

# **An Indoor Localization System Design Using RSSI and RFID Signals for Security Purpose by Distance Analysis**

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**ABSTRACT:** A global indoor localization system based on the radio frequency identification (RFID) technology. A reader, installed on the robot, measures the received signal strength indication (RSSI) and the phase shift of UHF-RFID signals coming from a set of passive tags deployed on the ceiling of the environment. The position of the tags in the environment is only roughly known at the beginning. Exploiting the complementary features of RSSI and phase-shift information in RFID signals, a multi hypothesis extended and unscented Kalman filter is proposed to localize the robot and to simultaneously improve the initial estimate on the tag coordinates. The simulative and experimental results are reported to illustrate the effectiveness of the proposed approach. THE localization of mobile robots using radio frequency identification (RFID) has received a considerable attention in the last few years see among many others. In many cases, the localization system is realized by installing a reader on the robot and by providing the environment with a certain number of tags placed in known position. In particular, when using passive tags, a list of appealing features can be pointed out: tags are cheap, virtually maintenance free, and can be univocally identified by the reader, bypassing the well-known data association problem. RFID data used for localization vary from a binary information the tag detection to a more complete set of information, like received signal strength indication RSSI or phase shift of the signal.

## **I. INTRODUCTION**

Global indoor localization system based on the radio frequency identification (RFID) technology. A reader, installed on the robot, measures the received signal strength indication (RSSI) and the phase shift of UHF-RFID signals coming from a set of passive tags deployed on the ceiling of the environment. The position of the tags in the environment is only roughly known at the beginning. Exploiting the complementary features of RSSI and phase-shift information in RFID signals together with odometer data, a multi hypothesis extended and unscented Kalman filter is proposed to localize the robot and to simultaneously improve the initial estimate on the tag coordinates. Localization of mobile robots using radio frequency identification (RFID) has received a considerable attention in the last few years among many others. In many cases, the localization system is realized by installing a reader on the robot and by providing the environment with a certain number of tags placed in known position. In particular, when using passive tags, a list of appealing features can be pointed out: tags are cheap, virtually maintenance free, and can be univocally identified by the reader, bypassing the well-known data association problem. RFID data used for localization vary from a binary information i.e., the tag detection to a more complete set of information, like received signal strength indication (RSSI) or phase shift of the signal.

The phase shift of RFID signals is very sensitive to the tag-reader distance with a variation at the frequency considered in this paper of about 2 mm. However, due to the high sensitivity of the phase measurements on the tag reader distance and to the cycle ambiguity in the phase measurements a cycle ambiguity in fact characterizes phase measurements, since an unknown number of full wavelengths are contained in the tag-reader distance and several possible distances would produce the same phase, small errors even in the order of a couple of centimeters in the

estimate of the tag positions could completely invalidate the system. From a practical point of view, this could require a laborious preparation of the environment and a calibration phase before the system can properly work.

## II. LITERATURE REVIEW

### **2.1 Tracking autonomous entities using RFID technology:** Dr.SamadAhmadi, De Montfort

GPS seems to be the best solution to develop outdoor location systems, but performance of these systems is not good enough to locate entities within indoor environments, mainly if accuracy and precision are required. In this article we propose a tracking indoor system based on passive RFID technology that is able to accurately locate autonomous entities, such as robots, people, etc, within a defined surface. In order to validate the proposal, we compared our system technology performance against other alternatives built on different technologies Wi-Fi, Bluetooth, IrDA, ultrasound, the system evaluation and final remarks with future improvements.

### **2.2 Efficient Object Localization Using Sparsely Distributed Passive RFID Tags:** Dr Bo Ai, Beijing Jiao tong , Francisco J. Bellido

Radio-frequency widely used in passive RFID localization application due to its flexible deployment and low cost. To resolve this problem, based on road traverses and a linear heading-change model, an MM algorithm that considers historical information is proposed. However, current passive RFID localization systems cannot achieve both highly accurate and precise moving object localization task owing to tag collisions and variation of the behaviour of tags. Most researchers increase the density of tag distribution to improve localization accuracy and then consider using either anti-collision process embedded in the hardware of the RFID reader .However, advanced anti-collision processes for RFID devices are challenged by the physical constraint characteristics of radio frequency; and improved localization algorithm cannot fundamentally reduce the impacts of tag collision on localization precision. This research work attempts to improve localization precision RFID localization using sparsely distributed RFID tags. This paper first defines a measure for accuracy and precision in a passive RFID localization system with regard to RFID tag distribution. An exponential-based function is then derived from experimental measurements, which reflects the relationship between RFID tag distribution and localization precision. This function shows that localization precision is mainly determined by tag density of RFID tag distribution. Based on the experimental findings, a sparse RFID tag distribution approach is proposed.

