Indoor Area Location System Using UWB Technology and Axis-Linear Bounding Boxes

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***Abstract*—Due to the need of determining the localization of elderly people in indoor spaces to detect their habits and potential anomalies in their behaviour, there is a need to manage the lack of real intelligent systems capable of calculating the area localization of a person within an enclosed space. This paper proposes an architecture that uses the commercial DWM1001 system from Decawave and a Raspberry Pi, employing Ultra Wideband technology and a proposed method based on axis-aligned bounding boxes to obtain the area localization where the person is. An experimentation with this system was deployed in a six-room apartment to show its effectiveness, achieving an accuracy rate exceeding 85%. Furthermore, the paper also discusses the extension of the proposed method with evolutionary algorithms. Finally, our proposal is complemented by a mobile application designed to collect and manage information from the localization sessions carried out by a person testing the system in the apartment.**

***Index Terms*—Ultra Wideband, indoor area localization system, active aging, Axis-Aligned Bounding Box, Decawave RTLS devices**

I. Introduction

Over the last few years, the ability to track the localization of individuals in indoor environments or enclosed spaces has become a crucial element in a wide range of sectors [1]–[3]. From healthcare [4], [5] to logistical management [6], [7], the ability to determine precise localization within buildings and enclosed spaces has had a significant impact on how we address security, operational efficiency and user experience.

One of the sectors where the indoor localization of people is gaining significant importance is in the field of active aging [8], [9], as it allows for estimating where these individuals are located and how much time they spend in a specific area. Based on this information, habits can be inferred [10] or anomalies in their daily routine can be detected [11].

In this context, existing methods in the literature primarily focus on determining the exact position of the person [12], [13]. However, there are many practical applications where the goal is not necessarily to know the exact and precise localization, but rather to understand the specific area where the person is situated [14]–[16]. Another significant limitation of the methods proposed in the literature is the lack of software implementations for such methods [17], aiming to facilitate their seamless transfer to society.

The focus of this paper is to address the existing gaps in the literature through the software implementation of an intelligent system for indoor area localization using the latest wireless communication technology in closed spaces, Ultra Wideband (UWB). To achieve this, the following three proposals are presented:

- An architecture enabling the integration of data collected from a set of anchor devices, the storage of such information, and the visualization of the area localization.
- Intelligent processing of data collected by devices to obtain the area localization using the bounding boxes method, along with the assessment of the proposal through an accuracy experimentation of the formulated method.
- A mobile application that enables real-time area localization based on the gathered data and the proposed method.

The structure of this work is outlined below. Section II reviews the scientific literature on indoor localization, detailing the use of devices in this context with UWB technology. Furthermore, the data returned by these types of devices is specified. In Section III, the architecture, technology, and devices employed for the indoor area localization system are presented. Section IV introduces the proposed method for estimating the area in indoor localization, its evaluation and its extension by using evolutionary algorithms. The mobile application implementing the proposed method is described in Section V. Finally, conclusions are discussed in Section VI.

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II. PRELIMINARIES

An Indoor Positioning System (IPS) is a real-time system that continuously calculates the location of an object or a person, whether in motion or static, within an enclosed space [18], [19]. IPSs have facilitated several navigation applications with the continuous purpose of tracking indoor locations of both people and objects. The increasing significance of these positioning systems has been particularly noteworthy in recent times, primarily driven by the advancement and widespread acceptance of smart devices and technologies.

Despite the reliability of Global Navigation Satellite Systems (GNSS) in outdoor environments, their performance proves insufficient in the context of enclosed spaces due to potential interferences caused by the structures of buildings [20], [21]. This scenario underscores the need for research to develop IPSs using wireless technologies, such us Wi-Fi [22], Low Energy Bluetooth (BLE) [23], Ultra Wideband (UWB), or radio signal tags [24].

Acquiring information about a person's location in enclosed spaces emerges as a crucial element in applications related to the Internet of Things (IoT) [25]. Within this context, UWB technology stands out for its ability to navigate in environments with obstacles, as well as for its low interference and high precision, especially in situations involving multipath signal trajectories for localization. These multipath scenarios occur when the signal reflects off surfaces or obstacles within the environment [26].

