Speed-Adaptive Location Estimation Approach in a Wireless LAN-based RTLS System

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Recently, there is increasing interest in accurate location finding techniques and location-based applications for indoor and local areas. Wireless LAN technology based on the IEEE 802.11b or Wi-Fi standard is in the middle of such interest especially in terms of enterprise applications, because wireless LAN infrastructure has already been deployed widely for data and voice communications.

In the wireless LAN-based real-time locating system (RTLS), ensuring the positioning accuracy is one of the crucial issues. To provide high positioning accuracy, many researchers have paid their attentions to the triangulation or fingerprinting approaches. It is reported in many literature that the triangulation and the fingerprinting can provide at least 3-meter and 1-meter accuracy, respectively, with 90% probability [1]. However, this high positioning accuracy is meaningful only for stopped mobile devices, not for moving ones.

In order to guarantee high positioning accuracy for moving mobile devices, we can simply increase the sampling rate of location information. However, increasing the sampling rate causes two significant problems: high power consumption due to frequent data transmission and performance degradation of data communications due to high traffic congestion.

To circumvent these adverse effects, we propose a speed-adaptive location estimation method in this paper. In this method, location estimation of mobile devices is made based on both location information transmitted from mobile devices as well as moving speed estimated by the proposed algorithm.

In the proposed algorithm, we can calculate the moving speed using the Euclidean distance and the observation interval. For this calculation, we assume that a mobile device carries out a rectilinear movement during the observation interval. This assumption is admissible because the movement distance is very short in practice.

If the mobile device is considered to move faster than a certain speed (e.g., 0.5 m/sec) after speed estimation, then the algorithm requests the mobile device to increase the location information sampling rate. If the algorithm notices that the mobile device stopped or is moving at a lower speed than a threshold, then it requests the mobile device to return its sampling rate back to default rate to prevent unnecessary power consumption.

To show that the proposed algorithm provides better location estimation accuracy than the conventional methods, which are based on arithmetic mean and median, we performed experiments as follows: The default sampling rate was set to be 4 samples/sec. When a mobile device was considered to move faster than 0.5 m/sec, we increased the sampling rate to 8 samples/sec.

In Table 1 and Fig. 1, we show that the proposed algorithm provided better estimation accuracy by 1.5 meter or more. Battery power was saved by up to about 60% (not shown here) depending on mobility of the device and power consumption specifications.

Table 1. Estimation error distribution and average estimation error for three estimation methods

Error	Proposed	Mean	Median
1 m	11 %	3 %	3 %
2 m	16 %	8 %	7 %
3 m	25 %	10 %	9 %
4 m	27 %	17 %	16 %
5 m	15 %	19 %	20 %
6 m	5 %	18 %	22 %
7 m	1 %	11 %	17 %
8 m	0 %	7 %	5 %
9 m	0 %	3 %	1 %
10m	0 %	0 %	0 %
Avg.	3.38 m	4.80 m	5.07 m

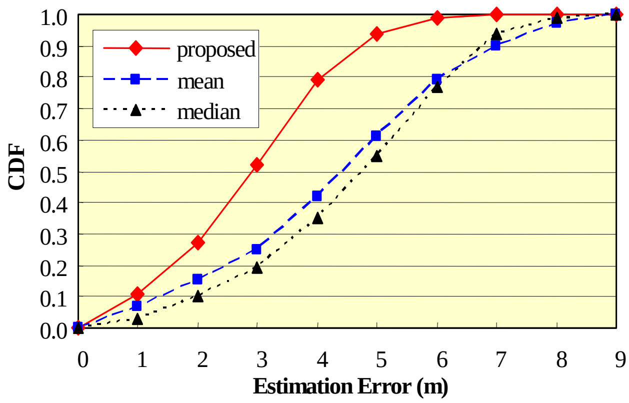

Fig. 1 Cumulative distribution function (CDF) of the estimation errors for three estimation methods

References

1. Hakyong Kim, Telecommunications Review, vol. 16, no. 2, pp. 188-202 (2006)