A Novel Correction Method for Location Fingerprinting

Tomáš Staník*
Department of Computers and Informatics
Faculty of Electrical Engineering and Informatics
Technical University of Košice
Letná 9, 042 00 Košice, Slovakia
tomas.stanik@student.tuke.sk

Abstract

This paper deals with the issues of indoor positioning and is based on the author's previous work [4]. It defines the basic concepts of location fingerprinting and points out different algorithms that are available. It further focuses on a correction method to refine the positioning estimates. It evaluates the method and the results acquired by experimental verification in different environments. In conclusion it describes the potential of accurate indoor positioning systems and the problems to be solved before such solutions can be used in practice.

Categories and Subject Descriptors

G.3 [**Probability and Statistics**]: Probabilistic Algorithms; J.m [**Computer Applications**]: Miscellaneous

Keywords

Location Fingerprinting, Correction Method, kNN

1. Introduction

The importance of estimating the current position of people and objects in real time is crutial for many applications. While the Global Positioning System (GPS) solved the problem on a global scale, it is still unable to determine the position inside buildings. Therefore the research is nowadays focused on ways to determine the position indoors, using various modern technologies.

The goal of this paper is to outline the benefits of location fingerprinting and to evaluate the research of the proposed method that aims to refine the results of the basic positioning algorithms.

*Master study programme in field Informatics. Supervisor: Assoc. Prof. Jaroslav Porubän, Department of Computers and Informatics, Faculty of Electrical Engineering and Informatics, Technical University of Košice.

Staník, T. A Novel Correction Method for Location Fingerprinting. Information Sciences and Technologies Bulletin of the ACM Slovakia, Special Section on the ACM Student Project of the Year 2012 Competition, Vol. 4, No. 4 (2012) 57-58

2. Location Fingerprinting

Indoor positioning systems estimate the position of objects using either a geometric method, proximity sensing, scene analysis, or location fingerprinting. Location fingerprinting is done by observing the existing infrastructure of wireless Access Points (AP) and then comparing the current and the previous observations, assuming a sufficient existing WLAN infrastructure. The main problem of such systems is lower accuracy compared to systems with custom beacons. To compensate for the deficiency, many refining methods have been proposed [3, 1]. The method described in the following section is using the results of a given positioning algorithm and can be thus reused with any algorithm that produces discrete estimates.

3. Correction Method

In location fingerprinting, a fingerprint is a vector of Received Signal Strength (RSS) values of ambient APs at a distinct place. The database of fingerprints is built during the training phase and the positioning is done during the estimation phase. Different algorithms are suitable for different situations, including k-Nearest Neighbors (kNN), Support Vector Machine (SVM), Smallest M-vertex Polygon (SMP), Bayesian Modeling (BAY), probability computation and neural networks. The proposed correction method is a universal filter for location fingerprinting that can be deployed in conjunction with any of the positioning algorithms. It filters the estimates in real time using a custom classification algorithm and refines the results by predicting the following position.

3.1 Classification Algorithm

The classification algorithm was designed to mitigate the undesirable deflections in RSS. Inaccurate estimations can be caused by as little as opening and closing of doors and are more apparent in environments with only a small number of APs. To improve the results, the classification algorithm divides the estimates into two classes: raw history contains all estimates, and fine history contains only estimates that are evaluated as fine, meaning that the current position could be reached from the previous position in time, moving at a reasonable speed. Another case for evaluating the estimate as fine is when the raw history contains a sequence of mutually achievable positions. For detailed information about the classficiation algorithm please refer to the original paper [4].

3.2 Delay Reduction Algorithm

The next step is the prediction of the following position, which uses the fine estimates to reduce the delay of real-time computations. The delay reduction algorithm estimates the next position only when the fine history is consistent with the raw history. The distance from the following position at time $t{+}t_p$ is computed as:

$$d = v_a \times t_p \times \frac{F}{F_{max}} \tag{1}$$

where v_a is the current movement speed, t_p is the time needed to compute the last position, F is the actual and F_{max} the maximum number of estimates in the fine history. The last step in the correction method is to predict the position based on the current position, computed distance and a compass sensor.

4. Testing and Evaluation

Because there is no reliable way of simulating the real world deployment of wireless APs, the most interesting part of the research was to verify the benefits of the correction method in practice. For this purpose, a mobile application for Google Android was implemented.