### **2.3 Passive UHF-RFID System for the Localization of an Indoor Autonomous Vehicle:** Yeong-Kang Lai, Jong-Hyouk Lee, Yong-Tae Lee

A global localization system combining odometry data with radio frequency identification (RFID) readings is proposed. RFID tags are placed at the ceiling of the environment and can be detected by a mobile robot unit traveling below them. The detection of the tags is the only information used in the proposed approach, but differently from similar localization setups reported in the literature, only a small number of tags are used. This is possible using a suitable tag's antenna in ultrahigh frequency band, expressly designed to obtain regular and stable RFID detection regions, which allows us to consider an efficient Kalman filtering approach to fuse RFID readings with the vehicle odometry data. A satisfactory performance is achieved, with an average position error of about 0.1 m. The hardware/software localization setup described in this paper is cheap and easy to use and may provide a satisfactory approach in several industrial and domestic scenarios. The detection of the tags is the only information used in the proposed approach, but differently from similar localization setups reported in the literature, only a small number of tags are used. Describe how Radio Frequency Identification(RFID) can be used in robot-assisted indoor navigation for the visually impaired.

### **2.4 A Standalone RFID Indoor Positioning System Using Passive Tags:** Scott Linfoot, Andrés MarínLópez, Joonki Paik

Indoor positioning systems (IPSs) locate objects in closed structures such as office buildings, hospitals, stores, factories, and warehouses, where Global Positioning System devices generally do not work. Most available systems apply wireless concepts, optical tracking, and/or ultrasound. This paper presents a standalone IPS using radio frequency identification (RFID) technology. The concept is based on an object carrying an RFID reader module, which reads low-

cost passive tags installed next to the object path. A positioning system using a Kalman filter is proposed. The inputs of the proposed algorithm are the measurements of the backscattered signal power propagated from nearby RFID tags and a tag-path position database. The proposed algorithm first estimates the location of the reader, neglecting tag-reader angle-path loss. Based on the location estimate, an iterative procedure is implemented, targeting the estimation of the tag-reader angle-path loss, where the latter is iteratively compensated from the received signal strength information measurement.

### **2.5 Self-Recognition of Vehicle Position Using UHF Passive RFID Tags:** Fernando PescadordelOso, Ulrich Reiter

A method that enables self-recognition of a mobile vehicle's current position by utilizing ultrahigh frequency (UHF) passive radio-frequency identification (RFID) tags. The proposed method can be used in real industry environments such as complex storage warehouses where many different goods are dispersed throughout a wide area. In particular, the proposed method makes use of two UHF RFID readers with identical emission configuration attached to a vehicle to identify a reference RFID tag. By utilizing the received signal strength indicator obtained by the readers from the reference RFID tag, the precise position of the moving vehicle can be obtained. The experiments prove the effectiveness of the proposed method in accurately estimating the vehicle position.

### **2.6 Mobile Robot Localization Using the Phase of Passive UHF RFID Signals:** EmidioDiGiampaolo and Francesco Martinelli

A global localization system for an indoor autonomous vehicle equipped with odometry sensors and a radio-frequency identification (RFID) reader to interrogate tags located on the ceiling of the environment. The RFID reader can measure the phase of the signals coming from responding tags. This phase has non-univocal dependence on the distance robottag, but in the considered frequency, it is really sensitive to a change in the position of the robot. In the experimental tests, an average position estimation error of about 4 cm is achieved using only two tags for an area of about 5 m<sup>2</sup>. While WSN-based streetlights have been designed and tested for several years, since every streetlight an approximate initial information on the position of the tags is required, even if errors up to about 1 m can be tolerated by the algorithm. A more difficult problem, however, arises if at the beginning, the tag coordinates are Completely unknown and must be estimated together with the robot pose. This kind of situation is known in the literature by simultaneous localization and mapping (SLAM). Compared with the localization literature, only a few papers deal with SLAM using the RFID technology. As pointed out in, the limited accuracy in RFID data excludes the possibility of applying well-established SLAM approaches in this context. This is particularly true when RFID tags are used as binary sensors. For this reason, a multi hypothesis Kalman filtering approach provides a really satisfactory performance even in the case that a very small density of tags is used.

