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MONITORING INTERACTIONS WITH RFID TAGGED OBJECTS USING RSSI

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ABSTRACT *--- In recent years, there has been an increasing interest within the robotics community in investigating whether Radio Frequency Identification (RFID) technology can be utilized to solve localization and mapping problems in the context of mobile robots. Passive RFID is an emerging technology allowing identification of devices, called tags, when interrogated by RFID readers. The Ultra High Frequency (UHF) RFID readers with identical emission configuration attached to a mobile robot to identify a reference RFID tag, using UHF readers it is possible to read multiple tags at a time. The particular product number can be entered into the mobile robot from the control room itself using Zigbee. By utilizing the Received Signal Strength Indicator (RSSI) obtained by the readers from the reference RFID tag, the precise position of the mobile robot can be obtained. The obstacle in the moving path of the mobile robot can be detected using obstacle sensors and redirects its path, by indicating an alarm signal. This method can be used in real industry environments such as complex storage warehouses where many different goods are dispersed throughout a wide area.*

Keywords: *Indoor positioning system (IPS), Localization, Mobile robot, Ultra high frequency (UHF) RFID reader*

I. INTRODUCTION

Radio Frequency Identification (RFID) and wireless Radio Frequency (RF) sensors is the conduit between the physical world and the digital world. Radio Frequency Identification technology (RFID) has been used in the past for several applications. RFID can be used where human accessibility is limited or dangerous. RFID is a technology to electronically record the presence of an object using radio signals. RFID is particularly useful where it can be embedded within an object. There have been many studies in which scholars have distinguished a strong signal zone from a weak signal zone of a reader. So that the location of the Tag situated within a reading zone of the reader can be statistically deduced [3], [10]–[18]. In this paper, we propose a method of using already disbursed Tags for the purposes of locating and

tracking a vehicle while overcoming environmental obstacles. Zigbee technology provides a improved performance with higher efficiency. According to Bekkali and Matsumoto [9], reference Tags were pre situated within the reader's reading zone to produce a signal strength mapping of such reference Tags. Next, signal strength obtained from a target Tag was compared to the above map, and any differences were identified as error values.

Thereafter, environmental disturbances were eliminated by using the Kalman filter, resulting in improved accuracy [7], [18], and [19]. The idea of particle filter approach proposed in this paper originated from studies pursued by Vorst *et al.* [5] and Hanhel *et al.* [10]. This method has the advantage of converging to an accurate estimation even when range-only sensors, e.g., Tags, are silent or when there is a lack of initial estimation [20]. However, this method is dependent on how accurately the vehicle's position that equates to the Tag's RSSI can be estimated. Furthermore, if the Tag's RSSIs are distorted due to environmental obstacles, the accuracy declines [5].The Proposed System improves overall efficiency and reduces manpower in warehouse.

II. PROPOSED SYSTEM

The proposed system is based on wireless technology with obstacle detection sensors. This can be possible using line following robot and PIC is shown in Fig 2.1. RFID tags are attached to an each product with its unique identification number, RFID readers are attached to the mobile robot. Passive RFID tags are an increasingly popular sensor that consists of a battery less transponder coupled to an IC chip. An external reader emits a low-power radio signal through its antenna to the passive tag. Upon receiving this signal via its own antenna, the IC in the RFID tag extracts the necessary power energize an IC and then reflect back a modulated signal that carries some information, typically a globally unique tag ID. The reader then provides the list of sensed IDs back to the host application. In this proposed system to enter a product number, laptop is replaced from the mobile robot and uses Zigbee technology. By using this, it is possible to enter the number from control room itself.

