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Research article

AUTOMATING PASSPORT LOCALIZATION PROCESS BASED ON WLST-RFID ALGORITHM

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Abstract

The electronic-passport is majorly used in worldwide. Many countries have started changing their conventional passports to electronic-passports due to upgraded security of the passport holder. Passports and any document probably enhanced using recent technology advancements - Radio Frequency Identification (RFID) technology for e-passports. The e-Passport is one of the important identification system of these applications of RFID, where the number of forged passports is increasing worldwide. It is great importance to examine a policy regarding to these information of the passport holder according to electronic approaches and developments, which are moving toward electronic data storage that focuses on the localization techniques. In this paper, we propose Weighted Least Squares Techniques (WLST) of generalized least squares that specifically estimate the accuracies of different measurements of the Passport Position (PP) to obtain a better estimation in airports. This algorithm achieves greater robustness results for accuracy in localization and tracking with a very limited in computational cost.

Keywords: wireless sensor network, WSN, e-passport, radio frequency identification.

摘要：電子護照主要用於全球。由於護照持有人的安全性提高，許多國家已開始將其常規護照更改為電子護照。使用最近的技術進步 – 電子護照的射頻識別（RFID）技術可能增強了護照和任何文件。電子護照是這些 RFID 應用的重要識別系統之一，其中偽造護照的數量在全球範圍內不斷增加。根據電子方法和發展來檢查關於護照持有者的這些信息的政策是非常重要的，這些信息正朝著關注本地化技術的電子數據存儲發展。在本文中，我們提出了廣義最小二乘法的加權最小二乘法（WLST），它專門估計了護照位置（PP）不同測量值的精度，以便在機場獲得更好的估計。該算法在定位和跟踪的準確性方面實現了更大的魯棒性結果，並且計算成本非常有限。

关键词: 無線傳感器網絡，無線傳感器網絡，電子護照，射頻識別。

I. INTRODUCTION

Localization in wireless sensor networks (WSNs) can be defined as one of the most important fundamental requisites that need to be resolved efficiently. It plays a significant model in many applications such as environmental monitoring, routing and tracking target which is all location dependent. The main idea for localization is that some deployed nodes with known coordinates termed as anchor nodes transmit beacons with their coordinates in order to help the other nodes in the sensing field to localize themselves [1]. WSNs can be diffused on a large area environmental monitoring parameters, such "temperature, humidity, luminosity, pressure, air quality, soil property, etc". Most of the applications of environmental sensing require to have information of sensor nodes locations (location of RFID tags) because of that sensing data analysis are meaningless without this requirement. Various communication network protocols are also depend on the location of sensor nodes information for the WSNs [2].

The methods of target localization which are based on many different types of measurements. The location schemes can be classified for its analysis into several categories, such as time of arrival (TOA)-of localization, time difference of arrival (TDOA))-of localization, received signal strength (RSS))-of localization, angle of arrival (AOA))-of localization [3]. In the last few decades, the problem of determining the location of mobile object by measuring the received signal has drawn considerable attention. In these systems, generally, there is multiple receivers-readers located in order to collect the emitted or reflected signals by a target at different spatial coordinates[4]. Measurements of the different types, localization technique based received signal-RSS receives researchers' most attention to its features such as easy-implementation, low-complexity and low-cost [5]. Therefore, we focus on a problem of the target localization using received signal measurements information in WSNs. A power of received signal mainly, it depends on the transmit power of a target tag and analysis of the path-loss exponent [6]. Therefore, e-passport with radio frequency (RF) transponder embedded in the cover of passport, which is difficult to forge it and increases the verification procedure of stability by intensifying electronic personal information. It is necessary to provide a possibility to trace the passport and determine its exact location when the owner of the passport is not licensed or is pursued by the security authorities as well as to preserve the passport when the loss or theft. The objective of this work is to provide strong authentication for passport holder through documents of identification and localization for object node information using the RFID chip.

