An RFID-Based Positioning System for Ad-Hoc Networks

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SYSTEM OVERVIEW

Existing positioning technologies such as GPS and other GNSS are not available when the terminal cannot get the signal from the satellites, especially in urban canyons and indoors. To enhance the service availability of the positioning systems, the usage of RFID tags as location markers is discussed and a national project called *"RFID-based Positioning Systems for Enhancing Safety and Sense of Security"* is conducted by our group at the University of Tokyo and other national institutes such as Geographical Survey Institute. As part of this project, we are now studying an innovative system to modify the position of the terminals based on the information from the RFID's and to enlarge the service area by using ad-hoc network.

A brief sketch of the mechanism is as follows. We assume that pedestrians carry a terminal with an RFID reader, sensors for dead reckoning and also with the capability of IEEE 802.11 (see Fig. 1). Once a terminal passes by an RFID, it receives the current position from an RFID, which is relatively accurate. As it goes out of the communication range of the RFID, which is, say, 10cm to 5m, it estimates its position by dead reckoning. Therefore, as pedestrians move and time passes by, the positioning error increases even with the dead reckoning. However, if the nearby terminals have the capability of exchanging each other, this error can be mitigated by modifying its position considering the position information and the estimated error of other near-by terminals (see Fig. 2). For example, if a terminal gets the position of a very near terminal, we can modify their position by averaging the positions of the two terminals. More sophisticated algorithm as used in the localization of sensor networks, where the position of the nodes are fixed, might work, but since the nodes have mobility and the density of them is rather low in our system, we have developed a new localization algorithm which works well in this condition. A rudimentary testbed system has already been set up using 18 terminals as shown in Fig. 3.

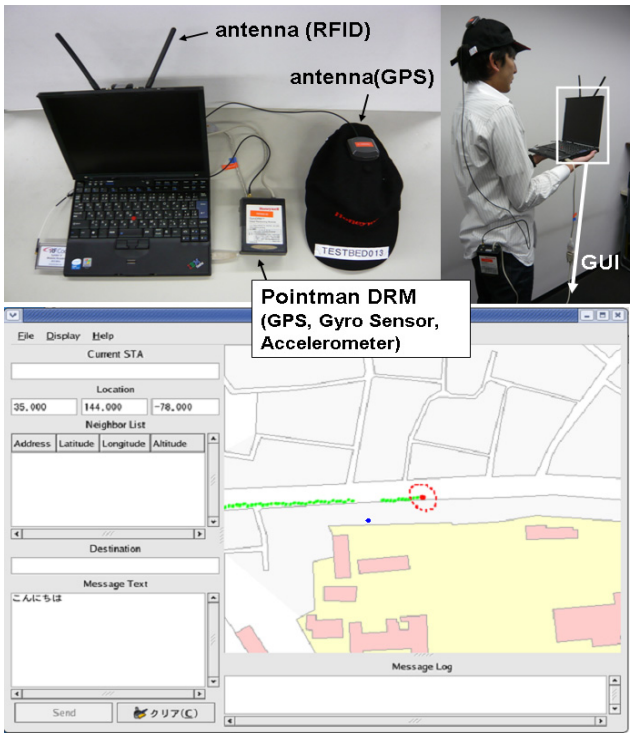
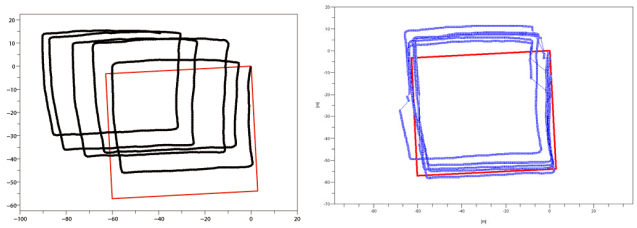


Fig.1 Brief sketch of the implemented system. We can utilize GPS where it is available. Otherwise, we use only the information from RFID, gyro sensor, accelerometer and location information (with estimated error) of neighbor person who is in the range of wireless receiver/transmitter.

Since the terminals exchange their location by wireless link, the terminals comprise ad-hoc network. Furthermore, since the terminals know their own positions, we can use them for the routing and application services, especially for Location Based Services. We have modified GPSR, which is a conventional point to point geographical routing algorithm, and developed a new geocast algorithm. We are planning to geocast alert and other information that enhance the security of the specific geographical area.



(a) (b)

Fig. 2 Visualization of the localization algorithm. The red rectangle shows a pedestrian's real trajectory. The black/blue lines show her estimated trajectories. The estimation error gradually increases when a pedestrian uses a DRM device only (a). Our system can reduce the error by using RFID reference points as well as proximity-based location information sharing. In (b), two pedestrians walked around the rectangular area, periodically exchanging location information to reduce the error.

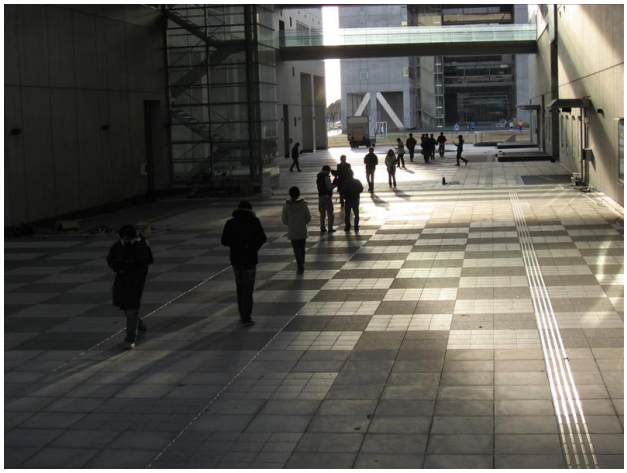


Fig. 3 Eighteen pedestrians using the rudimentary testbed. Each of them walked around in this space carrying the pedestrian terminal to capture location information from wireless reference points as well as other pedestrians' devices.

DEMONSTRATION

The Goals of the Demo

The goals of the demo are two folded. The first one is to show the capability and effectiveness of our localization algorithm that use RFID's as location marker and dead reckoning modules. The second one is to prove that our geocast algorithm works well on a real system where terminals get their position using the localization algorithm.

Space Needed

One small booth as 2m x 2m to display a system is necessary. We are planning to let the participants bring terminals and to let them really experience our system, it is desirable that they can walk along rather larger area, say, the entire conference site. Further, RFID's have to be deployed and embedded in the exhibition area. The number of embedded RFID's might be two to ten.

Setup Time Required

We have to give the RFID's their own position. It will take a whole day. If the exhibition map including the possible locations where RFID's are embedded is available in advance, it will help us very much. In this case, the setup time should be shortened to 3 hours or so.

Facilities Needed

Wired Internet connection for up to 3 computers including the Ether cables for them is necessary. Wireless LAN is OK but since it might interfere with our system (and other ad hoc networks), it should be avoided if possible. Ten outlets are necessary to charge the terminals and dead reckoning modules. The outlet type should be that of Japan. If you cannot provide this type, let us know the available type of outlet shape in advance.

Additional Information

Brief sketch of out project is included in "Urban Computing and Mobile Devices", IEEE Distributed Systems Online, vol. 8, no. 7, 2007:

http://dsonline.computer.org/portal/site/dsonline/menuitem.9ed3d9924aeb0dcd82ccc6716bbe36ec/index.jsp?&pName=dso_level1&path=dsonline/2007/07&file=o7002wip.xml&xsl=article.xsl&

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