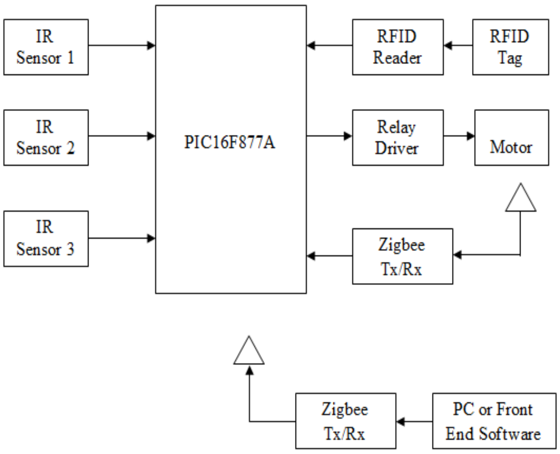

Fig 2.1: Proposed Block Diagram

Using Received Signal Strength Indicator mechanism RFID reader can read the tags. Obstacles can be detected using IR sensors. Relay driver is used to make the system cost effective and provides high load capacity. On the software front, the coding can be improved through improved compiler techniques.

2.1 IC Tag

The lower-cost tags generally are passive (meaning they have no internal power source), have limited data storage capacity (typically 32 to 128 bits), are read-only (not rewritable), and have restricted scan vary. RFID tags can either be active or passive, depending on their source of power. Active RFID tags are characterized by having their own internal power source, in general a battery is shown in Fig 2.2. Unlike passive RFID tags, which must be within the radio frequency (RF) field of an RFID reader to get the needed transmission power, battery-powered tags can transmit from outside the RF field, and hence at a much greater range.

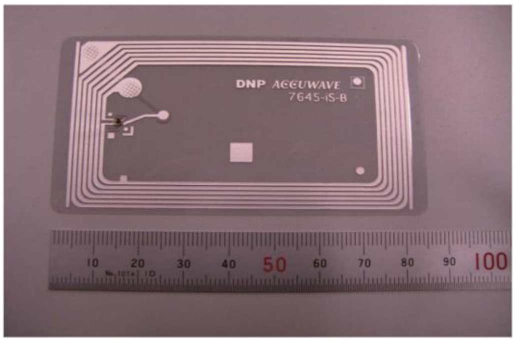

Fig 2.2: IC Tag

Active RFID tag systems are commonly used within logistics, transportation and supply chain management. These systems have initially been based on vendor specific solutions, where proprietary receiver units are used in the infrastructure.

2.2 Data Transfer

Reader reads the data from tag by producing electromagnetic signals. Fig 2.3 shows the Data transfer takes place between the reader and tag.

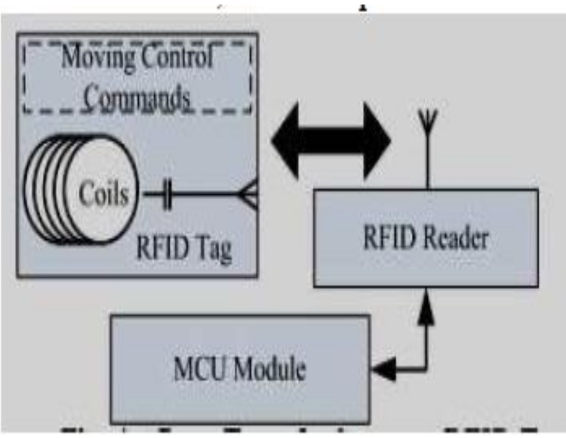

Fig 2.3: Data Transfer between RFID Reader and Tag

RSSI signal level is entirely based on the average received signal, decreasing logarithmically with distance and log-normal shadowing.

III. POSITION ESTIMATION OF A MOBILE ROBOT

In order to estimate the robot position using the RFID system, RFID tags are arranged in a fixed pattern on the floor, as shown in Fig 3.1. Since the tag arrangement on the floor is preplanned, each tag stores its absolute position data and sends them out when they are requested. The RFID reader (antenna) installed on the bottom of the mobile robot gathers the tag data.