Nowadays, a number of researchers tackled the RF-based localization approaches. There are many approaches based RF localization. This work mainly focusses on some previous studies about localization that is close and related to RFID localization. The rest of this paper is arranged as follows. In section 2, describes the related works. Section 3, introduces RFID and sensor networks integration. Section 4 discusses problem statement and formulation, Section 5 presents the RFID-Passport system. Finally, the conclusions are presented in Section 6.

II. RELATED WORKS

The RFID-based localization (LANDMARC) in [7], is one of the most prototype popular RF-based on localization technologies using radio frequency tags technique. The coordinates of K-nearest radio frequency tags are adopted in order to compute the coordinate measurement of the tracking tag. However, the environment influenced by the radio frequency RSS. To choose K-nearest in a large field where reference RFID tags are not close to the target tag, hence the accuracy drops dramatically.

SpotON is a well-known location sensing system [8]. It is used an aggregation algorithm for three-dimensional location sensing based on radio signal strength analysis. It uses received signal values measurements from long range of non-line of sight wireless RFID-tags to distances values between RFID-tags and RFID-readers. It collects the received signal measurements and then transform signals into distance estimations.

In [9], Scout system is proposed a system working on outdoor-cost-effective localization system based on RFID technique as well as a probabilistic approach for the localization problem using radio frequency readings. Its system relies architecture to cover the outdoor environment. It works in variable frequency range, with min coverage area-100m and a max coverage area 500m. MANTIS reader provide RSS readings for many tags within coverage area.

III. RFID and SENSOR NETWORKS INTEGRATION

RFID system and sensor network, especially WSNs, are the two most important technique for calculating everywhere because application of sensor networks in wide industries. Radio frequency system is often used to identify tag object and trace tag locations. WSN networks consist of a small, cost-effective sensors capable of providing data on the environments such as" humidity, temperature, light, sound, vibration, and pressure". They are widely used a different industries such as application of health care, environmental monitoring, smart home, military applications. The integration of radio frequency technique enhances RFID effectiveness and provides a wider range of coverage area of meaningful applications. This consolidation brings benefits including scalability, portability, expanded capabilities, and cost reduction [10].

A. RFID System Components

RFID wireless communication, uses radio frequency of received signal to transfer data between tags and readers. RFID system has three fundamental elements, as shown in Fig.1:

1. Tag: its components include of a microchip and an antenna. It possesses and identifies unique ID information after that transmits information to the reader when responses according to the request.

2. Reader: its requests data from RFID-tags, where it acts as a middle object between server and nodes.

3. RFID hostesses are the "brains" of an RFID system and often take the form of a workstation or a personal computer (PC). Most RFID networks consist of multiple tags and multiple readers. Readers are linked, and thus tags, together by the central host. Information obtained from tags in the RFID system is processed by an RFID host [11].

For commercial applications of RFID system such as supply chain, it simply worked such a memory card, capabilities of computation and communication. However, RFID systems in some applications such as authentication need a mechanisms to ensure its security in order to protect the user's privacy [12].

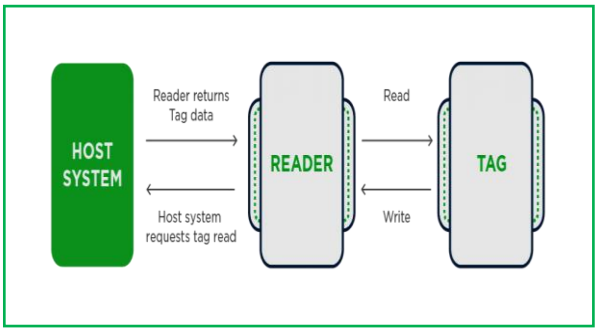

Figure 1. Structure of RFID system [13]

B. Components of Localization Systems

The localization system can be divided into three distinct components [14] as shown in Fig.2 :

1. Distance/Angle Estimation: To estimate the distances information measurement or angles measurement between two nodes. The components of the localization system will be used this information.

2. Location Computation: The information of reference nodes used a distances, angles and positions which, the component is responsible for computing a node's position where its available.

