PERSPECTIVE-COGNIZANT RESOURCE PROVISION IN CELLULAR SET-UPS

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ABSTRACT:

Wireless Sensor Networks (WSN) are applied to collect information by distributed sensor nodes (anchors) that are usually in fixed positions. Localization (estimating the location of objects) of moving sensors, devices or people which recognizes the location's information of a moving object is one of the essential WSN services and main requirement. To find the location of a moving object, some of algorithms are based on RSSI (Received Signal Strength Indication). Since very accurate localization is not always feasible (cost, complexity and energy issues) requirement, RSSI-based method is a solution. This method has two specific features: it does not require extra hardware (cost and energy aspects) and theoretically RSSI is a function of distance.

1. INTRODUCTION

Localization of an object (a person, fixed or moving object) is one of the significant topics of context aware systems in Wireless sensor networks (WSN) (Barsocchi et al., 2009; Papamanthou, 2008; Rasool et al., 2012; Artemenko et al., 2010; Ahn, 2010; Liu et al., 2012). Since the solution based on Global Positioning System (GPS) is not available in indoor environments (Barsocchi et al., 2009), the issues of complexity, energy consumption and cost efficiency are always significant, Wireless sensor networks (WSN) is considered as a solution to the indoor localization. Therefore, localization algorithms in WSNs are not based on GPS technique and expensive equipment. In WSNs, location estimation of a moving object (sensor with unknown position) is usually based on its communication with some fixed objects (sensors with known position). In one category of localization method (ranging-based), positioning of an object is based on signal propagation time, arrival angel or signal phase difference between unknown and known (anchor) sensors. Each of these methods requires specific support. In the signal propagation, the time should be measured precisely. Signal arrival angle methods require expensive equipments (antenna) and signal phase difference is limited by distance. Among different algorithms in the context of localization, the RSSI (Received Signal Strength Indicator)-based algorithm is the most popular method with respect to cost, energy and complexity (Ligong et al., 2013). Our focus in this study is on the RSSI-based and multilateral localization methods although different methods Received Signal Strength Indication (RSSI) is an indicator of the power that the receiver sensors gain as a valid packet. By the Friis transmission equation, the signal strength that is received by a sensor from another one is a function of its distance. Studies show that localizations based on RSSI are not very accurate since three factors influence RSSI values: path-loss, fading and shadowing effects. In fact, in real situation with people movement, different obstacles and conditions, we will receive different RSSI values that affect positioning accuracy (behavior is not completely same as theoretical formula) (Heurtefeux & Valois, 2012). Different researches and empirical studies try to find ideas or methods to improve RSSI-based localization algorithm and then increase accuracy. In this study, at first we try to understand the characteristics of the RSSI values and then design different experiments in a laboratory situation to gather enough RSSI values' vectors for further analyses. These experiments encompass different effects such as antenna direction, indoor and outdoor situations, effects of obstacles, sensor positions, time and number of samples, sensors' distances and people movement. Second, we try to analyze the RSSI values. In the analysis phase, software has been developed to implement RSSI algorithms, analyze our experiments data, and try to position a moving object. In fact the main approaches in the software development are both implementation of the analysis phase and then possibility for localization based on further experimental RSSI values. The software separates RSSI values for each anchor in different files and then calculates algorithms' parameters and distances in the relevant files. Also, path-loss effect is one of the significant parameters in the RSSI localization that software focuses on, to find and filter the best values. Moreover, this study considers some innovative methods of the RSSI localization with respect to RSSI limitation. Since contribution of empirical papers is important to find better solutions, this study systematically researches in the previous empirical papers to see the contributions in the context of the RSSI algorithm and environmental conditions' effects

1.1. Scope of the Study

This study focuses on a specific algorithm in the RSSI-based localization in indoor WSN. To perform this study and relevant analysis, initially the simple part of the algorithm is implemented as a server application to analyze the results of the experiments. To improve the precision of the localization algorithm, the results of experiments are evaluated and also the main effective parameter (Path-loss exponent and its relation with environmental condition) is considered. To show importance of the topic in previous research papers, the study also assesses, systematically, relevant papers which considered empirical studies in this context. Since this study is a continuation of the previous study in the Politecnico laboratory and company, it (this study) utilizes the network, sensors and developed software in the laboratory, applies 868 MHz radio signal frequency and Concentrator V1.0 as the sensor module (for moving object, fixed object, anchors and master node). The radio signal frequency (868 MHz) has been selected in previous studies due to points of energy consumption and low sensitivity against environmental conditions

