Accurate Positioning Based on a Combination of Power Attenuation and a Signal Strength Indicator Using Active RFID Technology

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***Abstract*—The aim of this paper is to develop a new positioning technique to assist the blind and people with low vision to indicate their locations and reach their destinations. The presented technique is based on a combination of attenuation level and Signal Strength Indicator (SSI) using active Radio Frequency Identification RFID technology. The system uses a mobile reader with power attenuation feature. SSI is used as a distance estimator for short range and in combination with one of eight receiver attenuation level settings for a wider range of up to 70 meters. Global Positioning System (GPS) works efficiently in an outdoor environment but is only accurate to around ten to twenty meters and it does not work efficiently at indoor environments. This research has produced an identification localization system which identifies various locations such as offices, labs, theaters and so on to assist users reach their destination of interest. Then it has been conducted as a real empirical case study to identify labs base on a combined technique with a successful identification rate of around 98%. The reader has eight attenuation settings, and the geographic range of each level using various tags has been calculated. Then, to evaluate reliability 108 experiments were conducted using three tags with distances from 1 metre to 25 metres using power attenuation settings 1 to 6. A successful detection rate of 93.5% was achieved, as well as a false positive rate of 1%.**

Keywords: Active RFID, Accurate Positioning, Power Attenuation, Signal Strength Indicator, Blind Assistance

I. INTRODUCTION

Determining their current indoor location for the blind or low vision people is a real challenge. Over the years various researchers such as [1], [2], [3] have discussed navigation issue in order to assist visually impaired people in indoor environments using RFID technology. The work in [2] produced an efficient RFID tag placement framework for in building navigation system for the blind, and the work in [1] developed a navigation system for blind people using GPRS network but their system had delay problems. Even when blind users are able to avoid obstacles using guide dog or white cane [4], [5], they still would be facing difficulty in reaching their destination accurately. This paper will focus on designing a system which is able to inform users of their current position and provide them with useful information to guide them to their destination. The system is based on a new technique which is a combination of a choice of eight attenuation levels and signal strength, so it enables users to determine their position using a portable mobile device. The paper is structured as follows: related work is outlined in section II; then the system description is given in section III. Next, the results and a case study are described in section IV, followed by the conclusion in section V.

II. BACKGROUND AND RELATED WORK

Over the years, many localization technologies have been developed, some of which aim to indicate locations in in-door and out-door environments [6]; based on a combination of GPS and Bluetooth ,[7] which can combine GPS with RFID for blind navigation purpose. Another group of researchers has concentrated on in-door localization issues using RFID technology[8], [9], [10], [11], [12], [13], [14]. In addition, many researchers[1], [2], [3] have used RFID technology for navigational purposes to assist the blind and visually impaired people in in-door environments. [4], [5] have combined electronic white canes with RFID technology to improve guidance systems for people with visually impairments.

III. OVERVIEW OF THE SYSTEM

The tags used are called RF Code M175 Rugged Tag as shown in figure. 1(B), which has a wide transmission range up to 300ft. Each tag should be located at a known location, such as an office door or entrance of a department. The user hangs the mobile reader in his or her belt as shown in figure. 2. The reader used, which appears in figure. 1(A), is the M220 Mobile Reader weighing is 162g with belt clip. The system offers two kinds of communication interfaces:

A B

Fig. 1. A: RF Code M220 mobile reader. B: M175 active rugged tag.

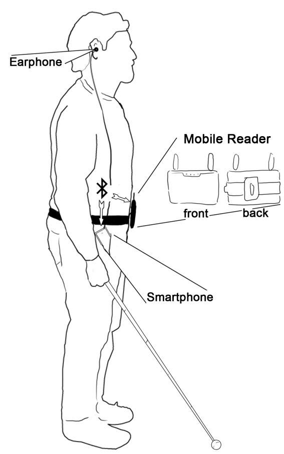

Fig. 2. The system components.

Bluetooth Serial 1.1 and wired USB 2.0. Therefore, users can install the mobile version API on their smart phones and can use it easily. The reader has eight factory programmed ranges. All the user needs to do is simply change the range from one to eight. Consequently, the system will determine the user's position based on the attenuation level itself or based on a combination of attenuation levels and Signal Strength Indicators (SSI) as shown in figure 4 which illustrates how the system indicates the closest tag to the reader, where AtnL represents attenuation level or range level and SSI represents Signal Strength Indicator.

A. Components of the System

The system contains hardware and software. The hardware consists of the reader, multiple tags and a smart phone which contains a built-in microphone and the software contains the voice to text converter, the reader API and the algorithm which indicates the closest tag to the reader. The system used is almost an Omni-Directional system. Also, it has a wide range of around 70 meters with high sensitivity. The system has been designed for an indoor environment, so it could be used to assist blind users to reach their destinations such as a particular apartment, lift, specific classroom and so on. Therefore, tags should be fixed at known locations. On the other hand, the reader is mobile so it can represent the current user's location. The system is very simple to use. The user counts from one

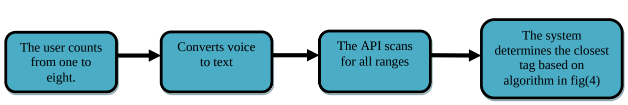

Fig. 3. Summary of the system steps.

