatial trajectory prediction. It is a multi-theme research topic. Three of the themes are spatial trajectory prediction, user privacy

Table 1. Worldwide PC and cellphone sales

Year	Number of Units Shipped (Million)				
	Mobile Phones	PCs and Servers	Smartphones	PDAs (Without Phone Capability)	Tablet PCs
2002	432	148	—	12.1	—
2003	520	169	—	11.5	—
2004	713	189	—	12.5	—
2005	813	209	—	14.9	—
2006	991	239	64	17.7	—
2007	1153	271	122	—	—
2008	1220	302	139	—	—
2009	1221	306	166	—	1
2010	1609	346	286	—	17
2011	1775	353	486	—	73
2012	1746	352	698	—	128
2013	1806	296	968	—	195

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