### **2.7 Constrained Kalman Filtering for Indoor Localization of Transport Vehicles Using Floor-Installed HF RFID Transponders:** ChristofRöhrig, Daniel Heß, Frank Künemund

Localization of transport vehicles is an important issue for many intralogistics applications. The paper presents an inexpensive solution for indoor localization of vehicles. Global localization is realized by detection of RFID transponders, which are integrated in the floor. The paper presents a novel algorithm for fusing RFID readings with odometry using Constraint Kalman filtering. The paper presents experimental results with a Mecanum based omnidirectional vehicle on a NaviFloor installation, which includes passive HF RFID transponders. The experiments show that the proposed Constraint Kalman filter provides a similar localization accuracy compared to a Particle filter but with much lower computational expense. Approximate information on the tag coordinates is available at the beginning, resulting, e.g., from handmade measurements or from an ad hoc approach, like a multilateration procedure based on RSSI measurements taken from a certain number of known positions of the reader. Second, the effect of the multipath and of other measurement uncertainties like the approximations just discussed on the antenna gains will be captured through a measurement error  $n_{RSSI}$  in such a way that, in dB, it will be possible to write. However, as is common in the literature, the methodology proposed in developed by assuming, unlike in this paper, that the positions of the antennas of the localization system are all exactly known at the beginning. Under this assumption, also the approach proposed in can be considered to obtain satisfactory results. In this paper, an approximate initial information on the position of the tags is required.

### **III. PROPOSED SYSTEM**

A global indoor localization system based on the radio frequency identification (RFID) technology. A reader, installed on the robot, measures the received signal strength indication (RSSI) and the phase shift of UHF-RFID signals coming from a set of passive tags deployed on the ceiling of the environment. The position of the tags in the environment is only roughly known at the beginning. Exploiting the complementary features of RSSI and phase-shift information in RFID signals (together with odometry data), a multihypothesis extended and unscented Kalman filter is proposed to localize the robot and to simultaneously improve the initial estimate on the tag coordinates. The simulative and experimental results are reported to illustrate the effectiveness of the proposed approach.

Modern embedded systems are often based on microcontrollers CPUs with integrated memory and/or peripheral interfaces but ordinary microprocessors using external chips for memory and peripheral interface circuits are also still common, especially in more complex systems. In either case, the processor used may be types ranging from rather general purpose to very specialized in certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP). The key characteristic, however, is being dedicated to handle a particular task. To reduce the prediction error of the IMM setup, this paper imports an iterated geometrical error detection method based on GIS data. The assumption that the automobile will remain on the road is made; therefore, the predictions of future locations that fall outside are corrected accordingly, making a great reduction to the prediction error. For a long range obstacle avoidance system, other types of sensors need to be implemented.

#### **1.1 LCD**

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images as in a general-purpose computer display or fixed images with low information content which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

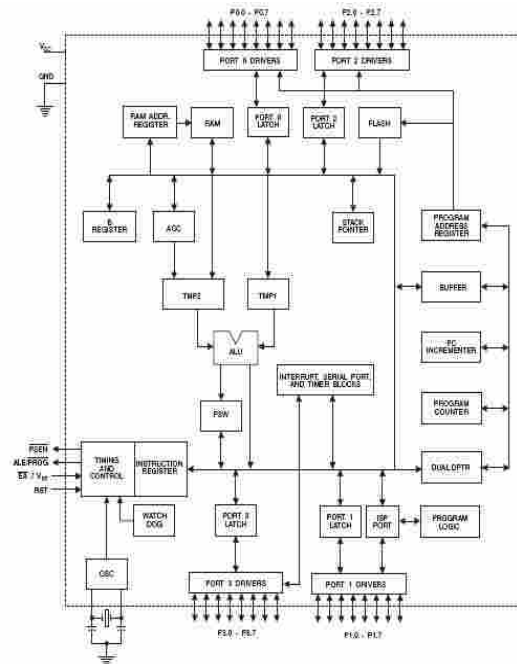
#### **1.2 GSM**

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones. Global System for Mobile Communications, originally Groupe Spécial Mobile, is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991. As of 2014 it has become the default global standard for mobile communications - with over 90% market share, operating in over 219 countries and territories.