3. Localization Algorithm: This is a main procedure of a localization technique. It determines the wireless sensor nodes on an available information will be manipulated in order to allow of estimation their positions.

The importance of this division lies in the require to understand that the localization systems performance depends on these components. These components have also its own purpose and methods of its solution. The sub-regions of the localization problem require to be analyzed and studied separately.

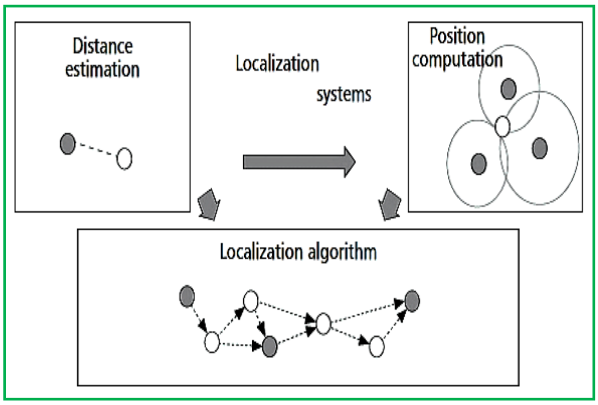

Figure 2. Localization system components [14]

IV. RFID-PASSPORT LOCALIZATION SYSTEM

Travel among countries and security concerns are driving efforts to improve the identification and passport documents. To use an embedded electronic chip-set in the passport document to store the data from the data page of passport in order to achieve the security of its document and to assistance travelers by improving the location of the passport holder, therefore it ability to verify identities of passport through its location. In this work, we suggest to integrates the RFID technology with the passport. this project called RFID-passport system.

The RFID-passport system needs RFID technology that gives a clear idea about the assistance of using radio frequency technology. This system avoids forgery and the security rate will have increased. This technique decreases the burden of documentation, thereby reduces the effect of time consumption. The smart card technology makes a centralized system technique to improve security procedure. That way, the security system can be further verified the localization in the passport system [15].

RFID-Passport system is a rapidly deployable, cost-effective and easily maintainable used for Identification and Localization in airports. The RFID-Passport system features an easy platform for analysis and processing. The strengths of this system are the integration of hardware and software components, mobility, ease of installation and maintenance, finally reliable wireless communications. This system consists of the following:

1. The embedded system of RFID-tag in the cover of the passport.
2. The identification station and localization (ISAL).
3. Four RFID readers, installed inside the airport building. These readers are directly connected to ISAL by Unshielded Twisted Pair (UTP) cables.
4. RFID-Passport middleware.

The middleware of the RFID-Passport indicates to software or devices that use to establish the connection between RFID readers and the data they collect, to the main software of the RFID-Passport system in ISAL. The middleware controls and manages the data flow between the readers and the applications of this system, which is responsible for the quality and thus the ease of using the collected data. On the other hand, it connects to the SQL server for communicates with the system database as shown Fig.3.

Figure 3: RFID-Passport System

If this passport embedded tag passed in the readers' coverage area, the reading data has provided to an ISAL. This data is matched with the database of this system if this data matches with information for a person is not authorized to cross or pass from the airport or is required for the security authorities displays a confirmation message on an LCD screen. It is also possible to track and locate the passport holder inside the airport and provide real-time information about his movements and as well as its exact location inside the airport.

V. THE WLST-RFID ALGORITHM

A. Formulation of RFI D-Passport Localization Problem

The e-passport is a biometric passport that combines both paper and an electronic chip. The goal of e-passport is to provide strong authentication through documents that unambiguously identify the passport holder. Weighted Least Squares Techniques (WLST) are specialization of generalized least squares and very well-known application that use radio frequency based localization problem with RFID technology. Whereas, the distances to different RFID tags are estimated. The algorithm applied to find the tracking and positioning passport inside the airport [17].