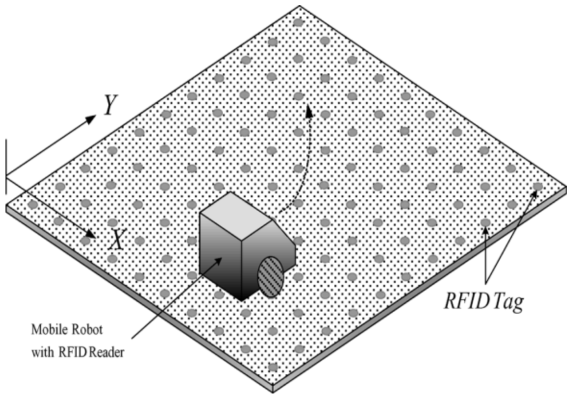

Fig 3.1: Localization System Using RFID.

When the robot moves and stays on any tags, the RFID reader antenna forms an effective area, as shown in Fig 3.2. All the tags within the circle of radius *r*, which are under the effective area of the RFID antenna, are activated. Notice that it is not desirable to increase *h*, since this may also increase the noise level when reading the tags. When the localization process starts, the RFID reader gathers the position data from the tags under the effective area of the antenna. The RFID reader sequentially gathers the tag information, since it can recognize only one tag signal at a time. In order to receive other tag data within the effective area of the RFID reader, the tag data previously read are stored in the memory. Then, the reader receives the next tag information and repeats this procedure until there is no unread tag left within the effective area.

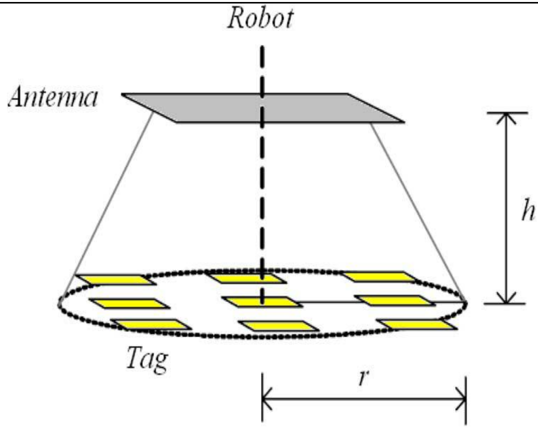

Fig 3.2: Effective Area of the RFID Antenna Model.

After all the information of the tags is stored, the location of the mobile robot is calculated based on the collected tag data. At that moment, a new set of tags is selected for the next step of localization. In this process, there are two critical factors which deteriorate the localization accuracy: the distance between the tags and the scanning and processing time. In this section, the localization error, based on the distance between the tags, is analyzed and a new tag-arrangement pattern is proposed. In the passive RFID localization system, the utilization of the tag information is dependent on the system characteristics. In other words, even though the RFID system reads the tags within the recognition area, it cannot obtain a precise-location value since there are several tags in the area. In addition, the distance between the tags is a crucial factor, which determines the localization accuracy. Therefore, the estimation error is unavoidable when the robot location is estimated by the coordinates of the tags within the recognition area of the reader.

IV. DISTANCE ESTIMATION

Because signal propagation in real environments is subject to fluctuations caused by fading, shadowing and reflections equation is not valid for non-free-field environments. A planning tool could be used to predict field strength propagation more precisely. Alternatively, such data can be generated by moving through an area and taking measurement samples (drive-test). While this approach is reasonable for simulations to achieve better results there are some disadvantages in using such data in real-time systems for daily use.