UWB is a short-range radio wireless technology that transmits information through narrow pulses across a wide spectrum [27]. According to the Federal Communications Commission (FCC) and the International Telecommunication Union (ITU), this spectrum harnesses an ultra-wide bandwidth of 500 MHz, enabling efficient transmission of large volumes of data with lower energy consumption compared to other technologies [18], [28]. This wireless technology operates in the unlicensed frequency spectrum, allowing its use without prior notification. The pulse emission nature of UWB enhances its penetration capability, meaning that UWB tagging on mobile objects does not require a direct line of sight with other UWB devices deployed in the environment (*anchors*), making it a highly suitable candidate for implementing IPSs.

However, this type of technology has some limitations, including its use in dense spaces with many objects. In such situations, the UWB signal may be affected, leading to potential multipath errors and interference with neighboring frequencies in the spectral range [18]. Additionally, the low transmission power may be ineffective in large indoor spaces, preventing the signal from traveling long distances due to signal attenuation. Therefore, additional *anchor* devices are required, increasing both cost and complexity [29]. It is essential to perform a preliminary study of the enclosed space where the IPS will be deployed to determine the number of devices and their optimal distribution.

The technical specification for a UWB signal is documented in the current standard 802.15.4z-2020. This standard was developed by the IEEE Computer Society LAN/MAN Standards Committee [30]. It specifies that UWB signals can be generated using different techniques, including Impulse Radio Ultra Wideband (IR-UWB), Direct Sequence Ultra Wideband (DS-UWB), Multiband Ultra Wideband (MB-UWB), Frequency Hopping Ultra Wideband (FH-UWB), Stepped Frequency Hopping Ultra Wideband (SFH-UWB), or Swept Frequency Ultra Wideband (SF-UWB).

In our study, and as documented in the literature, the IR-UWB technique is the most commonly used among systems employing UWB technology for indoor localization [31]. This is because it does not necessarily require carrier signals and can transmit information using short emission pulses.

III. ARCHITECTURE SYSTEM

In this section, the architecture system is presented. The goal of the intelligent system described in this paper is to determine the location of the area where a person is situated within an enclosed space. For this purpose, the implemented system has been based on the architecture shown in Fig. 1.

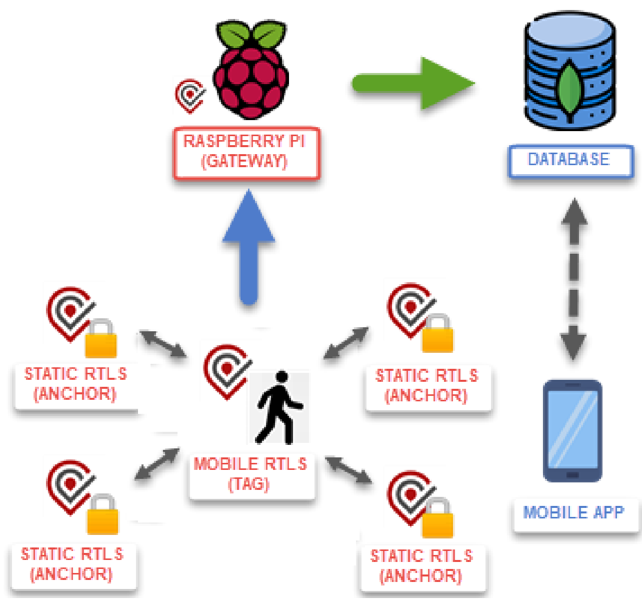

Fig. 1. Architecture of the proposed Intelligent System.[1]

This architecture will be explained in detail in the following subsections:

- Devices employed: in this subsection, the specifications of the employed Real-Time Location System (RTLS) devices and the model of Raspberry Pi used will be analyzed.
- Device interconnection: this subsection provides a detailed overview of the information swapped between the devices and the protocols utilized.
- Data storage: this subsection specifies the information that is stored in a database.