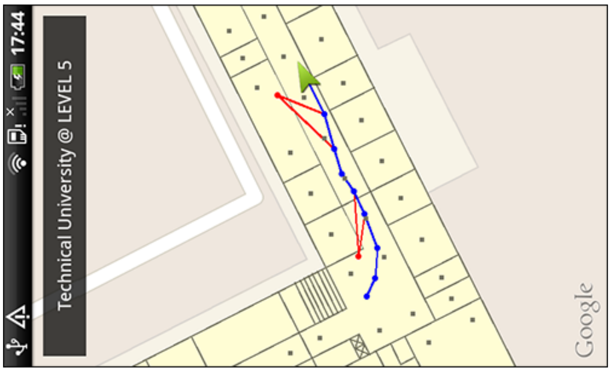

Figure 1: Mobile application for testing.

The screenshot above shows a person moving through the environment; the blue trace represents the fine estimates, while the red trace represents the raw estimates (also behind the blue trace). Current implementation is based on the kNN algorithm. Three configurations were used during the experiment - using the raw estimates of the positioning algorithm (A), using the classification algorithm (B) and using the delay reduction algorithm as well.

4.1 Fixed Position

The purpose of the first test was to evaluate the improvement in accuracy without moving through the environment. The following table shows the results for 20 measurements at 10 different locations.

Table 1: Fixed position estimates

	Error (m)			Accuracy (m)			
	MIN	MAX	AVG	80%	85%	90%	95%
A	0.79	30.91	4.60	5.11	7.10	8.60	18.95
B	0.58	12.17	3.52	4.33	5.74	8.44	9.93
C	0.23	9.97	3.23	3.88	4.15	5.06	8.03

4.2 Single Floor Movement

This experiement was done by moving through the environment, but only within one floor, recording 9 values for every iteration. 10 measurements were done for each of the configurations.

Table 2: Single floor movement estimates

	Error (m)			Precision (m)			
	MIN	MAX	Ø	80%	85%	90%	95%
A	1.05	26.20	6.14	9.25	10.22	14.30	17.88
B	0.07	20.28	4.29	6.95	7.95	8.27	9.07
C	0.31	30.65	5.62	8.19	8.96	12.20	14.25

4.3 Floor Estimation

The objective of the last test was to find out whether the classification algorithm (B) can improve the estimation of the correct floor while moving down the stairs. The positioning algorithm itself (red) produced estimates with undesirable deflections over the correction method (blue).

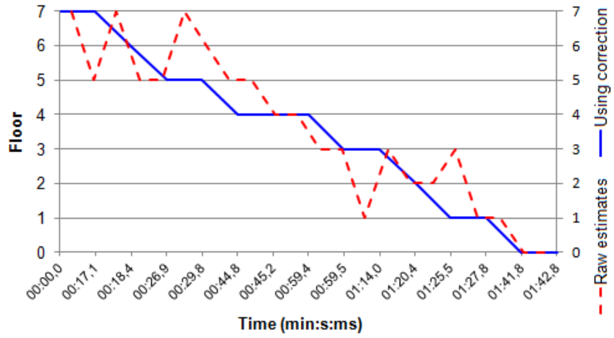

Figure 2: Improvement in floor estimation.

5. Conclusion

The experiment confirmed that the correction method can significantly improve the estimates of the positioning algorithm. The only unexpected outcome was the (C) measurement in 4.2, indicating that the delay reduction algorithm was unable to refine the estimates over configuration (B). The last test provided the most obvious improvement, when the order of floors while moving down the stairs was determined seamlessly in contrast with (A).

However, another problem has yet to be solved to ensure the reliability of location fingerprinting - the training phase has to be automated to ensure the correct data. On the other hand, the current implementation can be useful in certain situations. The modified version of the correction algorithm was used in a mobile application for navigating people through social events [2], where the system needs to be deployed only for a time span of a few days. This use case confirms the great potential of location fingerprinting to provide indoor location-based services.

References

[1] S. Ali-Loytty, T. Perala, V. Honkavirta, and R. Piché. Fingerprint kalman filter in indoor positioning applications. In *IEEE Multiconference on Systems and Control*, pages 1678–1683, St. Petersburg, RU, October 2010.

[2] M. Bačíkova, D. Lakatoš, J. Porubän, M. Pristáš, T. Staník, M. Šuščák, and M. Tomáš. Access one: Accessibility event guide. In *13th International Conference on Computers Helping People With Special Needs*, Linz, Austria, 2012.

[3] C. Laoudias, M. P. Michaelides, and C. G. Panayiotou. Fault detection and mitigation in wlan rss fingerprint-based positioning. In *International Conference on Indoor Positioning and Indoor Navigation*, pages 1–7, Guimaraes, PT, November 2011.

[4] T. Staník and J. Porubän. *Methods and Technologies for the Approximate Positioning Inside Buildings*. Technical University of Košice, 2012.