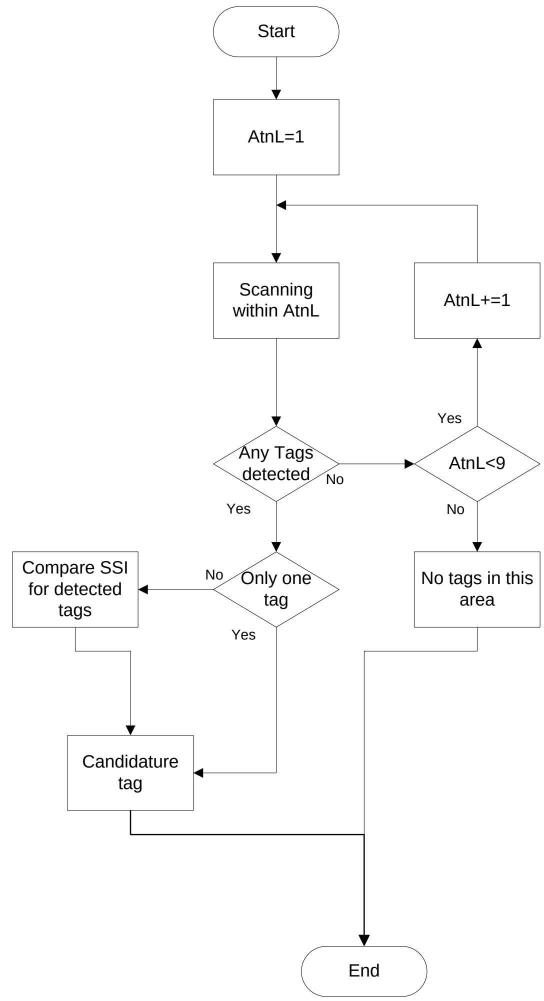

Fig. 4. The flow chart of algorithm of indication of the closest tag.

to eight to change the power attenuation level and the reader scans for tags using all ranges. A tag which is detected in a narrow range would have a higher priority over other tags on a wider range. Hence, based on this concept, the range itself could be sufficient to indicate the closest tag, unless more than one tag is detected in the same range. When there are two or more tags discovered in the same range, the system uses a combination of range and SSI techniques. Figure 3 shows the system steps from start to end and the algorithm is summarized in figure 4. Therefore, after the user counts, the system automatically indicates the closest tag.

IV. Experiments and Results

A. Localization Technique Implementation

Figure 5 presents the experiment implementation. Dots A,B,C,D and E represent tags, and the numbers from 1 to 15 represent the real locations for reader. In ideal circumstances, the system was 100% successful in indicating the closest tag for each location. For example tag (A) is the closest tag to location 1 and it was detected in this position on attenuation

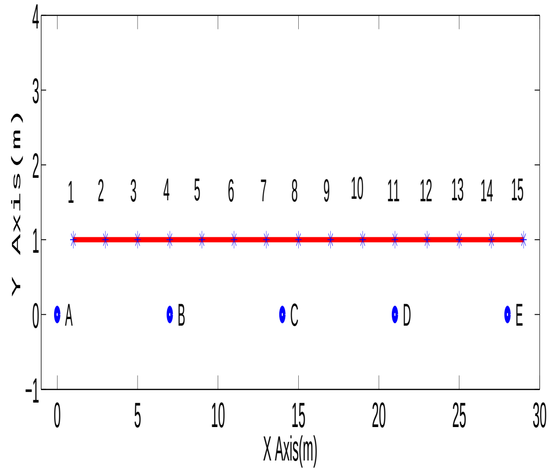

Fig. 5. Experimental Implementation

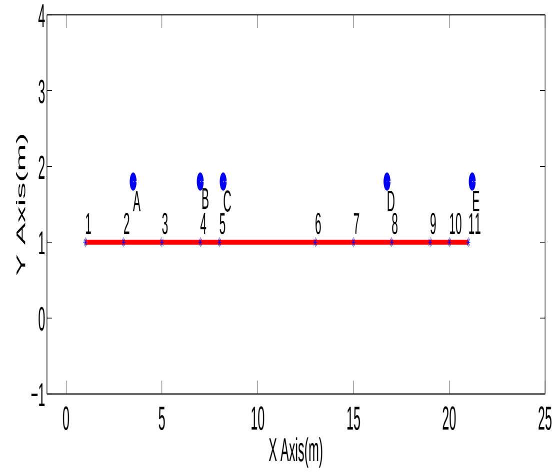

Fig. 6. Case Study, Laboratory Doors

TABLE I
THE RESULTS OF USING ATTENUATION LEVEL TO INDICATE THE CLOSEST TAG

Reading Position	Closest Tag	AtnL
1	A	1
2	A	2
3	B	2
4	B	1
5	B	2
6	C	2
7	C	1
8	C	2
9	C	3
10	D	2
11	D	1
12	D	2
13	E	2
14	E	1
15	E	1

TABLE II
THE RESULTS OF USING COMBINATION OF ATTENUATION LEVEL AND SSI TO INDICATE THE CLOSEST TAG TO THE USER

Reading Position	Closest Tag	Positioning Technique	
		Attenuation Level	AtnL and SSI
1	A	3	Yes
2	A	1	No
3	A,B	2	Yes
4	B	1	No
5	C	1	No
6	D	4	No
7	D	2	No
8	D	1	No
9	E	2	Yes
10	E	2	No
11	E	1	No

level 1 as shown in table I. Also the same tag has been detected alone on attenuation level 2 at position 2. For all 15 samples, the system indicates the closest tag by giving a tag which is detected on a narrow range higher priority over the other tags on wider ranges.