[1]https://github.com/AntonioAlbin-dev/ipsUwbAabb/blob/main/Figures/Figure01.png

A. Devices employed

The RTLS devices employed in this architecture enable real-time indoor localization of individuals or objects. The chosen devices are part of a commercial real-time location system, the DWM1001 version 2.1 [32], developed by Decawave.

This localization system is capable of calculating the position of a person in motion based on defining a set of coordinates that delineate an enclosed space. To achieve this, it is necessary to deploy a set of RTLS devices within the indoor space and statically define their positions to establish the areas into which the enclosed space is divided. These devices are referred to in Fig. 1 as Static RTLS (*anchor*). Additionally, defining a mobile RTLS device is required, is named as Mobile RTLS (*tag*), enabling the calculation of its position based on the locations of the surrounding *anchors*.

The RTLS devices of the DWM1001 system are equipped with an internal board model DWM1001-DEV [33], as shown in Fig. 2.

Fig. 2. DWM1001-DEV development board.

This board allows plug-and-play development to evaluate the characteristics and performance of the UWB transceiver module DWM1001C [34]. It is based on the DW1000 Ultra-Wideband transceiver IC, which is an implementation of the IEEE 802.15.4-2011 UWB [35]. The following are some of its main features:

- Range accuracy of 10 cm.
- UWB antenna (6.5 GHz).
- Transmission rate of 6.8 Mbps.
- 3-axis accelerometer-based motion sensor.
- Power consumption optimized for low-power sleep mode.
- Extended communications range up to 290 meters of 110 Kbps.

The indicated communication range is approximate and will depend on the configuration and parametrization used in the devices [35] and the nature of the environment (obstacles) in which the system is deployed.

This way, a fully wireless real-time localization system can be easily implemented, including anchor devices, tag device, and a third type of device as a gateway implemented on a Raspberry Pi, as detailed below.

The selection of the Raspberry Pi is made because it is a low-cost development board that allows the execution of an operating system. Its functionality enables the execution of programs capable of receiving, processing, and loading data into a database. The choice of this device is based on its frequent use in Internet of Things (IoT) networks, its cost-effectiveness, low power consumption, and compact size. In the defined architecture, a Raspberry Pi 3 Model B [36] is used.

In the architecture system, the Raspberry Pi serves as a data sink for the information sent by the *tag* device, responsible for receiving, processing, and subsequently sending it to the database.

B. Device interconnection

For the proper functioning of the proposed system, the presented devices must be connected to each other. To achieve this, communication between RTLS devices is carried out through the Decawave RTLS network (DRTLS), which uses UWB technology, and is established by the commercial system [32].

This network allows the calculation of the position of the mobile RTLS device (*tag*) within the enclosed space, through the 4 nearest static RTLS devices (*anchors*) distributed in the space. To select the closest devices, the DRTLS uses the Two-Way Ranging (TWR) protocol, which determines the 'time of flight' of signals emitted by the devices, i.e., the time it takes for the signal to travel from one device to another, and calculates the distance between them by multiplying this time by the speed of light. In this way, the system will be calibrated, and the distance between the RTLS devices located in the enclosed space will be determined to ensure proper system operation.

Regarding the communication between the *tag* and the Raspberry Pi, it is necessary to implement a gateway on the Raspberry Pi. To achieve this communication, a new RTLS device is physically connected to the Raspberry Pi through the DWM1001-DEV development board, it will be necessary to identify the pins on both boards and establish the connection between them as shown in Table I.