#### **1.3 MICROCONTROLLER**

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a AVR small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of storage, as opposed to one-time programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time. The AVR is a modified Harvard architecture machine where program and data are stored in separate physical memory systems that appear in different address spaces, but having the ability to read data items from program memory using special instructions.



**Figure 1: Architecture of ATMEL AT89S52 microcontroller**

### 1.3.1 FEATURES OF ATMEL AT 89S52

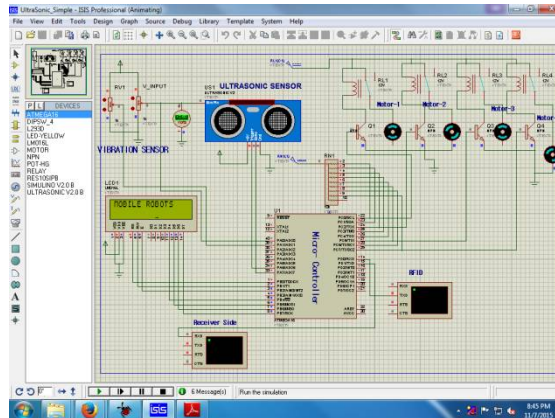
- Compatible with MCS-51 Products
- 8 Kbytes of In-System Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 256 x 8-Bit Internal RAM

### 1.3.2 DESCRIPTION OF AT89S52

The AT89S52 provides the following standard features: 8Kbytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counters, six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the AT89S52 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

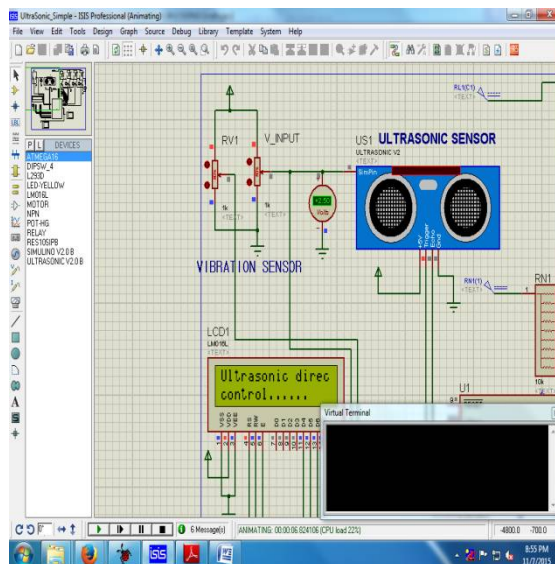
## IV. RESULT AND DISCUSSION

**OUTPUT DESIGN:** A global indoor robot localization system based on the RFID technology has been proposed in this paper. A reader, installed on board the robot, measures the RSSI and the phase shift of UHF-RFID signals coming from a set of passive tags deployed on the ceiling of the environment, whose density is relatively low compared with other indoor RFID localization approaches proposed in the literature and whose position is only roughly known at the beginning.



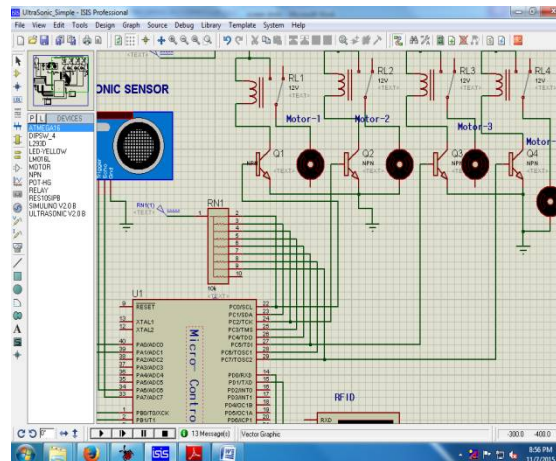
**Figure 2: System Design**

The RSSI and the phase can be considered two redundant measurements of the same quantity: the distance of the robot from the projection of the tag on the floor. The information delivered by these two quantities presents different features, for some aspects complementary.



