IteMinder: Finding Items in a Room using Passive RFID Tags and an Autonomous Robot

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ABSTRACT
We propose a novel search technique called IteMinder that helps users find property in a room using passive RFID and an autonomous robot. First, we attach RFID tags to the target items and at typical locations in a room. We also attach an RFID reader and a laser rangefinder to the robot. The robot can move around the entire room automatically while avoiding obstacles using the laser rangefinder. When the robot finds a tagged item, it uploads the tag ID and location information to the database. Users can then browse target items and their locations on a common web browser.

Author Keywords
Search, robot, RFID, property

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces.

General Terms
Design, Human Factor

INTRODUCTION
There are various techniques to help people find items in the real world using RFID tags. These approaches are mainly divided into two groups based on tag types: "active tag" and "passive tag". The active RFID systems have a long communication range and are often integrated with additional sensors (e.g., position detectors). For example, one system employs active RFID tags and ultrasonic position detectors to locate items in a room [3]. However, the active tag method has several problems, such as battery life, size and cost. Although passive RFID systems [4] have advantages in these regards, passive systems require users to carry around RFID readers to find items because of the short communication range. To solve these problems, we propose a novel search technique called IteMinder that helps users find tagged items in a room using an autonomous robot.

ITEMINDER
First, we attached RFID tags to target items (e.g., keys, wallets, and other property) and typical locations in a room.

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In this paper, we refer to a tag attached to an item as an "item tag", and a tag attached somewhere in the room as a "location tag" for simplicity. Next, we attached a RFID reader, a laser rangefinder, and a small PC on a robot with 4 wheels. The robot can move around the entire room automatically while avoiding obstacles using the laser rangefinder. When the robot finds a tagged item, it uploads the tag ID and location information to the database. Users can browse this information (target items and their locations) using a common web browser. IteMinder basically consists of (1) a logging system to record the locations of the target items using an autonomous robot, and (2) a browsing system to help users check the location of the items with a common web browser (Fig. 1).

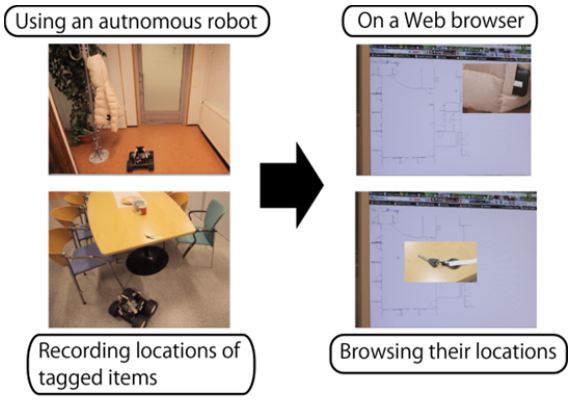

Figure 1. The basic concepts of IteMinder

LOGGING SYSTEM
The logging system mainly consists of a robot with 4 wheels (WiFiBoT), a laser rangefinder (Hokuyo URG-04LX-UG01), a RFID reader (SkyeModul M9), and a host PC attached on the robot (Fig. 2). The RFID reader is connected to a directional antenna with a recognition distance of about 2m maximum.

The operating procedure of the IteMinder is as follows:

1. The system detects the distance to objects around the robot using the laser rangefinder.
2. When the system detects no obstacles in front of the robot, the robot moves forward for a second. Otherwise,

the robot turns around to identify a safe direction.

3. The system then tries to find location tags using the RFID reader.

4. When the system finds a location tag, the robot starts rotating in 45 degree increments in an attempt to find item tags using the reader.
5. When the system finds an item tag, it automatically uploads the item ID, location information (location ID and relative direction), and timestamp to an online database.

Thus, our system can collect the position of tagged items in a room automatically without any additional effort by the user.

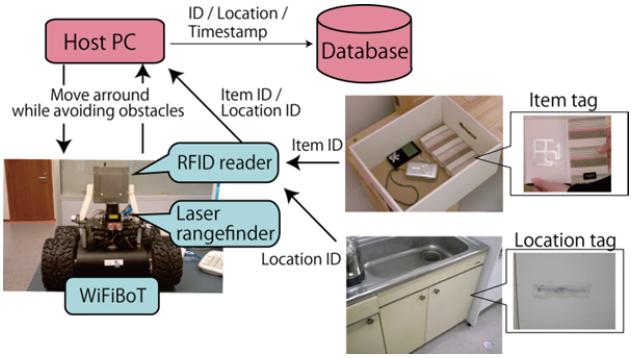

Figure 2. The system architecture of IteMinder

BROWSING SYSTEM

We developed a simple browsing system that enables users to browse target items and their current locations in the room through a common web browser (Fig. 3). When a user selects a target item using a combo box, the system overlaps the item picture on the map based on its location information. Thus, our system helps users find tagged items easily without walking around the room.

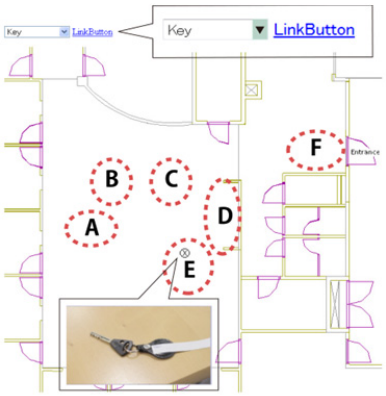

Figure 3. The appearance of browsing system

DISCUSSION

Although we have not performed a formal evaluation yet, we have installed the IteMinder system in our laboratory. We attached six location tags at typical locations in our laboratory – the entrance, kitchen, coffee tables (left/right), a meeting table, and a desk – as shown in Fig. 3. We also attached item tags on valuable items such as keys, a mobile phone and a bag.

First, we discuss the basic performance of the robot. In most cases, the robot can move around the room automatically while avoiding obstacles (e.g., desks, walls, and human occupants). However, the robot sometimes failed to avoid obstacles due to problems with detection by the laser rangefinder.

Second, we discuss the basic performances of the RFIDs. Since we have used an UHF RFID reader with a long recognition range, the system can detect items in various positions: on a desk, on the floor, or inside a pocket of a coat hung on a hanger. However, as we attached only a small number of location tags in the room, the system sometimes failed to recognize item tags located away from location tags.

RELATED WORKS

There have been several research projects working on the application of RFID tags. Cohn et al. [1] proposed ultra-low-power wireless sensor nodes using coupling over the power line. While this project focused on active RFID tags with ultra-low-power consumption, our approach focused on expanding passive RFID tags by attaching a reader on an autonomous robot. We have proposed a DrawerFinder system [2] that helps users find items in storage boxes using visual markers. We aim to support various search activities in the real world through these projects.

CONCLUSION AND FUTURE WORK

We propose a novel search technique called IteMinder that helps users find property in a room using passive RFID tags and an autonomous robot. We plan to develop a system that helps users register items with RFID tags quickly. Moreover we will install more location tags in a room, improve search algorithms, and perform long-term evaluation for further improvements.

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