1.2.RESEARCH METHODS:

Localization in WSNs is a wide concept with different methods and algorithms. Different experiments and studies try to find more precise position of a moving object. In this study, initially a common Literature Review (LR) is carried out to find out general information about "localization algorithms", "Wireless Sensor Networks" and "RSSI-based method". This LR is based on papers and literature that are prepared by the collaborating company, the supervisor and also ad-hoc search in scientific databases. Moreover, this LR continues during the software design, implementation and experiments. To support scientific phase of this study, "Systematic Mapping Study" forms the basis of our experiment. A close relation between different research methodologies in this thesis is made by: defining of dependent and independent variables (that are used in the planning phase of the experiments), considering different mathematical models for the environmental condition, how frequent is “applying experiment method” in the context of the RSSI-based localization and how frequent is “consideration of environmental condition effects” in the previous experiments. With this method we concentrated on three issues; thematic analysis, classification and identifying publication forums The last research method is experimentation. We wanted to develop software and analyze the results in limited scope and laboratory condition. Each experiment includes five steps: definition, planning, operation, analysis and package. The results of the experiments represent how accurate our localizations is and how much the distance error, with respect to different experiment planning, is.

RELATED WORK

The approaches in [38–43] studied both the target localization problems in both non-cooperative and cooperative WSNs (the terms non-cooperative and cooperative WSNs are used here to denote the localization problems in which the targets are permitted to exchange information with anchors only or any sensor node within their communication range (whether they are anchors or targets), respectively).

Nevertheless, these estimators are all based on RSS and range observations exclusively. The algorithms described in [36,44,45] are founded on the integration of RSS and ToA observations. Another hybrid system that combines range and angle measurements was studied in [46]. Two estimators for the non-cooperative target localization problem in a three-dimensional space were proposed in [46]: linear least squares (LS) and optimization based. The former is a relatively simple and well-known estimator, while the latter was solved by the Davidon–Fletcher–Powell algorithm [47]. In [48], an LS and a maximum likelihood (ML) estimator for a hybrid scheme that merges RSS difference (RSSD) and AoA observations were derived. To estimate the target’s location from multiple RSS and AoA observations, the authors in [48] used a non-linear constrained optimization. However, both LS and ML estimators are l-dependent, where l represents a non-negative weight assigned to regulate the contribution from RSS and AoA observations. In [49], the authors described a selective weighted LS (WLS) estimator for the RSS/AoA localization problem. The target location was determined by taking advantage of weighted ranges from the two nearest anchor observations. These were then integrated with the serving base station's AoA observation. Nonetheless, like [48], in [49], the authors only investigated the non-cooperative hybrid RSS/AoA localization problem in a two-dimensional space. Another WLS approach was proposed in [50]. This estimator was designed for a three-dimensional RSSD/AoA non-cooperative localization problem for unknown transmit power. Even so, the authors in [50] studied a small-scale WSN, with extremely low noise powers only. In [51], the authors presented an estimator founded on the semidefinite programming (SDP) relaxation technique for the cooperative target localization problem. The method in [51] is an extended version of the previous SDP algorithm, developed by the same authors, for pure range information into a hybrid one, by adding angle information for a triplet of points. Owing to the use of triplets of points, the computational complexity of the SDP approach grows significantly with the network size. Two estimators for the three-dimensional RSS/AoA localization problem in non-cooperative WSNs founded on thesecond-order one programming (SOCP) relaxation technique and squared-range (SR) approach to convert the localization problem into a generalized trust region sub-problem (GTRS) framework were proposed in [52]. The work in [53] addressed the RSS/AoA non-cooperative localization problem in two-dimensional non-line of sight (NLoS) environments. The authors in [53] proposed an alternating optimization algorithm, composed of fixing the value of the scatter orientation and solving the SDP representation of the localization problem and later using the obtained location estimate to update the value of the scatter orientation, for localizing a mobile target in a WSN. In [14,54], a cooperative RSS/AoA localization problem was investigated. The authors in both [14,54] proposed an SDP estimator to simultaneously localize multiple targets. However, the proposed algorithms are for centralized applications only, and their computational complexity depends highly on the network size. Distributed algorithms based on convex optimization techniques were proposed in [13,15,55] to solve the cooperative RSS/AoA target localization problem with unknown transmit powers in a large-scale WSN. Although the computational burden of the distributed approaches does not depend on the size of the network, but rather on the size of neighborhood fragments, they are executed iteratively, which makes them sensitive to error propagation and increases energy consumption.