TABLE I
CONNECTIONS BETWEEN RASPBERRY PI AND DWM1001-DEV MODULE

Development Board RPi Connector		Pin Number from DWM1001 Module
Pin Number	Schematic Net Name	
3	SDA_RPI	Pin 23 (GPIO_15)
5	SCL_RPI	Pin 25 (GPIO_8)
9	GND	GND
15	GPIO_RPI	Pin_19 (READY)
19	SPI1_MOSI	Pin_27 (SPIS_MOSI)
21	SPI1_MISO	Pin_26 (SPIS_MISO)
23	SPI1_CLK	Pin_25 (GPIO_8)
25	GND	GND
2	VRPI	Input power to Development Board (not connected directly)
4	VRPI	
6	GND	GND
8	TXD	Pin_18 (UART_RX)
10	RXD_RPI/RXD	Pin_20 (UART_TX)
12	RESET	Pin_33 (RESETn)
14	GND	GND
20	GND	GND
24	CS_RPI	Pin_29 (SPIS_CSn)

Additionally, to enable this communication, it is necessary to install a small piece of code provided by Decawave [37]. This RTLS device will act as a bridge in the communication between the *tag* and the Raspberry Pi itself, allowing the desired information to be received.

The developed system proposes the exchange of information between devices through the Message Queuing Telemetry Transport (MQTT) protocol. This protocol employs the publisher/subscriber pattern that operates over TCP/IP. For this, a central server (or broker), in our case the Raspberry Pi, receives the messages, filters them through topics, and distributes them to devices subscribed to that topic.

The use of this protocol allows the mobile application used in the system to listen to the topic generated by the Raspberry Pi. In this way, it is capable of collecting data on the person's area location. This interaction is illustrated in Fig. 3.

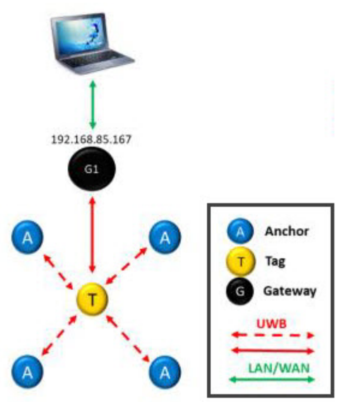

Fig. 3. Example of interaction between RTLS devices and Raspberry Pi.[2]

In the proposed architecture, *tag* transmits signals received from the four nearest anchors to the gateway, Raspberry Pi, via UWB every second, then Raspberry Pi promptly receiving them through MQTT. Therefore, the proposed system operates with an approximate delay of one second plus the bias introduced by the system's communication. Thus, in this type of setup, it can be argued that the system operates in real-time.

C. Data storage

Decawave commercial system provides an API [38] through which it is possible to obtain the information transmitted by the *tag* to the Raspberry Pi. Among the data sent by this RTLS device, the (x, y, z) coordinates in which the device is located in the enclosed space are used, as well as a *quality factor* for this position. This quality parameter represents how good the indicated position of the device is, according to the commercial system.

Once the information is received by the Raspberry Pi, it processes it and subsequently persists it in a database. In this database, the areas in which the enclosed space is divided and the location of the areas where the person is at each moment are also stored.

The database used is a non-relational database based on collections of documents. This type of approach is chosen for its flexibility in terms of information structure since it does not need to follow a predefined schema, allowing the integration of new types of data without affecting the database structure. Thus, the information stored in the database includes:

- *Data_raw Collection*: it contains the raw positions calculated by the *tag* and sent to the Raspberry Pi. The information stored in this collection is specified in Table II, detailing the type of each property and a description of its content.
- *Locations_real_time Collection*: it contains the areas in which the enclosed space is divided, defined from the mobile application. The way in which these areas are defined is explained in detail in Section IV. The type of information stored in the collection is documented in Table III.
- *Session Collection*: stores information about the location of the area where the system infers the person to be in different localization sessions, as shown in Table IV. This means that each document stored in this collection includes the different areas where the person has visited during the test session.

TABLE II
DATA_RAW COLLECTION

Property	Type	Description
_id	ObjectId	Unique identifier
position	Object	Raw position of the *tag*
x	Float	X-coordinate of the *tag*
y	Float	Y-coordinate of the *tag*
z	Float	Z-coordinate of the *tag*
timestamp	Float	Timestamp of the moment when the position of the *tag* is received

TABLE III
LOCATIONS_REAL_TIME COLLECTION

Property	Type	Description
_id	ObjectId	Unique identifier
location	String	Area name
p1	Array	Contains the minimum (x, y) of the area
0	Float	Minimum x-coordinate
1	Float	Minimum y-coordinate
p2	Array	Contains the maximum (x, y) of the area
0	Float	Maximum x-coordinate
1	Float	Maximum y-coordinate

About the way to persist information in the database, it is implemented in MongoDB using JSON notation, as it allows grouping the information of each entity in different collections, and the data upload is also straightforward.