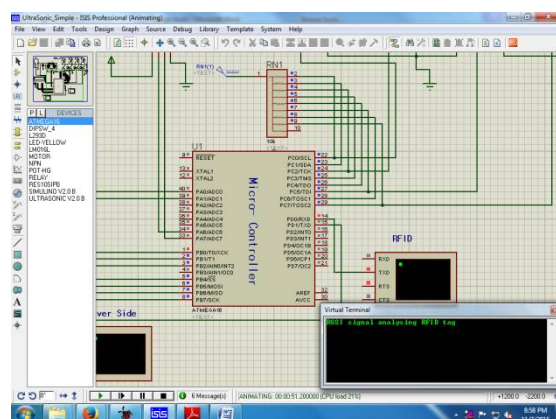
**Figure 3: Ultrasonic sensor direct control**

The optimal combination of the two measurements is not straightforward and represents a challenging problem, dual in a sense to the problem of the dynamic allocation of redundant actuators. An effective solution is proposed in this paper by considering an algorithm characterized by two stages: in the first stage, only the RSSI is used for estimation purposes, while in the second stage, also the phase measurements are considered. A dynamic criterion, based on the observation of the variance of the estimation of the tag coordinates, is adopted to decide the switching time between the two stages, which is performed independently on each tag. Ultrasonic sensors can detect movement of targets and measure the distance to them in many automated factories and process plants. Sensors can have an on or off digital output for detecting the movement of objects.



**Figure 4: Inoperative Condition**

The proposed two-stage algorithm estimates the robot pose and simultaneously improves the estimate on the tag coordinates. Errors up to about 1 m can be tolerated by the algorithm on the initial estimate of the tag positions. If no information is available at the beginning on the tag coordinates. With access control, version control, bug and feature trackers, mailing lists and wikis, Atmel Spaces provides a secure and efficient place for sharing design tips, tricks and resources and for tracking progress of projects with your peers. You can access Atmel Spaces at [spaces.atmel.com](http://spaces.atmel.com) or directly from Atmel Studio with an extension available in Atmel Gallery.



**Figure 5: Acknowledgment to Terminal**

Phase measurements are more sensitive than the RSSI to a change in the robot position but suffer from a cycle ambiguity. Extreme Burner AVR is a High Quality but low cost USB port based programmer for the popular AVR18F and AVR16F series MCUs. The main advantage of Extreme Burner AVR over other programmer is the USB connectivity. These days Laptops are becoming popular among students and professionals. Modern Laptops and even desktops does not have any legacy ports like Parallel and Serial Ports and therefore many device programmers cannot be used with them. So solve this problem we have designed a programmer that is far ahead of these programmers and perfectly fits in modern days which complicates matters. Range only SLAM techniques could be considered to solve the problem, capitalizing on the ideas presented in this paper to properly combine RSSI and phase measurements.

#### IV. CONCLUSION

A reader, installed on board the robot, measures the RSSI and the phase shift of UHF-RFID signals coming from a set of passive tags deployed on the ceiling of the environment, whose density is relatively low compared with other indoor RFID localization approaches proposed in the literature and whose position is only roughly known at the beginning. The RSSI and the phase can be considered two redundant measurements of the same quantity the distance of the robot from the projection of the tag on the floor. However, the information delivered by these two quantities presents different features, for some aspects complementary: phase measurements are more sensitive than the RSSI to a change in the robot position but suffer from a cycle ambiguity, which complicates matters. The optimal combination of the two measurements is not straightforward and represents a challenging problem, dual in a sense to the problem of the dynamic allocation of redundant actuators. An effective solution is proposed in this paper by considering an algorithm characterized by two stages: in the first stage, only the RSSI is used for estimation purposes, while in the second stage, also the phase measurements are considered. A dynamic criterion, based on the observation of the variance of the estimation of the tag coordinates, is adopted to decide the switching time between the two stages, which are performed independently on each tag. The proposed two-stage algorithm estimates the robot pose and simultaneously improves the estimate on the tag coordinates. Errors up to about 1 m can be tolerated by the algorithm on the initial estimate of the tag positions. If no information is available at the beginning on the tag coordinates, range only SLAM techniques could be considered to solve the problem.

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