To use received signal-based on positioning algorithms to find passport localization (object tag), this algorithm has two simplest common positioning are the circular positioning algorithm [15] and the hyperbolic positioning algorithm [16]. The clear vision of the circular positioning algorithm is to obtain the position $(x.y)$ of the movable object tag (passport) which, estimated distance to minimize the squared errors. If $(x_i.y_i)$ is the position of reader, i $(i = 1.2.\dots.N$, where N is the number of readers)) and $\widetilde{di}$ is a distance estimation to reader i, this error is given by

$$\varepsilon = \sum_{i=1}^{N}\left(\sqrt{(x_i - x)^2 + (y_i - y)^2} - \widetilde{d}i\right)^2 \quad (1)$$

where $(x.y)$ position of a passport that can be calculated iteratively according to this technique.

In order to converts this problem into a linear problem use the hyperbolic positioning algorithm that can be solved with estimator of least squares, where the square distance between the RFID-Passport and reader i can be expressed a

$$d_i^2 = (x_i - x)^2 + (y_i - y)^2 \tag{2}$$

To take the reader of origin coordinates, can be taken a reader i = 1 that is,

$$x_i = y_y = 0, \text{ for } i > 1$$
$$d_i^2 - d_1^2 = x_i^2 - 2xx_i + y_i^2 - 2yy_i \tag{3}$$

Expressing Eq.(3), in matrix form

$$\begin{bmatrix} 2x_2 & . & 2y_2 \\ \vdots & \vdots & \vdots \\ 2x_N & \cdots & 2y_N \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x_2^2 + y_2^2 - d_2^2 + d_1^2 \\ \vdots \\ x_N^2 + y_N^2 - d_N^2 + d_1^2 \end{bmatrix} \tag{4}$$

Received signal localization, the real distances di is unknown between object tag and readers. It has some noisy for distance estimation $\widetilde{di}$, that way, the problem can be written as

$$H \cdot \tilde{x} = \tilde{b} \tag{5}$$

where

$$H = \begin{bmatrix} 2x_2 & & 2y_2 \\ & \vdots & \\ 2x_N & & 2y_N \end{bmatrix} \quad \tilde{x} = \begin{bmatrix} x \\ y \end{bmatrix}$$

and $\tilde{b}$ is a random vector given by

$$\begin{bmatrix} x_2^2 + y_2^2 - \tilde{d}_2^2 + \tilde{d}_1^2 \\ \vdots \\ x_N^2 + y_N^2 - \tilde{d}_N^2 + \tilde{d}_1^2 \end{bmatrix} \tag{6}$$

That way, the object tag position can be calculated as the least-squares definition according to the equation, given by

$$\tilde{x} = (H^T H)^{-1} H^T \tilde{b} \tag{7}$$

In Eq.(5), linear problem can be written by using WLS estimator, formulated as

$$\tilde{x} = (H^T S^{-1} H)^{-1} H^T S^{-1} \tilde{b} \tag{8}$$

Where, S a covariance matrix according to vector $\tilde{b}$, where the measurement of vector $\tilde{b}$ affected by the noise. The of estimator Eq.(8), is biased because vector $\tilde{b}$ doesn't have zero mean. Assuming, the distances measurements of the $\widetilde{d_i}$ to different reference tags are independent, x_i,y_i are constants, the matrix S can be written from Eq.(9),

$$S \begin{bmatrix} V(\tilde{d}_1^2) + V(\tilde{d}_2^2) & V(\tilde{d}_1^2) & \cdots & V(\tilde{d}_1^2) \\ V(\tilde{d}_1^2) & V(\tilde{d}_1^2) + V(\tilde{d}_3^2) & \cdots & V(\tilde{d}_1^2) \\ \vdots & \vdots & \ddots & \vdots \\ V(\tilde{d}_1^2) & V(\tilde{d}_1^2) & \cdots & V(\tilde{d}_1^2) + V(\tilde{d}_N^2) \end{bmatrix} \tag{9}$$