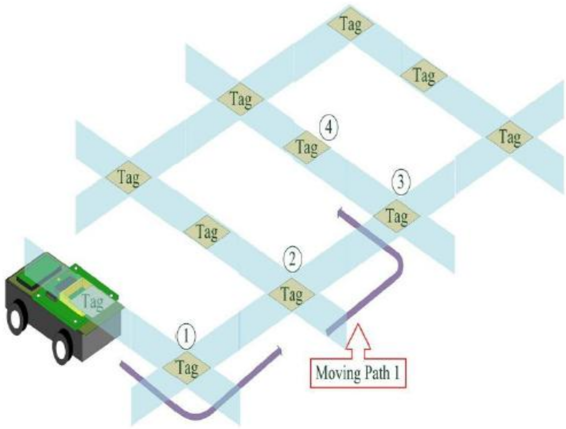

Fig 3.3: Driving Circuit for the Mobile Robot

For example, calculating fields regarding the environment and measuring can usually not be done by small terminals in real-time. Therefore, a ready-made database has to be used. A problem of using such databases is that they are subject to obsolescence and need much memory capacity is shown in Fig 3.3. If a new base station is added to or removed from the network for example the measured samples are no longer valid. Furthermore influences of the environment like weather and moving objects like cars can't be considered. Due to this we assume that a precision of about 70m cannot be reached in systems for daily use. With regard to the mentioned problems we decided to implement a simple propagation model based on and a dynamically generated map of base stations. A new set of particles is obtained according to the importance weight from the old set of particles. Off-the-shelf readers by Impinj (Type XCODE IU9003, 917–923.5 MHz) were used. Such readers are mono static types that can both transmit and receive signals through a single antenna. If more than one antenna are attached to a mono static reader, they would function by switching to a single active antenna per each reading.

V. RESULTS AND DISCUSSION

Table 5.1: Comparison

Different speeds of vehicle (m/sec)	Existing method (cm)	Proposed method (cm)	
0.1 m/sec	5.23	3.52	
0.3 m/sec	5.25	3.515	
0.5 m/sec	5.26	3.51	
0.7 m/sec	5.29	3.5	
1 m/sec	5.32	3.35	

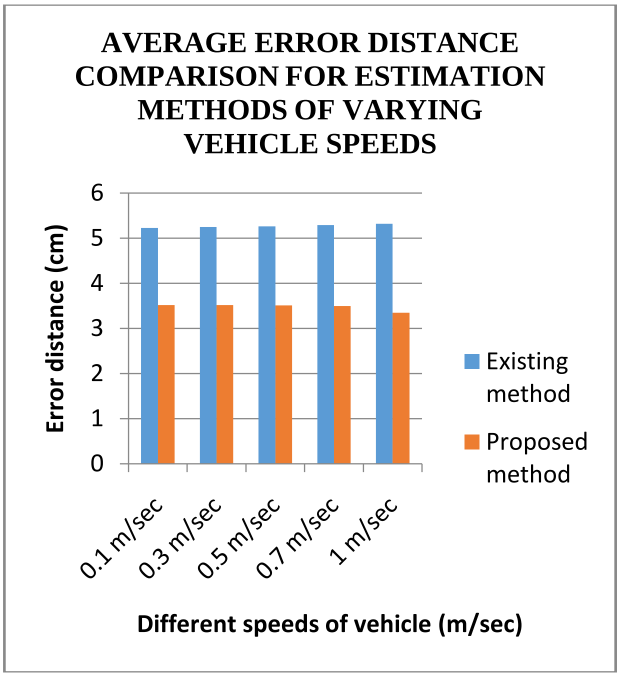

Fig 5.1 Graphical Representation of Speed of Vehicle

VI. CONCLUSION

A novel method for achieving a highly accurate self-localization and industrially useful application has been presented. In order to identify the location of a vehicle, first the RSSI values for the position estimations of the mobile robot are obtained. Second, the RFID reader can measure the phase of the signals coming from responding tags. The robot moves itself to reach the product by following the line on the ground. The wireless technology based Zigbee mechanism provides an improved efficiency and the overall performance is increased by using IR sensors for obstacle detection. The experimental results show that, when the Tags were placed on the floor and the vehicle was moving at the speed of 0.1 m/s, the average error distance was 1.35 cm, regardless of the Tag arrangement. Based on the foregoing results, the method proposed in this paper can be ideal for real life industrial uses.

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BIOGRAPHY

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