Investigation of Indoor Location Sensing via RFID Reader Network Utilizing Grid Covering Algorithm

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Abstract One of the biggest challenges in RFID (radio frequency identification) large scale deployment, such as in warehouse RFID deployment, is the positioning of RFID reader antennas to efficiently locate all the tagged objects distributed at RFID reader environment. This paper has investigated a novel location sensing system based on geometric grid covering algorithm that can use any passive or active RFID standard for positioning or tracking objects inside buildings. This study involves design of RFID reader antenna network which focuses on placing the reader antennas on a grid to cover all the tags distributed at two dimensional planes and position calculation using statistical averages algorithm. The statistical averages algorithm simply computes the location coordinates of the tagged object by statistical average of the reader antenna’s location. The proposed grid of reader antennas can assist in minimizing the actual number of reader antennas required for RFID large scale deployment. The proposed prototype system is a simpler positioning system which presents the solution of placement pattern of RFID reader antennas, gives less complicated mathematical calculation, and is able to provide a high degree of accuracy. The obtained results show that the proposed location sensing system can achieve better positioning accuracy as compared to existing positioning system and in some cases accuracy improvement of about 50% can be reached.

Keywords Indoor positioning · Tracking · Location sensing · RFID reader network

1 Introduction

Over the years, there have been many systems and architectures dealing with the problem of automatic location sensing. Triangulation, scene analysis, and proximity are three major techniques for automatic location sensing [1]. Recent research trend have focused on RF (radio...
frequency) technology as a basis for position determination which uses the techniques such as differential time of arrival or signal strength measurements. RADAR [2] is an RF based indoor positioning and tracking system that uses standard 802.11 network adapter. RADAR operates by recording and processing signal strength information at multiple base stations positioned to provide overlapping coverage in the area of interest. It combines empirical measurements with signal propagation modeling to determine user location and thereby enable location-aware services and applications. The major advantages of this system are that it is easy to setup, requires few base stations, and uses the same infrastructure that provides general wireless networking inside buildings. But down side of RADAR system includes poor tracking accuracy in most cases. The 50% error of the RADAR project is around 2.37–2.65 m and its 90% error is around 5.93–5.97 m. In Carnegie Mellon University, client-centric triangulation based remapped interpolated approach (CMU-TMI) is developed as an RF based indoor location sensing system [3]. This implementation is based on signal strength and access point information from the IEEE 802.11b WaveLAN wireless network. CMU-TMI requires less training efforts compared to RADAR system (i.e. training 1/8 of RADAR system) and generates 50% results accurate for 2 m but generates good results for errors greater than 2 m.

The proposed indoor location sensing system in this paper is motivated by RFID (radio frequency identification) technology. RFID is now becoming recognized and visible technology which had penetrated into almost all application fields including supply chain management, toll-payment, libraries, e-passports, shopping, and many other areas as an alternative to barcode based tracking [4]. One of the most important RFID applications is objects tracking and positioning due to its ability of high speed contactless identification in non-line of sight (NLOS) shared medium. Several RFID based positioning technologies have been developed for indoor. To create and analyze a fine-grained indoor location sensing system, a tagging technology known as SpotON [5] is developed using RFID for three dimensional (3D) location sensing based on radio signal strength. The researchers have designed and built hardware that serve as object location tags. SpotON tags use the received radio signal strength information as a sensor measurement for estimating inter-tag distance. However, a complete system has not been made yet. LANDMARC [6] on the other hand is an active RFID calibrated positioning system in which fixed RFID tags are used to serve as reference points. The LANDMARC approach does require signal strength information from each tag to readers, if it is within the detectable range. In this approach, each reader has a pre-determined power level, thus defining a certain range by which it can detect RFID tags. Based on the signal strength received by the RFID reader, the reader reports the power level of the tag detected. LANDMARC performs a preliminary measurement to know which power level corresponds to what distance. The accuracy of this approach is determined by the number of readers required, the placement of these readers, and the power level of each reader. It is seen that 50% error distance of LANDMARC is around 1 m while the maximum error distances are less than 2 m. However, LANDMARC system suffers some problems such as: (i) standardization and (ii) there is no solution of actual placement pattern of readers and reference tags while the size of the area varies. Besides the RFID based positioning technologies discussed above, the most recent research work have been done in probe card management system for throughput improvement via tracking of probe cards [7] and in the field of food technology to create a safer food supply chain in order to provide a full traceability of food products [8].

This paper refers to the development of a grid of reader antennas to cover all the tags distributed at two dimensional planes. There exist various researches based on coverage and connectivity issues in the context of wireless network [9–11]. As opposed to cover a given region, Booth [12] investigates the coverage and continuum percolation properties of the