B. Channel Modeling Localization

This section describes a channel modeling for localization method. A wireless network collected of both movable tag and unmovable reader. The object tag position can be measured using the approach.: First, the mobile node (RFID tag embedded in passport) calculates the received signal from the readers. Second, resolve the received signal values from a channel model which depends on their distances (object tag and each reader). Finally, the object tag position is found according to these distances using " Multilateration algorithm". Channel model for received signal-based localization is the log-normal Gaussian distribution,

$$\overline{PL}(d) = \{\text{Path loss model}\} + \{\text{Gaussian distribution}\}$$

$$\overline{PL}(d) = PL(d_{tr}) + N$$

$$\begin{bmatrix} x_2^2 + y_2^2 - d_2^2 + d_1^2 \\ \vdots \\ x_N^2 + y_N^2 - \tilde{d}_N^2 + \tilde{d}_1^2 \end{bmatrix} \tag{6}$$

Shadowing path loss model is the main ingredient of a propagation model. It is related to a distance of the coverage area of RFID systems, as shown Fig.4;

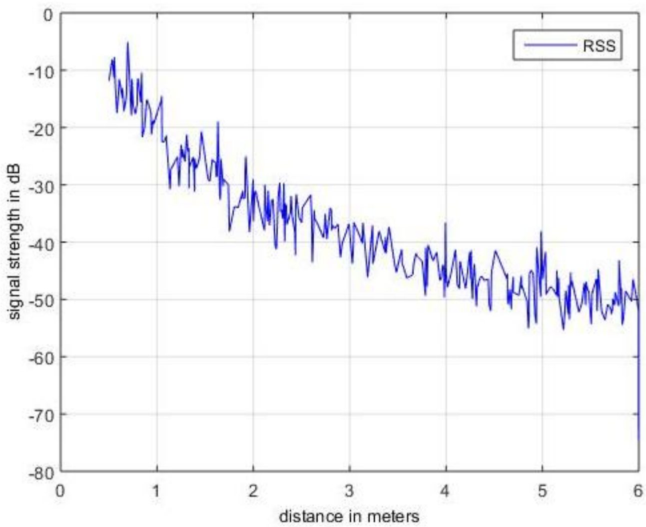

Figure.4. received signal strength vs distance

The distance measurements between RFID-tags and received signal is estimated, when a relation between (P_{RX}) , (d) object tag and reader respectively. lognormal channel model is given by

$$\mathbf{P_{RX}(dBm) = A - 10nlog\frac{d}{d_0} + N} \qquad (10)$$

Where (P_{RX}) a received power, A a constant term, n a path loss exponent, and $N \sim N(0.\sigma^2)$ is a zero-mean Gaussian Random variable with σ standard deviation. A-term depends on P_{TX}, the tag's and reader's antenna gains, the power loss of d_0 -reference distance has experimentally determined. Path loss exponent ranges from 2 till 4 depending on the environment.

C. Performance Evaluation

In this section, we simulate the WLST-RFID algorithm using a set of data (314) excel files, which contain a standard dataset of RSS values that were used in the suggested algorithm of location estimation. Each file contains RSS values of (24-103) RFID tags with four readers. During the simulation process and in the beginning, the simulation gets to take a set of the real coordinates of 20 RFID-Passport tags that represent the actual coordinate of the RFID tags of a virtual environment has an area 10×10 m. In this work, the proposed algorithm was applied to those coordinates to estimate their location. Table.1, illustrates the results of estimation of tags location of the RFID-Passport and Fig.5, shows error estimation using WLST. Fig.6, demonstrates the results of implementing the WLST algorithm.

