Indoor Mapping Using RFID

Atharva Chandorkar[1], Shivam Mishra[2], Vinit Badhe[3], Anurag Singh[4]
Shailaja Kadam [5]

Students, Dept. of Electronics, Terna College of Engineering Nerul, Maharashtra, India

Abstract – ***Indoor*** *mapping using RFID technology is a challenging task. A location and tracking system become very important to our future world of pervasive computing, where information is all around us. Location is one of the most needed types of information for emerging and future applications. There are some of the challenges that include the efficiency of energy, communication interference, fault tolerance, higher capacities to handle data processing, cost feasibility, and an appropriate integration of these factors. Another paper suggests that the orientation of the tag concerning the receiver influences signal energy, and less energy might not power the chip inside the tag leading to no response.*

1. INTRODUCTION

In recent years, the rise of the Internet of Things (IoT) has brought great convenience to our lives. Using a local network or Internet communication technology, we can connect sensors, controllers, machines, persons, and objects through IoT technology to obtain information, for remote management, control, and services. At present, object location awareness is a very important part of the IoT's application, but it cannot obtain this through traditional satellite and cellular
location with GPS in indoor environments. To implement indoor positioning, there are many different
technologies, such as WIFI, Radio Frequency Identification (RFID), and so on.

RFID technology can be used in many fields, such as warehouse asset management, product tracking, supply chain management, anti-counterfeiting identification, healthcare, and so on. With the development of RFID technology, RFID indoor positioning has been selected as one of the indoor wireless location technologies, and its development has been rapid. RFID technology has many advantages for positioning, such as low cost, lightweight, and multiple tag identification. However, there are still some problems to be solved for RFID indoor positioning. The RFID technology positioning system usually consists of antennas, tags, readers, and positioning algorithms. The following algorithms are among the RFID-based indoor
positioning algorithms: Time of Arrival (TOA), Time Difference of Arrival (TDOA), Angle of Arrival (AOA), and Received Signal Strength Indication (RSSI).

Compared to TOA and TDOA, the RSSI-based RFID positioning algorithm does not require a strict synchronization mechanism between the tag and the reader, making it easy to implement, and its positioning accuracy is within a reasonably acceptable range.

2. LITERATURE SURVEY

RFID is a term used to define wireless non-contact use of radio frequency electromagnetic fields to transfer identification data of an object to identify and track. The data is stored in tags which an electronic data storage devices like smart cards [1].

On the other hand, unlike smart card systems, the power needed for both tags and transferring data between reader and tag is provided by the use of a non-contact electromagnetic field. A reader is required to receive data from a tag. A reader loads energy to its antenna to make it transmit radio signals for activating tags and receiving data from tags. An activated tag transmits its data [2].

The antenna provides communication between the reader and tag and some properties differ such as frequency range which affects the performance of the system depending on the shape and size of the antenna. RFID tags can be either active or passive according to the power source. An active tag has its power source generally obtained from a battery and this kind of tag transmits its ID periodically. A passive tag gets its power from the signal of the reader. Two fundamental components of an RFID system are the reader and the tag [3].

Besides this, antennas, computers, and database systems are used to make the system more effective. Another important issue is the frequency range of the reader. Available frequencies are LF (Low Frequency), HF (High Frequency), and UHF (Ultra High Frequency). In addition, frequency ranges such as SHF (Super High frequency) or microwave can be used [4].

Another method is to illustrate the operational principles of a typical passive RFID system, where the power source for a passive RFID tag is provided by the reader. When a radio signal is transmitted from the reader and the RFID tag enters the reader's signal field, it is powered on by the signal. The reader subsequently captures the ID and data from the tag and sends this information to a host computer. The computer, equipped with RFID middleware, processes the data and sends it back to the reader, which, in turn, transmits the processed data to the tag. Passive RFID systems are typically used for applications with shorter reading ranges.

In the case of a semi-passive RFID system, the principles are similar to those of a passive system, but with the addition of a battery embedded in the semi-passive RFID tag. This battery serves as an onboard power source for the telemetry and sensor asset monitoring circuits of the tag, providing the tag with more power for communication. However, it's important to note that this onboard power is not directly used to generate radio frequency (RF) electromagnetic energy, distinguishing semi-passive systems from fully active RFID systems. Semi-passive tags use the battery to support additional features and functions beyond what passive tags can provide, while still relying on external RF signals for power [5].

The "RFID Indoor Positioning Algorithm Based on Bayesian Probability and K-Nearest Neighbor" is a sophisticated positioning system designed for indoor environments. It leverages RFID technology to precisely locate objects or individuals within buildings. This algorithm combines the principles of Bayesian probability and K-Nearest Neighbor (KNN) to determine the position of RFID-tagged entities. Through KNN, it selects the most relevant reference tags based on proximity, applies a Gaussian filter to reduce noise in the collected data, and utilizes Bayesian probability to estimate the final position accurately. This approach addresses the challenges of fluctuating Received Signal Strength (RSS) values in indoor settings, making it a valuable tool for applications such as indoor navigation, asset tracking, and environmental monitoring, where precise location information is crucial [6].