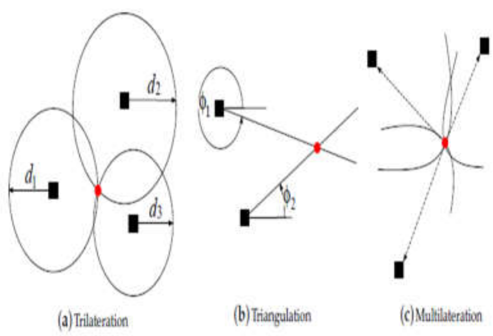


Figure 3. Illustration of geometric-based approaches.

DISTANCE ESTIMATION

Distance estimation between two nodes is an important function performed by range-based algorithms. A range-based algorithm estimates the position of a sensor node by using the distance information between the nodes which, in turn, is calculated using some physical measured quantity. The distances between dumb nodes and the beacon nodes are usually determined by adding some additional hardware to the nodes or by using the existing radio communication facility on the sensor nodes. Certain characteristics of wireless communication between dumb and beacon nodes are determined by the distance between them. If these characteristics are quantified and measured at the receiving sensor node, these can be used to estimate the distance between the nodes. The characteristics generally used for this purpose are: • Received Signal Strength Indicator (RSSI)

• Time of Arrival (ToA)

• Time Difference of Arrival (TDoA)

• Angle of Arrival (AoA)

RSSI:

In telecommunications, received signal strength indicator (RSSI) is a measurement of the power present in a received radio signal.[1] RSSI is usually invisible to a user of a receiving device. However, because signal strength can vary greatly and affect functionality in wireless networking, IEEE 802.11 devices often make the measurement available to users. RSSI is often derived in the intermediate frequency (IF) stage before the IF amplifier. In zero-IF systems, it is derived in the baseband signal chain, before the baseband amplifier. RSSI output is often a DC analog level. It can also be sampled by an internal ADC and the resulting codes available directly or via peripheral or internal processor bus In an IEEE 802.11 system, RSSI is the relative received signal strength in a wireless environment, in arbitrary units. RSSI is an indication of the power level being received by the receive radio after the antenna and possible cable loss. Therefore, the higher the RSSI number, the stronger the signal. Thus, when an RSSI value is represented in a negative form (e.g. −100), the closer the value is to 0, the stronger the received signal has been. RSSI can be used internally in a wireless networking card to determine when the amount of radio energy in the channel is below a certain threshold at which point the network card is clear to send (CTS). Once the card is clear to send, a packet of information can be sent. The end-user will likely observe a RSSI value when measuring the signal strength of a wireless network through the use of a wireless network monitoring tool like Wireshark, Kismet or Inssider. As an example, Cisco Systems cards have an RSSI maximum value of 100 and will report 101 different power levels, where the RSSI value is 0 to 100. Another popular Wi-Fi chipset is made by Atheros. An Atheros-based card will return an RSSI value of 0 to 127 (0x7f) with 128 (0x80) indicating an invalid value. There is no standardized relationship of any particular physical parameter to the RSSI reading. The 802.11 standard does not define any relationship between RSSI value and power level in milliwatts or decibels referenced to one milliwatt. Vendors and chipset makers provide their own accuracy, granularity, and range for the actual power (measured as milliwatts or decibels) and their range of RSSI values (from 0 to RSSI maximum).[2] One subtlety of the 802.11 RSSI metric comes from how it is sampled—RSSI is acquired during only the preamble stage of receiving an 802.11 frame, not over the full frame.[3]

