Using RFIDs for Effective Disassembling and Reassembling

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Abstract— Almost in every industry there often arises a need to disassemble some machinery or some structure and then to reassemble it at some other place. This is done because transporting the whole structure as a whole is uneconomical and may also cause damage to the structure. Reassembling a structure which is complex in design is an arduous and time consuming task and may also cause the system to malfunction in case the reassembling hasn't been done correctly. Here we present a methodology not only to facilitate the reassembling procedure but also to verify whether the structure has been correctly reassembled or not. To do this we employ RFID tags which have been affixed to each component of the structure and a Reader equipped with RSSI to determine the relative positions of the tags. The information hence obtained is stored in database and is later used to place the components in the correct order as well as at the correct position at the time of reassembling.

Key words: RFID, UHF Tags, RSSI

I. INTRODUCTION

It often becomes important to determine the relative positions of the various components of a structure or machinery. Conventional means for doing so include Ultra Wide Band (UWB) technology and Ultrasound systems such as Active Bat. There are two basic problems associated with these technologies:-

- Larger size of tag
- High cost of installation [1]

RFIDs offer not just an effective but also an inexpensive solution to both of these problems. With advancements in technology the size and price of RFID tags is constantly decreasing while their accuracy and range are constantly increasing. A typical passive UHF RFID tag can be read from as far as 12m and a few tags are as small as a grain of rice. Also the cost of tags and equipment is decreasing by the day.

A. RFIDs:

Radio Frequency Identification or RFIDs were primarily invented inventory tracking and have been around for quite some time now. Until very late RFID readers were being used for tag detection only, i.e. detecting whether a given tag was in the read range of the reader or not. If the location of a tag was to be found it was done by employing techniques such as trilateration or multilateration. These techniques required the presence of an array of antennas for effective localization and this was not always practically possible. With advancements in technology and improvements in tag and reader design it is now possible to determine the location of a tag with higher accuracy and by using lesser number of antennas. A technique for localization of tags is the use of the Received Signal Strength Indicator (RSSI) associated with an object as a measure of distance between the tag and the reader [2]. We employ the same technique here for the localization of tags in three dimensional spaces & try to determine the position of every tag.

B. RSSI

The received signal strength of an RFID tag, as is obvious is a function of distance. It would be more for a tag closer to the antenna while it will be lesser for a tag further away. This parameter is also found to vary with the orientation of the tag. However the variation becomes insignificant if circularly polarized antennas are used, and hence here we assume that the RSSI associated with a particular tag remains almost constant at a particular distance irrespective of the orientation of the tag.

II. RELATED WORK

We basically examine two categories of related work. First, we look into existing smart shelf applications, which are similar to our general idea of tracking objects on a surface such as shelf or a table. Second we look at the methodologies for localization of RFID tags and their applications.

A. Smart Shelves

Smart shelves have been studied by several research groups and there already are industrial initiatives that apply these technologies. These applications, however, focus on identifying single-tagged objects in range, i.e., retrieving information of what objects are on the shelf at any given time. Determining the exact position and orientation of the goods, however, is irrelevant. The main purpose of this research is the higher transparency and optimization of replenishment and storage management in retail stores.

B. Methodologies for Localization of RFID tags and their Applications

Localization is usually done by two methodologies. The first one relies on getting the RSSI, which is basically the signal strength. The main difficulty using this indicator is that signal strength depends on a lot of factors that can influence it like, reflections if the signal needs to pass a wood cabinet or a wall, the quality of the tag, etc. This problem comes into the picture in applications such as navigation to RFID tags or mobile manipulation where the line of sight between the reader and the tag may be largely obstructed by external objects; also there may be RF noise in the environment [3]. However in our application the line of sight if at all is obstructed, is by the components of the structure which lie in between the tag and the antenna.

The second one is by using the time in which response is received to an enquiry (Time Difference of Arrival between tags). Given that we know the speed of the beam, we can estimate the distance given a very precise timer. The problem here is that this also is influenced by a lot of factors: the mean time the tag needs to complete a cycle & the timer precision which usually is not built precisely for these purposes.

Apart from these two basic methodologies a few companies have also developed solutions that deliver great location accuracy. Mojix, for example, uses a phased-array antenna system to locate passive tags in three-dimensional space, usually to within about 3 square feet. And Impinj recently released its Speedway xArray antenna system, which is mounted overhead and provides some location information, though not to within a few square inches.

III. ASCERTAINING THE LOCATION OF A TAG

The object is placed in a setup as shown in figure

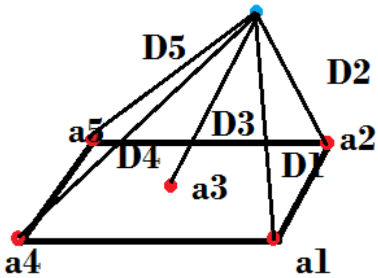

Fig. 1: Localization of a tag

Here the red dots (a1, a2, a3, a4, a5) are antennas while the blue dot indicates the position of the tag. The RSS indications receive from the tag by each antenna is used to determine the distance between the tag and the antenna using an algorithm which converts the RSSI readings (in dB) into whole numbers. The location of a tag is mentioned in terms of distances D1, D2, D3, D4 and D5 [4]. Since 5 different points are used the combination for every point is unique. Similar is the setup used for reassembling the components.