The development of an indoor navigation system of an autonomous mobile robot using image processing methods of industrial television. The system analyzes the surrounding space with a simple monocular TV camera. Color beacons placed on objects in the environment are used as reference points. The developed system is tested under different environmental conditions. The mobile robot navigation accuracy is evaluated in the case of the simultaneous detection of two beacons [7].

We also study a novel high-precision positioning algorithm that was proposed by using Visible Light Communication (VLC) with only a simple and single receiver. The received voltage-level difference with multi-level modulation was adopted as the input variable, to minimize the negative consequences of noise. Then, the relationship between the received voltage-level difference, noise, and position was developed based on the optical propagation model. The minimum mean squares error algorithm and extended Kalman filter were employed to improve the accuracy of the optical model and achieve high performance. Using the developed algorithm, high-accuracy results with a 0.9 cm average position error in the simulation and a 2.56 cm average position error in the practical experiments were obtained. An indoor navigation system based on visible light communication (VLC) technology is proposed in this paper. Indoor positioning is realized by a received-signal-strength (RSS)-based method using modulated light-emitting-diodes (LEDs). In addition to the simple positioning, we use Kalman and particle filters to give the system tracking capability. Simulation results show that particle filtering converges to the true track faster than Kalman filtering, at the price of higher computational complexity [8].

Lora WAN, or Long-Range Wide Area Network, is a wireless communication protocol designed for long-range communication with low-power devices. It's commonly used in the Internet of Things (IoT) for various applications, including asset tracking. Lora WAN enables efficient and long-range communication between low-power devices, such as

asset trackers, and a central server. Asset trackers equipped with Lora WAN technology can transmit location and sensor data over significant distances, making them suitable for tracking assets in diverse environments. Lora WAN offers an extended communication range, making it suitable for tracking assets across large areas. It can operate on low power, leading to extended battery life for asset trackers. It supports a large number of devices, making it scalable for widespread asset-tracking deployments, and is relatively cost-effective compared to some alternatives, making it a viable solution for asset-tracking applications [9].

Firstly, this work presents an up-to-date application of IPSs and the wireless technologies that can be used for IPS. Then, UWB characteristics and principles of position estimation methods and algorithms are discussed. The second objective of this article is to present a review of the NLoS signal's effects on the UWB positioning system. Finally, the article discusses the existing ML algorithms used to classify or mitigate the positioning error caused by NLoS signals and the main challenges for further work. The key contributions of this work are as follows:

This work provides a detailed survey of the most common wireless communication-based technologies for IPSs and evaluates these technologies using an evaluation framework to highlight their pros and cons.

This paper provides a detailed discussion of various principles of position estimation methods that can be used for IPS and highlights the advantages and limitations of using algorithms for UWB IPSs.

In addition, this paper presents a detailed explanation of UWB. Then, it presents an overview of the unique characteristics of UWB technology and the challenges still faced by IPS implementation.

This paper also presents an exhaustive review of the non-line-of-sight (NLoS) signal's effects on the UWB positioning system and discusses the existing ML algorithms used to classify or mitigate the positioning error caused by NLoS signals and the main challenges for further work.

Finally, this work surveys and discusses the emerging state-of-the-art ML-based research efforts in solving the challenge associated with NLoS effects for the UWB presented and summarizes the existing popular ML algorithms for UWB IPS NLoS classification and mitigation, such as k-NN, SVM, DT, NB, and NN [10].

UWB technology has become a popular choice for precise location estimation in Underived positioning and navigation systems mainly due to its high-accuracy localization capability, i.e., typically at around 10 cm to 20 cm. Many surveys and reviews in the literature have explored various aspects of UWB technology, including its theories, techniques, the technology itself, its applications, and its future perspective. Compared to other technologies, UWB transmits over a broad frequency spectrum between 3.1 GHz and 10.6 GHz (Ramos et al., 2016). It uses nano-pulses of about two nanoseconds which are easy to distinguish from reflections (Shi & Ming, 2016). This enables an accuracy of up to ±10 cm at LOS (Line of Sight) by calculating Toa, TDOA, and AoA [11].

SLAM (Simultaneous Localization and Mapping) relies on sensors like cameras and depth sensors to build a map of the environment while simultaneously determining the device's location within it. SLAM algorithms process the sensor data to construct a real-time map, enabling applications such as indoor navigation, augmented reality, and robotics to understand and navigate indoor spaces autonomously.

SLAM is crucial in scenarios where GPS signals are unavailable or unreliable, making it a powerful tool for mapping and navigating indoor environments with precision. These features are crucial for the SLAM algorithm to track and understand the surroundings. Here are some common types of features:

Corners: Points where edges intersect, providing strong and distinctive features.