IV. METHOD AND DISCUSSION

The system presented in this paper employs a method to estimate the location of areas in an enclosed environment using

[2]https://github.com/AntonioAlbin-dev/ipsUwbAabb/blob/main/Figures/Figure03.png

TABLE IV
SESSION COLLECTION

Property	Type	Description
START OF THE SESSION		
_id	ObjectId	Unique identifier
timestamp	Float	Timestamp of the beginning of the session
command	String	Command indicating the start of the session
location_list	Array	Set of areas defined from the mobile application. The areas follow the same structure as the *Locations_real_time* collection, with the exception of the _id property
SESSION		
_id	ObjectId	Unique identifier
timestamp	Float	Timestamp of the moment when the position of the *tag* is received. It coincides with the timestamp property of the *Data_raw* collection.
x	String	X-coordinate of the *tag*
y	String	Y-coordinate of the *tag*
location	String	Name of the inferred location area where the *tag* is located, as determined by the system
END OF THE SESSION		
_id	ObjectId	Unique identifier
timestamp	Float	Timestamp of the end of the session
command	String	Command indicating the end of the session

UWB technology. To achieve this, we first propose the method based on bounding boxes, followed by an experimentation, and finally, an evaluation of this method.

A. Method based on bounding boxes

As explained in Section III, the presented system makes use of the Decawave DWM1001 commercial system. This system provides the location of a device at the coordinate level (x, y, z). This level of precision does not address the proposed solution, as the goal is to obtain the location of a device at the level of specific areas within the enclosed space where the system is deployed.

The proposed method makes use of dividing the enclosed space into bounding boxes, which are Axis-Aligned Bounding Boxes (AABB). These boxes allow defining rectangles to outline the perimeter of each area within the interior space. An AABB is defined using the geometric concept of rectangular coordinate systems. It is determined by two points, representing the minimum and maximum values of the coordinates. This way, the four corners of the rectangle are established.

With the definition of different AABBs and the coordinate (x, y) returned by the *tag* device, it is possible to determine in which AABB the person is located within the interior space. Therefore, if the coordinate (x, y) is within a defined AABB, the system indicates that the person is in that specific area location.

B. Experimentation

To carry out the experimentation, the system was deployed in a six-room apartment. Eight static RTLS devices (*anchors*), one mobile RTLS device (*tag*), and a gateway were utilized. The floor plan, along with the positions of the *anchors*, is depicted in Fig. 4.

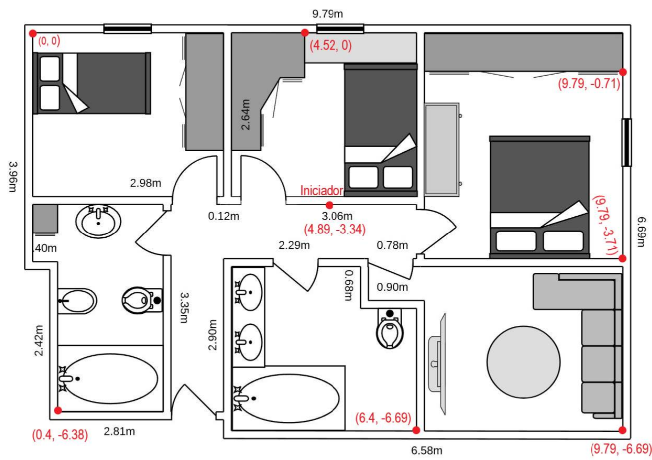

Fig. 4. Floor plan with positioning of *anchor* devices.