IV. TYPE OF RFID TAGS USED

In our application we use (Ultra High Frequency) UHF passive RFID tags. There are several reasons for using these tags:-

- UHF passive tags have a high read range (as high as 12m). This allows us to take even larger objects into consideration.
- UHF passive tags are faster than HF passive tags.
- UHF tags are almost as accurate as HF tags.
- UHF tags are easier to manufacture and hence are cheaper than HF tags.
- UHF tags may be a bit larger than HF tags, but are still small enough for our application

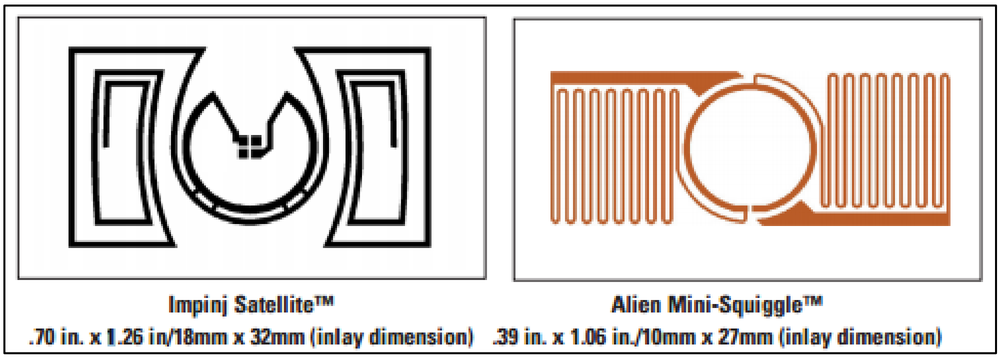

Fig. 2: Typical passive UHF tags

It can't be said with certainty which UHF tags are to be used since the type of tag will vary according to the type of material it is being attached to. [5]

Since there's no need to determine the position of a tag at extended ranges we decrease the power output or the RFID reader to about 50%. This allows higher accuracy in reading of tags. [6]

V. OUR APPROACH

We take here the example of a house made of lego blocks.

Fig. 3: Original Structure before disassembling

Before removing a block we first attach a UHF tag to the block. A computer program ascertains the position of the tag using the algorithm earlier described and saves this position as well the order in which the tag was placed in the database. Note that here we aren't writing anything onto the tag. We are merely using the tag's unique id (which is read by the reader) [7] to enter its corresponding position and the order in which it was placed on the structure (whether it was the first tag to be placed, or the second or the third).

Tag ID	D1	D2	D3	D4	D5	Order
13bt126621	67	34	89	67	33	x
13bt334456	89	54	21	90	32	x-1
13bt667782	54	54	23	54	78	x-2

Table 1: An example of certain database containing tag positions and respective order.

Here D1, D2, D3, D4 and D5 are the distance values determined through the respective RSSI readings from the antennas. X is the total no. of components in the structure. Once the Disassembling is complete the value of X is available to the program (the program has a counter which is incremented each time a tag is placed onto a component) and hence the database is modified as shown in the figure below.

Tag ID	D1	D2	D3	D4	D5	Order
13bt126621	67	34	89	67	33	4
13bt334456	89	54	21	90	32	3
13bt667782	54	54	23	54	78	2

Table 2: Modified database after disassembling has been completed

A. Reassembling:

The structure is reassembled in a similar setup (with antennas placed at the same locations as before) as the one in which it was disassembled. Now the components are placed in increasing order, i.e. the component bearing the tag of order 1 is the first one to place. The one with order 2 is placed next, so on so forth.

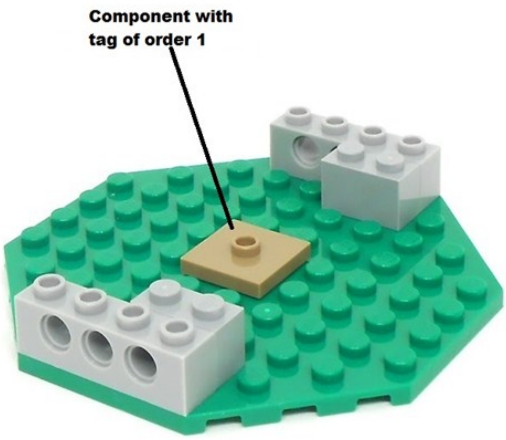

Fig 4: Reassembling the components of the Structure

When a component is placed the reader detects its position and sends it to the computer. The program verifies whether it has been placed at the correct location or not by matching the current coordinates of the tag on the object with the ones in the original database. In case the object has been incorrectly placed an error signal is generated. The same happens in case an object is placed in the incorrect order. Hence the structure is reconstructed in an order exactly reverse of the one in which it was disassembled. This may be done manually or by using an autonomous robot.

VI. CONCLUSION

In this paper we present a novel approach to reconstruct a disassembled structure by employing techniques for localization of tags. This system is advantageous because it is easy to implement and inexpensive. We used RSSI to determine the distances of tags from the antennas and hence mark their relative locations. This approach may be employed in assembling machinery and automobile equipments.

Our future work will be focused on making the localization of tags more accurate by improvising the algorithm used to determine the position and employing other techniques in addition as aids.

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