Edges: Linear features in the environment that can be easily identified.

Surfaces: Planar regions or surfaces with consistent textures that can serve as landmarks.

Key points: Specific points in an image that are selected for their uniqueness and repeatability.

Descriptors: Information associated with key points that helps differentiate one key point from another. Landmarks: Points in the environment that serve as reference points for navigation.

These features are extracted from sensor data, such as images from cameras or depth information from sensors, and they play a crucial role in constructing and updating the map while simultaneously determining the device's location within that map in real time. The ability to accurately identify and track features is fundamental to the success of SLAM algorithms in various applications, including indoor mapping and navigation [12].

An RFID-based navigation system for in-building navigation for blind people. The proposed system helps blind people to find the shortest path from their current location to a destination. It also helps them when they get lost by automatically detecting the loss and recalculating a new route to the same destination. The proposed system embeds RFID tags into a footpath that can be read by an RFID reader with a cane antenna. The proposed work can also be used as a tourist guide system for a museum or a navigation system for rescue in hazardous environments where it is difficult to find an emergency exit [13].

Typically, an RFID system consists of a reader, tags, and a computer that holds and processes the tag's information. In general, RFID tags can be classified into active, passive, and semi-passive tags. Active tags embed an internal battery that continuously powers themselves and their RF communication circuitry. Readers can thus transmit very low-level signals, and the tag can reply with high-level signals. Tags without battery are called passive tags. Generally, it backscatters the received carrier signal from a reader. Passive tags have a smaller size and are cheaper than active tags, but have very limited functionalities. The third type is semi–passive tags. These tags communicate with the readers in the same way as passive tags but they embed an internal battery that constantly powers their internal circuitry. Low-cost systems usually use passive tags instead of active tags [14].

Each RFID tag is attached to a location in a building as a location information reference. The RFID reader is attached to a firefighter and an inertial sensor system. When a firefighter moves, the inertial sensor records the movement and estimates the location of the firefighter. The location of the firefighter is adjusted when he passes through the point of location reference which is the location of RFID tags. The feasibility study of such a navigation system has shown that it is possible to locate users in a building with a location error of 10% - 15% of the distance between waypoints. Another RFID-based navigation system is proposed for a user-friendly guidance system for disabilities [15].

3. CONCLUSION & FUTURSCOPE

A Radio Frequency Identification (RFID) based approach that performs an object level mapping of the indoor environment using a portable RFID reader, RFID Ultra High Frequency (UHF) passive tags. This approach identifies each object in the indoor environment using one or more passive tags. Towards the goal of adopting an RFID system as a good solution for indoor localization, a low-complexity and low-cost algorithm for indoor positioning, has been introduced.

A system prototype that includes RFID tags embedded in a footpath block, the embedded system as a navigation device, and a navigation server that is remotely connected to the device via the Internet. The system prototype has shown a promising result although its size is still large.

4. REFERENCES

1. *Meers S, Ward K (2005) A substitute vision system for providing 3d perception and GPS navigation via electro tactile stimulation.*
2. *Koyuncu H, Yang SH (2010) A survey of indoor positioning and object locating systems. IJCSNS Int J Computer Sci Netw Secure 10(5):121–128.*
3. *Zandbergen PA, Barbeau SJ (2011) Positional accuracy of assisted GPS data from high-sensitivity GPS-enabled mobile phones. J Navig 64(3):381–399.https://doi.org/10.1017/S0373463311000051*
4. *https://doi.org/10.3390/s17081806*
5. *https://www.ijireeice.com/upload/2016/april-16/IJIREEICE%2055.pdf*
6. *https://doi.org/10.1109/WD.2008.4812905*
7. *https://link.springer.com/article/10.1134/S1054661816010260*
8. *https://doi.org/10.1109/ICCE.2014.6776093*
9. *https://www.irjet.net/archives/V7/i12/IRJET-V7I12258.pdf.*
10. *https://www.researchgate.net/publication/300329314_Survey_of_Indoor_Positioning_Systems_Based_on_Ultra-wideband_UWB_Technology*
11. *https://www.mdpi.com/1424-8220/23/12/5710*
12. *indoor mapping using SLAM. PD*
13. *RFID-blind-navigation-final.pdf*
14. *L.-W. Yeh, M.-S. Hsu, Y.-F. Lee, and Y.-C. Tseng, "Indoor localization: Automatically*

constructing today's radio map by iRobot and RFIDs," in 2009 IEEE Sensors, 2009, pp. 1463–1466.

15. *Hirohiko Ohkubo, Seiji Kitakaze, Yo Fujishima, Naoto Watanabe, Minoru Kamata, "Integrated Way Finding/Guidance system using GPS/IR/RFID with a mobile device, Technology & Persons with Disabilities Conference, March 14-19, 2005, Los Angeles, CA*