Human-Aware Guidance Robot with Wireless Sensor Network and RFID Fusion Navigation

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1. Introduction

There are numerous applications for guidance robots that require relatively high levels of speed and precision. Additionally, for true guidance to be performed, a human-awareness component is also needed. In mobile robot navigation, often times there is a trade-off of movement speed for precision. This research attempts to create a useful and practical guidance system by combining a wireless sensor network with a passive radio frequency identification system for navigation and a vision-based tracking system for human awareness. The sensor network provides general navigation in open areas and the RFID system provides precision navigation near static obstacles. The vision system provides a relative location of the human. By fusing the data from both systems, we are able to provide accurate navigation for a human-aware guidance robot.

2. Related Works

Wireless Sensor Networks (WSN) can be used much like other radio-based navigation systems, [1]. For example, in [2], a virtual potential field was created using the radio signal strength intensities (RSSI). That system also showed how a camera could be used for human aware guidance. Radio Frequency Identification (RFID) technology is often used for localization and navigation tasks. In [3], a navigation method using only a passive RFID was presented.

3. Human-Aware Guidance Navigation

In order for a robot to perform guidance, it requires two components; navigation and human awareness. For the navigation aspect, the robot navigates along a virtual potential field created by the WSN, however this approach suffers from a lack of precision due to the nature of radio waves. The precision is reduced further when the robot is an area occupied by many obstacles or people. To add precision, the RFID system is used in a fusion algorithm to determine how the RFID information can be used to improve the precision of the WSN calculations. The human awareness aspect is provided by a vision system that monitors the relative distance to the human, and feeds this to the fusion algorithm to ensure navigation is completed.

There are two parts to the navigation algorithm; the WSN calculations and RFID tag handling. RFID tags are placed near critical areas, such as doorways and corners. When no tag is read, the system behaves much as in [4], with the angle suggested by each WSN node calculated so large static obstacles are avoided. Node RSSI basically determine how much influence they have on the directional imperative sent to the robot. When a tag is read, its angle is looked up in a database and two angles orthogonal to it are calculated. The angle closest to the directional imperative is chosen. This allows the robot avoid obstacles where precision is required.

4. Experiment and Results

4.1 Experiment Setup

A simple experiment was devised to test the system. Six tables, Fig. 1, are arranged for the robot to pass between, staggered so that it must make sharp turns to avoid a collision. Additionally, the human intentionally makes a mistake after passing the first two tables by continuing forward, to show that the robot will wait for the human before continuing on. The gap between tables is 90cm, a distance not normally feasible when only the WSN is used. 156 RFID tags were laid out in radial strips at the entrance and exit of each set of obstacles and 8 WSN nodes were arranged at each entrance to the obstacles.

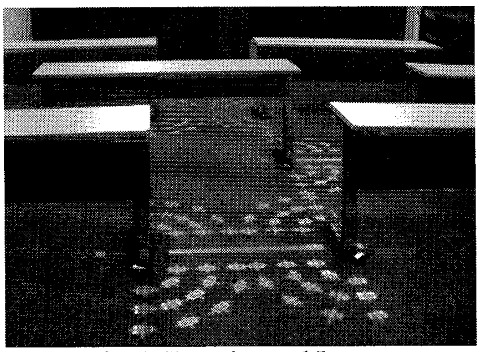

Fig. 1: Experimental Layout

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4.2 Mobile Robot and Hardware

For our experiment we used a robot called Chamuko, Fig. 2, which uses a MobileRobots Pioneer 3-DX differential drive base. It is equipped with sonar sensors, however they are not used. Mounted internally is an RFID reader with an antenna attached underneath the chassis. A base WSN module is mounted on the front bumper and an internal compass is utilized for pose estimation.

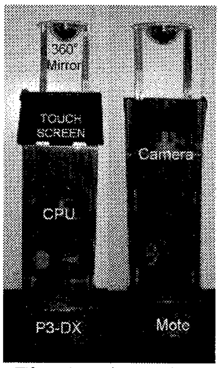

Fig. 2: Chamuko.

For the WSN module we use Crossbow Technology MICAz MPR2400 Mote, which operate in the 2400 MHz to 2483.5 MHz band and utilize the Chipcon CC2420 transceiver and integrated Atmega128L micro-controller. The RFID system_uses a Midrange Reader Module (S6350) by Texas Instruments that has an anti-collision function, making it capable of reading multiple RFID tags simultaneously. We constructed a circular antenna capable of reading RFID tags within 5cm vertically and 10cm horizontally of the antenna center. In consideration of creating a low maintenance, cheap, indoor system, we opted for passive RFID tags, which we placed with an arrangement interval of 15cm on the floor according to the sensing range of the antenna. The omni-vision system consists of an Artray 200MI CMOS camera. It is mounted vertically pointing at a hemispherical mirror, producing an image showing all 360°around the robot.

4.3 Results

We ran our experiments several times, testing both the human following correctly and making a mistake. The robot was able to not only successfully navigate to the goal, but also stopped when the human moved too far away. The path taken in an exemplar run is shown in Fig. 3. The curvy line shows the path the robot took. The humans show where the human is at the start and end, as well as where the human makes the mistake and how far the wander. In response to this, the robot stops and waits, marked by a star. After the human returned to a reasonable distance, the navigation continued until reaching the goal.

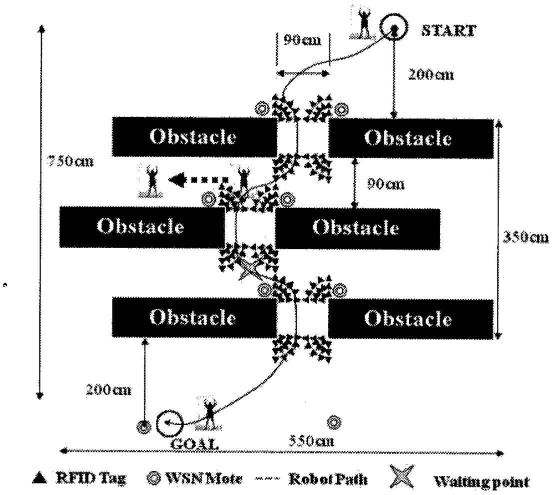

Fig. 3: Example Robot Path.

5. Conclusions and Future Works

In this research we proposed a human-aware guidance system, combining a Wireless Sensor Network and a passive RFID system for navigation and an omni-vision camera for human-awareness. The WSN performs general navigation in open areas and the RFID improves precision near static obstacles. Based on the performance of the system in our tests, the system has shown able to navigate to the goal, as well as detect the human has strayed.

Using this system as a stepping stone, our future plans include dynamic obstacle tracking and an improved vision system to differentiate humans and improve stability.

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