As early as 2000, researchers were able to use RSSI for coarse-grained location estimates.[4] More recent work was able to reproduce these results using more advanced techniques.[5] Nevertheless, RSSI does not always provide measurements that are sufficiently accurate to properly determine the location.[6] However, RSSI still represents the most feasible indicator for localization purposes as it is available in almost all wireless nodes and it does not need any additional hardware requirements.[7] Received channel power indicator For the most part, 802.11 RSSI has been replaced with received channel power indicator (RCPI). RCPI is an 802.11[3] measure of the received radio frequency power in a selected channel over the preamble and the entire received frame, and has defined absolute levels of accuracy and resolution. RCPI is exclusively associated with 802.11 and as such has some accuracy and resolution enforced on it through IEEE 802.11k-2008. Received signal power level assessment is a necessary step in establishing a link for communication between wireless nodes. However, a power level metric like RCPI generally cannot comment on the quality of the link like other metrics such as travel time measurement (time of arrival).

TIME OF ARRIVAL

This technique of distance estimation uses the following relationship that relates the distance travelled by a signal to the time taken provided that the speed of propagation is known.

$d = v \times t$

where d is distance, v is speed of the signal and t is time taken by the signal to travel the distance d. Therefore, if the time taken by a signal to propagate from the beacon node to the dumb node, which is called time of arrival or time of flight is measured and speed of propagation of the signal is known, the distance and hence position of the dumb node can be calculated

TIME DIFFERENCE OF ARRIVAL (TDOA)

Time difference between the receiving of two signals at a node is easier to measure compared to time of arrival of a signal. This time difference information can then be used to estimate the distance between the two nodes. Advantage of using time difference instead of time of arrival is that errors in time difference measurement are tolerable and do not have a pronounced effect on the accuracy of estimation of distance between two nodes. As a result, the hardware required for time measurements is less complex and less costly and hence the method is also efficient in terms of energy consumption

ANGLE OF ARRIVAL

The direction of arrival of a signal at the dumb node can also be used to estimate its position. The direction of a received signal can be determined by measuring the angle it makes with some reference direction or orientation. Alternatively, the angle between the dumb node and the beacon node may be measured. For the localization of a dumb node using this technique, angles of arrival from a minimum of three beacon nodes are measured. Position information of three or more beacon nodes along with the three angles of arrival can be used to estimate the location of the dumb node.

SYSTEM MODEL:

The EM algorithm is a well-known iterative algorithm to perform maximum likelihood estimation in hidden Markov models [10]. Each iteration of this algorithm consists in a Estep where the expectation of the complete data log-likelihood (log of the joint distribution of the states and the observations) conditionally to the observations is computed; and a M-step, which updates the parameter estimate

Algorithm 1 Bootstrap_filter_recursion (BFR)

Require: $\{\xi_{t-1}^{\ell}, \omega_{t-1}^{\ell}\}_{\ell=1}^{N}$, Y_t, θ.
1: **for** $p = 1$ to N **do**
2: Draw I in $1, \ldots, N$ with probabilities proportional to $\{\omega_{t-1}^{\ell}\}_{\ell=1}^{N}$.
3: Sample $\xi_t^p \sim q(\xi_{t-1}^{I}, \cdot)$.
4: Set $\omega_t^p \propto g_\theta(\xi_t^p, Y_t)$.
5: **end for**
6: **return** $\{\xi_t^p, \omega_t^p\}_{p=1}^{N}$