For greater precision in the experimentation, the positioning of *anchors* was done manually, ensuring an equitable distribution based on the available space and furniture layout. This setup will allow for proper system calibration, considering the manufacturer's recommended configuration [35], the functioning of the previously mentioned TWR protocol, and the nature of the indoor space to be covered. The calibration tests conducted ensure that the signal emitted/received by the devices is appropriate.

The coordinates of each *anchor* are calculated based on the chosen coordinate axes. In this case, the upper-left corner serves as the origin of coordinates, working in the fourth quadrant, i.e., positive abscissa and negative ordinate. Following Decawave's recommendation, the devices are positioned at a height of 2 meters above the ground.

At the time of deploying the DRTLS network of the commercial system, a initiator *anchor* device (the coordinator device of all communication), must be within the reach of the rest of the devices in the network. Therefore, its location in this case is at the center of the enclosed space. It is worth noting that, within the maximum range of the initiator device, having a higher number of *anchors* per area increases precision. Although the *tag* device needs the four nearest *anchors* to calculate its location, potential obstructions in the path, such as furniture or walls, may attenuate the signal or even cause a brief loss of signal.

After positioning the devices, the entire space is divided into AABBs, calculating the minimum and maximum coordinates (x, y) for each of them, as shown in Fig. 5.

When there are non-square rooms, such as the *Bathroom 2*, a decision has to be made on how to define the bounding box. In this case, it was decided to add the small piece of the door, belonging to the *Living room*, to the *Bathroom 2*. With this division, it takes up less space in another room that, if added to the *Living room*, would fill a third of the space in the *Bathroom 2*.

The computational cost of localization depends on the number of areas obtained in the floor plan to discriminate

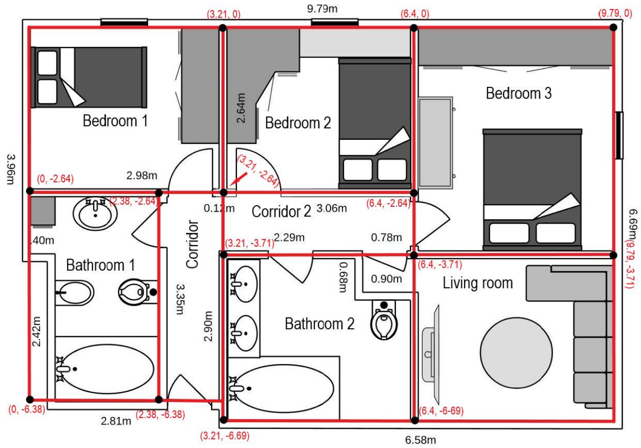

Fig. 5. Definition of the AABBs.

each AABB. As the number of areas in the localization space increases, the complexity of the calculation required to determine the position of the tag within the location system also increases. This increase in the number of AABB leads to a higher computational processing load, as more time and resources are required to analyze and compare the signals received in each area and accurately calculate the location.

The carried out experimentation involves a person moving through the floor across different rooms while wearing the *tag* device. The individual or tester manually notes the exact time of entry and exit for each room over a period of 10 minutes. This manual annotation during the experimentation will allow for a subsequent comparison between the system's inferred area location and the manually annotated area during the same time of entry and exit for each room.

Regarding the tester's behavior, the person has been continuously in motion. This means that when entering a room, the *tag* moved as much as possible throughout the area, emphasizing the perimeter of the rooms or walls adjacent to other rooms to challenge the proposed method.

C. Evaluation

The results of the experimentation are based on comparing the samples inferred by the system with those manually annotated by the tester. In this way, it is possible to calculate the accuracy of the proposed method by checking if all the area locations calculated during a time interval match the actual room or area where the tester was during that period of time.

For the evaluation of the results, samples with NaN (Not a Number) values for x and y in the database are disregarded. These values can be attributed to various causes:

- At some moment, the *tag* stops receiving the signal from one of the four *anchors* it is using for position calculation.
- Abrupt changes in location, meaning if the tester moves between different areas quickly, it prevents the *tag* device from having enough time to communicate with the new set of four *anchors* required, and consequently, it is unable to accurately recalculate the new area where the person is located.
- The *tag* does not have, within its communication range, four *anchors* available for location calculation.

