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Uncontacted Indoor Localization using RFID

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Abstract People or objects localization based on radio frequency identification (RFID) technology has promising potentials. However, the existing applications of RFID localization are always required to attach the tags to objects or human bodies. In this paper, we propose a novel method for indoor human localization without carrying tags. Our implementation and experiment show that the proposed scheme has high accuracy and efficiency.

I. Introduction

With the popularity of indoor location sensing systems, RFID has gained widespread attentions and offers substantial advantages for indoor localization. A typical RFID system consists of tags, antennas and readers. The tags are made up of a microchip with an antenna. The reader sends out electromagnetic signals via antennas. The tag antenna is tuned to receive these signals. A passive RFID tag draws power from field created by the reader and uses it to power the microchip's circuits. The chip then modulates the signals that the tag sends back to the reader and the reader converts the new signals into digital data.

Human localization, i.e., finding the locations of family members in house, is important and provides the most fundamental information about living activity. Most of existing work for human localization requires that the target person should carry an RFID tag [1]. For example, an RFID tag can be attached on clothes, so that we can find the human location by localizing the RFID tag. However, this approach suffers from two weaknesses. First, the monitoring area is small because the signal issued by an RFID reader is directional. Localization fails if the tag is out of the signal region of RFID reader [2], [5]. Second, it is difficult or impossible to impose a tag on a person in some scenarios (e.g., showering). In our research, we propose to design an RFID-based uncontacted sensing system for indoor human localization. In our system, RFID tags and readers are deployed in house and users do not need to wear any special devices.

The reminder of the paper is structured as follows. Section II introduces the system model and describes the localization algorithm. Section III shows the experiments evaluation results. Finally, section IV concludes this work.

II. System Design

Given a single person moving in the target indoor environment, our objective is to find his/her locations in real time. As shown in Fig. 1, we deploy RFID tags on the floor and RFID antennas on the ceiling in a room. All antennas are connected to an RFID reader. We can read the RFID signal strength and phase from a computer that connects to the RFID reader. When a person walks into the room, he/she will affect the signal dissemination between tags and antennas. By analyzing the RSSI (received signal strength identification) and signal phase, we can identify human locations with high accuracy. Specifically, we design a human localization algorithm based on machine learning techniques. The whole algorithm contains two stages. The first one is an initialization stage that we collect some sample data (RSSI and signal phases) and use them to train a model. To collect data, we let a person stand in different room locations and measure the corresponding RSSIs and signal phases from all tags. In addition, we also obtain the RSSI and signal phases when nobody is in the room. The second stage is a working stage. As shown in Fig. 2, we continuously read RSSIs and signal phases from all tags and store them into a buffer. The localization algorithm outputs human locations by comparing the incoming data in the buffer with the model we construct using historical data. Meantime, the data in the buffer are stored into a database. Our training algorithm will periodically retrain the model using the updated data in the database.

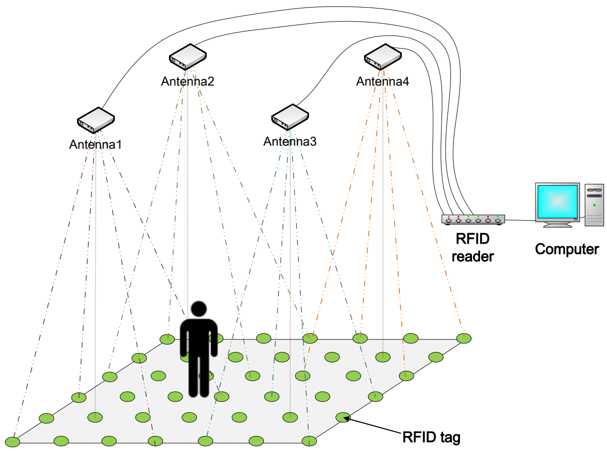


Figure 1: System design

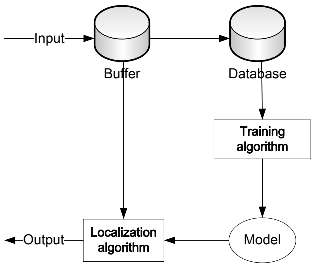


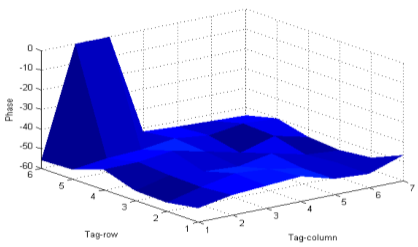
Figure 2: Main system module

Although many machine learning algorithms can be applied, we choose the k-Nearest Neighbors (k-NN) algorithm because of its high speed and simplicity [3]. Specifically, we organize the sample data into the forms of (X1, Y1), (X2, Y2), … , (Xn, Yn), where Xi is a vector of RSSI or signal phases from all tags, and Yi is the class label indicating human location. When a new vector Xj arrives, we calculate a distance metric (e.g., Euclidean distance) with each neighbor and then identify a location by a majority voting among K nearest neighbors. If K=1, then the case is simply assigned to the class of its nearest neighbor.

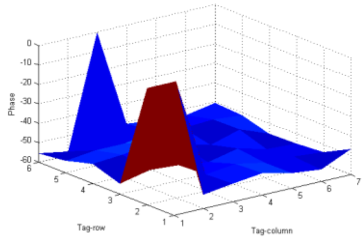
III. Performance Evaluation

We deploy our RFID system in an experiment room of 10.5 square meters. As shown in Fig. 3, the floor is divided into a grid of 42 cells, each of which is 0.25 square meters. A passive RFID tag is put at the center of each cell [4]. There are 4 RFID antennas (YAP-101CP) on the roof and they are connected to the same RFID reader (Speedway Revolution Japan) via dedicated cables. We use a LAN cable to connect the RFID reader with a computer of Intel Core i7-4770 CPU and 8GB memory.

To show the feasibility of our proposed method, we plot signal phases of all RFID tags when nobody in the room, as shown in Fig. 4(a). Almost all tags have similar phase values except two in the margin. When a person walks into the room, the corresponding signal phase values are illustrated in Fig. 4(b). We can easily observe that a new pick emerges at the location where the person stands.



(a) Nobody is in the room.



(b) A person is in the room.

Figure 4: Signal phases of all RFID tags

Figure 3: Experimental environment.

IV. Conclusion

We propose a novel method to localize person without carrying RFID tags and get high accuracy. Future work includes achieving the person identification and tracking people movements.

Acknowledgments

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