Algorithm 2 BOEM_SLAM_indoor

Require: θ^0, $\{\tau_k\}_{k\geq 1}$, $\{Y_t\}_{t\geq 0}$, N, N_b.
1: Set $\bar{\theta} = \tilde{\theta} = \theta^0$.
2: Sample $\{\bar{\xi}_0^p\}_{p=1}^{N}$ and $\{\tilde{\xi}_0^p\}_{p=1}^{N}$ independently and uniformly in C.
3: Set $\bar{\omega}_0^p = \tilde{\omega}_0^p = \frac{1}{N}$ for all $p \in \{1, \ldots, N\}$.
4: Set $\rho_0^p = 0$ for all $p \in \{1, \ldots, N\}$, $k = 1$, $T_0 = 0$, $T_1 = \tau_1$.
5: **for all** $t \geq 1$ **do**
6: *Selection and propagation step.*
7: Set $\{\bar{\xi}_t^p, \bar{\omega}_t^p\}_{p=1}^{N} = BFR\left(\{\bar{\xi}_{t-1}^{\ell}, \bar{\omega}_{t-1}^{\ell}\}_{\ell=1}^{N}, Y_t, \bar{\theta}\right)$
8: Set $\{\tilde{\xi}_t^p, \tilde{\omega}_t^p\}_{p=1}^{N} = BFR\left(\{\tilde{\xi}_{t-1}^{\ell}, \tilde{\omega}_{t-1}^{\ell}\}_{\ell=1}^{N}, Y_t, \tilde{\theta}\right)$
9: *Position estimations.*
10: Set $\bar{p} = \underset{p\in\{1,\ldots,N\}}{\operatorname{argmax}} \bar{\omega}_t^p$ and $\bar{X}_t = \bar{\xi}_t^{\bar{p}}$.
11: Set $\tilde{p} = \underset{p\in\{1,\ldots,N\}}{\operatorname{argmax}} \tilde{\omega}_t^p$ and $\tilde{X}_t = \tilde{\xi}_t^{\tilde{p}}$.
12: *Forward computation of the intermediate quantity*
13: **for** $p = 1$ to N **do**
14: Compute $\{\rho_t^p\}_{p=1}^{N}$ following (11).
15: **end for**
16: *Map estimation.*
17: **if** $t = T_k$ **then**
18: Set

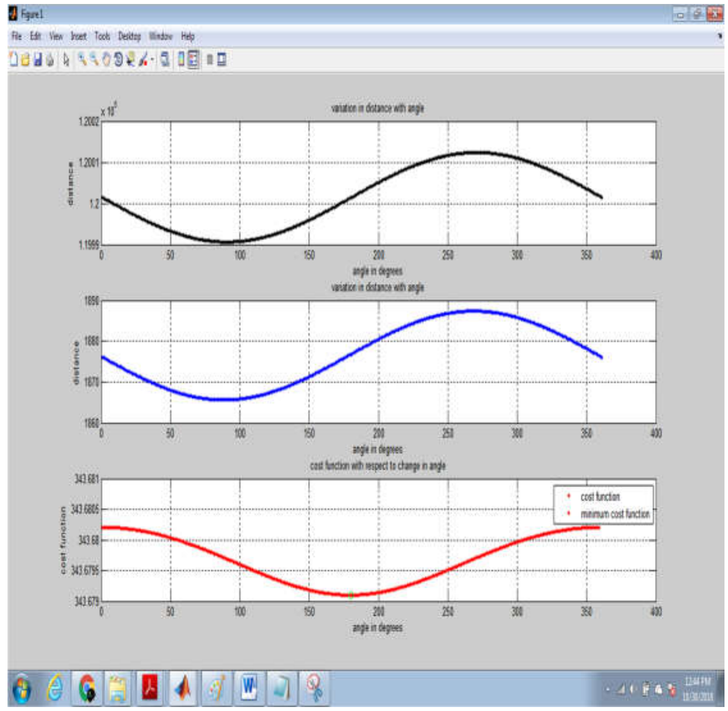
$$\bar{S}_k = \sum_{p=1}^{N} \bar{\omega}_t^p \rho_t^p .$$