Table V presents the results of the experimentation, and Table VI shows the accuracy percentages.

TABLE V
RESULTS OF THE EXPERIMENTATION

Period	AABB	#Samples	#OK	#NOK
14:59:00 / 14:59:59	Corridor	50	50	0
15:00:00 / 15:00:59	Bathroom 1	46	46	0
15:01:00 / 15:02:59	Bedroom 1	44	31	13
15:03:00 / 15:03:39	Bedroom 2	37	37	0
15:03:40 / 15:05:19	Corridor 2	98	78	20
15:05:20 / 15:06:29	Bathroom 2	47	44	3
15:06:30 / 15:06:39	Corridor 2	0	0	0
15:06:40 / 15:07:39	Living room	43	27	16
15:07:40 / 15:09:00	Bedroom 3	80	67	13
TOTAL		**445**	**380**	**65**
TOTAL(%)			**85.4%**	**14.6%**

TABLE VI
ACCURACY PERCENTAGES OF THE EXPERIMENTATION

AABB	OK(%)	NOK(%)
Corridor	100.0%	0.0%
Bathroom 1	100.0%	0.0%
Bedroom 1	70.5%	29.5%
Bedroom 2	100.0%	0.0%
Corridor 2	79.6%	20.4%
Bathroom 2	93.6%	6.4%
Corridor 2	0.0%	0.0%
Living room	62.8%	37.2%
Bedroom 3	83.7%	16.2%

As observed in Table VI, a good accuracy rate has been achieved in the calculation of the location compared to the actual location of the tester. Out of a total of 600 recorded samples (one sample per second for 10 minutes), 74% are non-null, leaving the remaining 26% (155 samples) as NaN or null samples that have not been considered for evaluation.

Some of the null samples, like those in the second case of *Corridor 2*, are due to the *tag* moving rapidly from the range of one set of *anchor* devices to another. As a result, the *tag* is unable to locate the nearest four *anchors* and calculate its position. Other limitations in the calculation of area localization, such as in the *Living room*, are due to the definition of the AABBs. As detailed in Section IV-B, the entry into the *Living room* was included in the bounding box of the *Bathroom 2*. Therefore, upon entering the *Living room*, it continues to calculate that the person is in the *Bathroom 2* until they move out of that area.

As conclusions, most of the errors obtained are derived from the use of the DRTLS network, such as moments when the signal from the *tag* device is lost, the placement of *anchor* devices, etc. It can be stated that the mobile application and the system serve as an area localization system with a high success rate but are somewhat less precise in tracking the person's movement. The experimentation involved continuous movement of the person carrying the *tag*, emphasizing the limits of the defined AABBs, and the results obtained correspond to the worst-case scenarios for the system's operation.

D. Discussion in the context of EC

To integrate evolutionary computation (EC) into the indoor area localization system using UWB technology and AABBs, the use of evolutionary algorithms is proposed to optimize various key aspects of the system. This integration could focus on three main areas:

- Optimization of the UWB anchor device locations: Utilizing genetic algorithms to determine the optimal coordinates (x, y) of the anchor devices within the indoor space. The goal would be to maximize signal coverage and minimize signal-free areas, ensuring precise localization throughout the space.
- Adjustment of localization algorithm parameters: Applying evolutionary strategies to optimize the internal parameters of the algorithm that calculates the position of the *tag* based on the anchor signals. This would include optimizing weights, thresholds, and other critical parameters that influence the accuracy and efficiency of the location.
- Definition and adjustment of AABBs: Implementing evolutionary algorithms to adjust the coordinates of the vertices of AABBs that divide the space into specific areas. This would allow for more effective space division, adapting areas to the specific needs of the environment and improving area localization accuracy.

This evolutionary computation approach would enable automatic and efficient optimization of multiple interdependent parameters, dynamically adapting the system to changing environmental conditions and specific indoor localization needs.

V. Mobile Application

In this section, the functionality of the mobile application is presented. The main goal of the mobile application is to define the AABBs of the localization space, visualize the data inferred by the system, and display the real-time area localization of the user.