B. Evaluation of The System (Case Study)

To evaluate the efficiency of the system we conducted a practical experiment to identify the laboratories in our school. We placed tags on laboratory doors which are represented by A,B,C,D and E in figure. 6. Then, we took readings from various locations; 1 to 11 as shown in the same figure. The system aims to inform the user of a destination of interest in the surrounding area. Furthermore, as shown in this case study, the system identified the lab based on the user's location. Table II presents how the system indicated the tag closest to a user. For instance, at position 1 the reader could not discover any tag on power level 1 or 2, but on power level 3 tag A and tag B were detected so it was necessary to use a combination technique to indicate which one of them to select. At position 2, the reader was very close to tag A, so A was detected alone on power level 1 so the power level technique was sufficient to indicate the closest tag. As shown in table II there was a partial error in position. The system reported that the user was in the middle of A and B; this is true but it was biased 45 cm to tag A. In contrast, the system had very high accuracy at position 9 because the reader was closer to tag E than tag D by only 5 cm and the system was able to detect this.

C. Evaluation of System Reliability

1) Analysis of The Relationship Between Attenuation Ranges and Distance: Figure 7 shows six geographic ranges of the reader power attenuations. As mentioned in previous sections, power attenuation is the core technique in the provided system. Therefore, 108 experiments have been conducted to evaluate the reliability of power attenuation. The results given in table III show that there were only seven incorrect samples of 108 samples using three different tags for a variety of distances.

2) Analysis of The Relationship Between SSI and Distance: The main techniques of the provided system are power attenuation and the signal strength indicator. The experiments showed that power attenuation was reliable but a higher degree of accuracy was achieved when power attenuation was combined

TABLE III
EVALUATION OF SYSTEM RELIABILITY

Distance	True +ve	False -ve	True -ve	False +ve
1m	18	0	0	0
5m	15	0	3	0
10m	8	4	6	0
15m	9	0	9	0
20m	5	1	12	0
25m	2	1	14	1

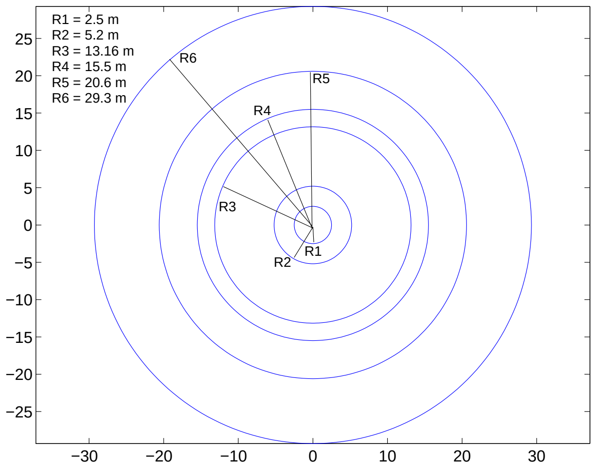

Fig. 7. The geographic range representation.

with SSI. Therefore, we tested the effect of distance on SSI and found there is an inverse linear relationship between SSI (measured in dB) and short distance (up to ten metres) as shown in figure. 8. When the reader detects more than one tag on the same attenuation level, this means all detected tags are in same range. In similar circumstances the SSI technique is useful to indicate a closer tag from a distant one.

V. CONCLUSION

This paper has discussed a new technique to assist the blind or low vision people to reach their destinations. A wide range active RFID system had been used. The mobile reader has eight power levels and the geographic range of each level has been calculated. A successful detection rate of 93.5% was achieved, as well as a false positive rate of 1%.

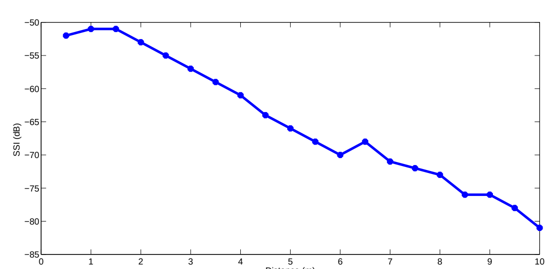

Fig. 8. The linear relationship between distance and signal strength indicator.

Furthermore a combined technique of power level and SSI has been formulated to identity locations to assist visually impaired people to reach their destinations accurately. To evaluate this technique, a case study was conducted and a very high satisfactory rate was achieved.

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