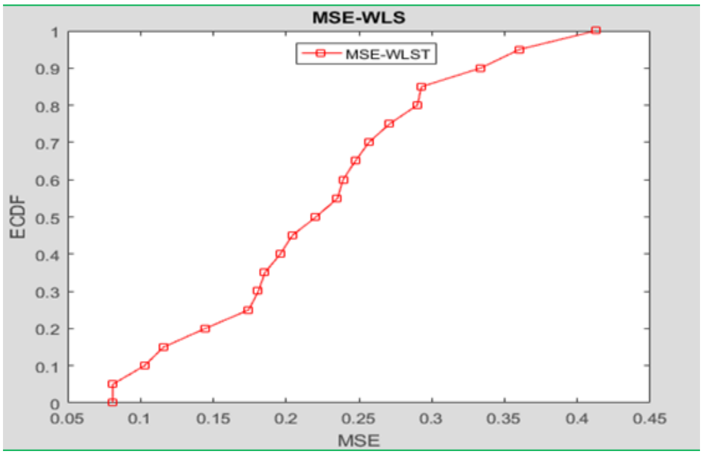

Figure 5. Error estimation using the WLST

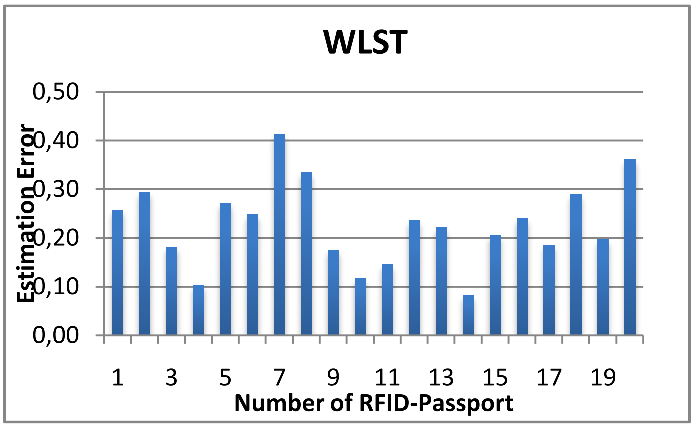

Figure 6. Results of implementing WLST

VI. CONCLUSION

Automating passport localization process track and locate the e-passport at the airports was suggested. In this work, RFID technology was used and integrated with the passport to produce so-called WLST-RFID technique. Weighted least squares techniques has suggested to use for identifying and locating of the e-passport based on a set of estimations of distance to between tags and the readers. This technique enhanced the accuracy of localization in our system to reduce the computational cost. This localization algorithm ultimately improves the performance of the identification and localization system. The RFID-passport is a localization and authentication system where the object tag-passport is authorized through RFID technology system. The object tag -passport have an RFID tag which contains all the passport holder details information. Simulation results showed that the WLST-RFID algorithm can significantly outperform existing multilateration-based methods.

Table 1: Localization results using WLST

No.	Coordinates of the Actual passport		Coordinates of the estimated passport		Error in WLST
	X	Y	X1	Y1	
1	6.7000	2.3400	6.5883	1.4157	0.2567
2	2.3860	6.1170	2.5020	6.2277	0.2930
3	8.6410	2.8790	4.9680	2.9247	0.1810
4	8.9150	1.7590	3.8690	4.5731	0.1028
5	6.3470	1.8330	6.0784	2.0537	0.2711
6	5.5720	7.2160	5.4143	2.2266	0.2475
7	6.7380	2.6920	2.9008	1.4444	0.4125
8	3.3000	3.1900	3.0181	5.0694	0.3336
9	5.9280	9.6330	5.9858	2.7627	0.1744
10	0.6680	6.1920	3.5848	2.3341	0.1159
11	5.6920	3.0910	6.2857	2.2560	0.1445
12	7.7510	7.4800	5.7340	5.3416	0.2354
13	1.5300	5.6700	6.2448	3.5718	0.2205
14	8.4290	5.5900	2.5691	5.5468	0.0810
15	6.0570	7.7960	2.2211	3.7432	0.2043
16	3.4340	3.5110	3.3838	3.4123	0.2391
17	9.6120	4.0770	1.8149	2.2707	0.1854
18	3.5010	2.1500	6.1462	4.2003	0.2900
19	8.4050	1.2150	3.0501	5.1090	0.1960
20	0.1230	5.9760	6.0061	5.8281	0.3602

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