The interface of the application can be seen in Fig. 6.

As shown, the flow of information in the mobile application goes through the following screens:

- On the *Main* screen, the user can choose between two options: *Real Time Localization*, to visualize the real-time localization area of the person, and *Localization Session*, to start a new localization session.
- From the *Real Time Localization* screen, the current position (x, y) of the person and the inferred area location are displayed. This information is updated every second. This screen allows managing the defined AABBs in the enclosed space.

[3]https://github.com/AntonioAlbin-dev/ipsUwbAabb/blob/main/Figures/Figure06.png

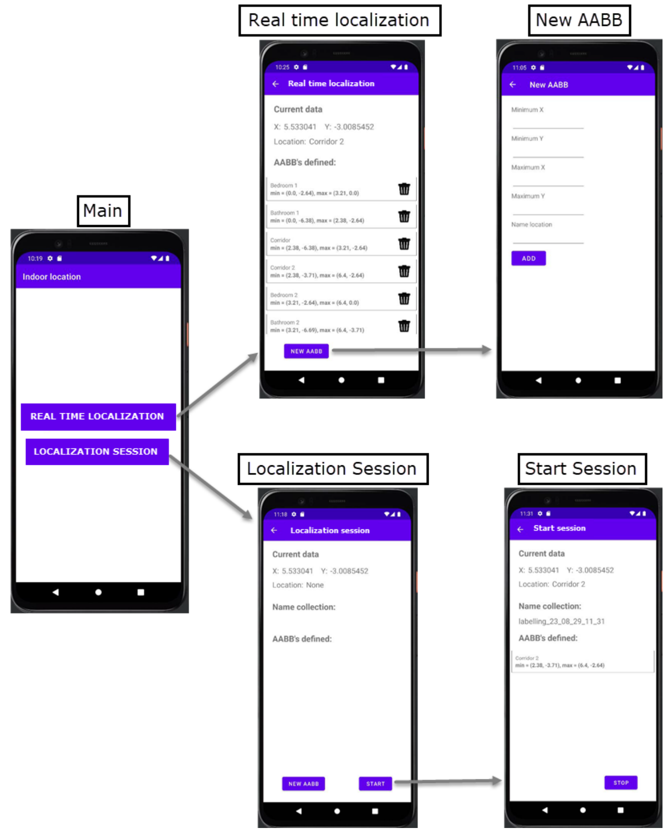

Fig. 6. Navigation between the screens of the mobile application.[3]

- On the *New AABB* screen, the user can define a new AABB by indicating its minimum and maximum coordinates, as well as its name.
- On the *Localization Session* screen, the current position (x, y) is displayed, updating the inferred area location if the localization session has started. Additionally, the name of the collection that will persist the session information in the database is shown. It allows starting a new session where the person will move through the closed space where the system has been deployed, as well as managing the defined AABBs.
- On the *Start Session* screen, it indicates that the localization session is in progress, allowing the user to finish it.

VI. Conclusions

This paper has proposed an indoor area localization system using devices with UWB technology and a bounding box method.

It has outlined the selection of devices for the localization system, the chosen method for data extraction, the implementation of protocols for communication, and the development of a mobile application for information management and visualization. Additionally, it has covered the calculation of the person's area localization based on their position in an enclosed space.

An experimentation of the system was carried out in a six-room apartment. The deployment of the system faces the inherent limitations of the enclosed space and the division of its rooms. The precise distribution of *anchor* devices and the division of space into AABBs depend on this. The effectiveness of the proposed method after this experimentation reveals an accuracy rate exceeding 85%. Furthermore, the integration of evolutionary computation into the indoor area localization system has been discussed in order to optimice key aspects via evolutionary algorithms. This evolutionary computation approach enables automatic optimization of parameters, adapting dynamically to changing environmental conditions and specific indoor localization needs. So, in future work, we aim to further explore the integration of evolutionary algorithms into indoor area localization systems, with a focus on enhancing the efficiency and adaptability of the proposed method.

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