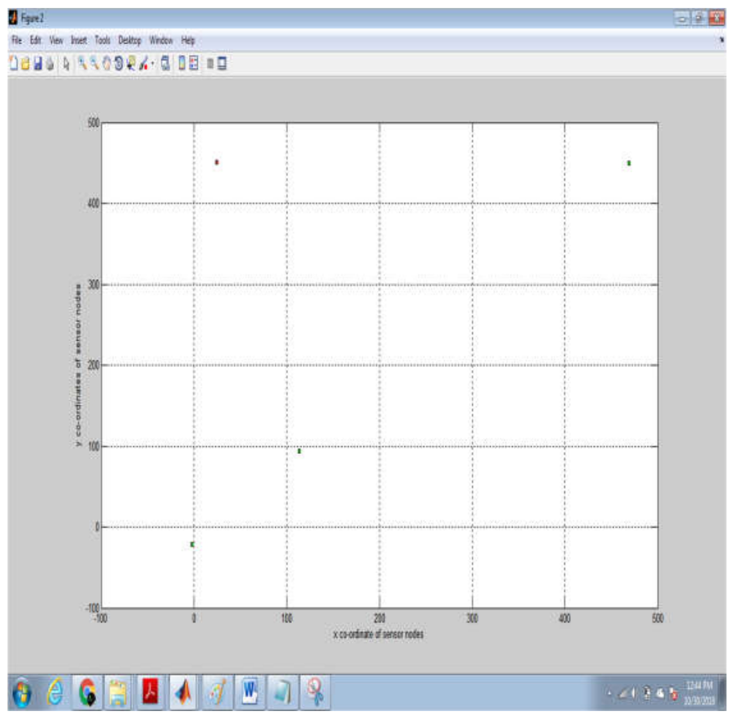
19: $\bar{\theta} = \bar{\theta}(\bar{S}_k, \tau_k)$.
20: Set $\rho_t^p = 0$ for all $p \in \{1, \ldots, N\}$.
21: **if** $k = 1$ **then**
22: Set $\tilde{S}_k = \bar{S}_k$.
23: **else**
24: Set

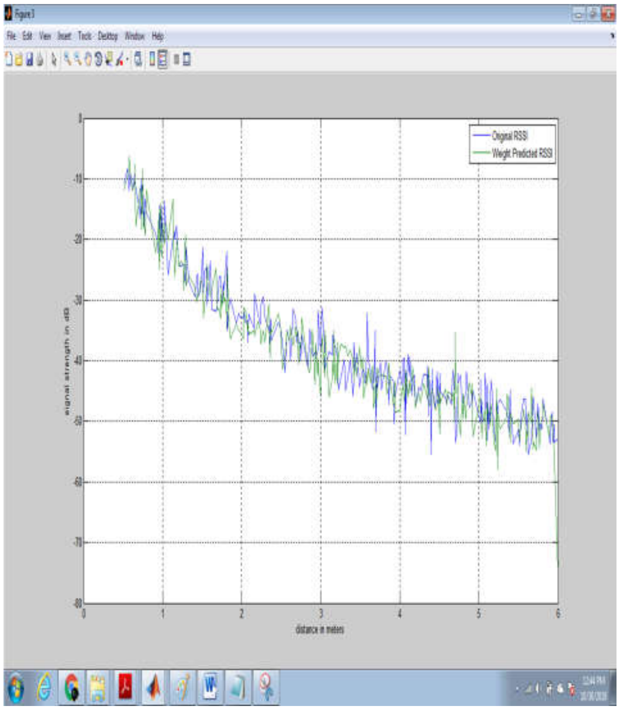
$$\tilde{S}_k = \left(T_{k-1}\tilde{S}_{k-1} + \tau_k \bar{S}_k\right)/T_k .$$

25: **end if**
26: $\tilde{\theta} = \tilde{\theta}(\tilde{S}_k, T_k)$.
27: *Stabilization step.*
28: **if** $k = 0$ mod N_b **then**
29: Set $\bar{\theta} = \tilde{\theta}$
30: **end if**
31: $k = k + 1$ and $T_k = T_{k-1} + \tau_k$.
32: **end if**
33: **end for**

SIMULATION RESULTS:







CONCLUSION

In this paper we propose a stabilized version of the BOEM algorithm to estimate the signal propagation maps needed in any WiFi based localization system. The main difference with the existing solutions is that these propagation maps are estimated using the data sent by the mobile device originally used for localization purposes. On the contrary, the existing WiFi based localization systems establish these propagation maps either in a deterministic way or by running a previous hand made survey. In case of environmental modifications, the propagation maps are thereby changed. Our technique can easily be adapted to these changes by regularly reinitializing the sufficient statistics while hand made survey based systems can not take into account these modifications without renewing the survey.

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