Review of Ultra Wide Band (UWB) for Indoor Positioning with application to the elderly

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Abstract

The objective of this review is to analyze Ultra Wide Band (UWB) technology, as an option that allows developing new solutions in indoor positioning systems (IPS), mainly with a approach applied to the elderly. The methodology that has been applied corresponds to the definition of some basics concepts about UWB and some tests in the lab; the above to demonstrate the degree of accuracy that UWB offers compared to other technologies. The findings found and presented in this paper correspond to the identification of UWB as a technology with a high degree of accuracy for IPS; also, that there are other works related to the subject, with application in different areas, but specifically as an application for older people; regarding to the tests, these allowed to verify in the laboratory the operation and accuracy of UWB, for its possible application in IPS. The research described in this paper is the beginning of a implementation in a residence center, where accuracy in location and real-time response are important, in the future we hope make conclusive contributions of the implementations made.

1. Introduction

Indoor Positioning Systems (IPS) are currently a subject of study with great relevance, because there not exists technique or technology that allows to determine the precise location of a person inside a house or a building. Many studies have been carried out about this subject, but with technologies commons, such as Bluetooth Low Energy (BLE)[1] and wireless network with WiFi[2], where mainly smartphones and commercial solutions are used. Just a few years ago, a technology with great projection its being studied for IPS, which was used in the past for military applications, its Ultra-Wide-Band (UWB)[3]. On the other hand, we identify a population, which requires this kind of technology in an important way due mainly to the characteristics of it. We refer to elderly people, who because of their age, its require more attention and care, where the IPS could be very important to know the localization of an elderly person at any time, but its expected, that this systems is the most accurate possible, situation that doesn't happen currently. According to the above, in this document, we relate the situation about IPS for elderly people, as well as the reviewing the technologies and methods that currently exist for IPS, focusing mainly on UWB technology and possible implementation. It is also important to say that, nowadays all existing technologies for indoor positioning are inaccurate which precision error is from a few centimeters the most accurate to few meters in most technologies[4]. Therefore, the study of these technologies is currently open and it offers many possibilities to develop new solutions based on a smallest precision error, either through technological solutions with new electronic development or through new methods and techniques that improve technology existing[5]. Therefore, in this paper we research the different methods and technologies that exist around the indoor positioning (IP), but mainly focusing on the use these technologies for the elderly. As a starting point we have that, the elderly represents an important segment of the population[6], which is gradually going to increase. For example in Spain it is projected that by 2050, 44.1% of people will be over 60 years old[7], as well as,the same will occur in: i) USA with 32%[8] and ii) Colombia with 22,5%[9]. These statistics justify the need that to research new and different ways to take care of these people from now on. An important need is the localization of the elderly inside a building, residence center or home quickly and timely, in order to avoid any risk or accident. Some elderly may suffer different pathologies, for example Alzheimer's or dementia[10], among other, which it are very commons in this kind of persons, it making necessary the permanent attention and above all the monitoring a control of their location at every moment, where the technology can help prevent accidents and monitor the daily activity. On the second hand, UWB is a relatively new technology for data transmission wireless, which appeared in the 60's, but its application for IP is related to a few years ago. The main features are potential low

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cost and low power consumption and transmits pulses of power spectral density (PSD) in the range of the ultra wide frequency spectrum[3]. Currently this technology is being studied by several scientists around the world, mainly for its benefits and reduction of precision error in indoor positioning. There are some previous works about researches and applications related to elderly people and IP through UWB technology. Here, we present some works related to this topic. First, we highlight the works of Wang et al[11] and Cozza et al[12], which focused on the review of state-of-the-art for wearable technologies for elderly. Wang et al[11], explain that "UWB is one of the most accurate and promising technologies to realize accurate indoor positioning despite its high costs". Bonizzoni et al[13] focus on the design of a tracking network that provides a robot with the position of the elderly, in order detect falls[14] and checking the condition general of the elderly, generating an alarm in necessary case. The technology used in this work is based in UWB. Kolakowski[15], propose a solution consisting in deploying anchors directly at the floor level with UWB for IPS, the system provides positioning error lower than 30 cm at 95% of tests realized. In the work of Arsan and Kepez[16], we find a work where the authors tested three technologies for error ranges and they found an average error of 1.39 m for WiFi, 86 cm for the Bluetooth low energy (BLE) and 24 cm for UWB evidencing once again the power of UWB, regarding to other technologies. And finally we note the work of Corchia et al[17], where the authors propose the fabrication of wearable antennas that can be fully integrated with clothes and that can be used for remotely transmitting/receiving the sensor data, in order to determine the localization of the a person, in the paper the use of UWB technology is proposed.

Based on the foregoing, in this paper, we present a review some previous work related to the UWB and IP methods, with the aim of proposing a new IPS design with UWB for the elderly, which will be evaluated in an intelligence laboratory environmental and in a residential center for the elderly. The design proposed in this document tries to use different indoor positioning methods, such as the Time difference-of-arrival (TDOA) and Fingerprinting method in a hybrid IPS, in order to improve the accuracy in locating a person, in this case an elder. In this paper, we present the design and a basic implementation. In the near future, we will carry out the implementation in a broad context. This paper is organized as follows: Section 2) Previous Concepts, where we define some important concepts about the IPS. In the Section 3) Related Works, we include some works related to UWB and IPS. In the Section 4) Proposal IPS with UWB, we explain the basic implementation and we propose a future implementation IPS for elderly with UWB, and finally Section 5) concludes our paper with some future directions.

2. Previous Concepts

2.1. Indoor positioning (IP): is the process of obtaining a device or user location in an indoor setting or environment[18]. This technology has been extensively researched in recent years, mainly in older people's environments with the application of wireless sensor networks (WSN) and intelligence environments. The main reason the wide-scale proliferation of this technology is due to the development of new smartphones and wearable devices with wireless communication capabilities, where new technologies are now most applicable, such as UWB[19], BLE and WiFi.

2.2. Ultra Wide Band (UWB): is a radio technology that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum[20]. UWB has a frequency spectrum ranging from 3.1 to 10.6 GHz, where the signal have a fractional band-width greater than 0.20 y occupies bandwidth greater than 500 MHz [3]. UWB sensors operating in frequency band 5 GHz have different features, one of the most important is their capability to detect not only the targets located line-of-sight (LOS), but also the target situated behind a non-metallic obstacle (non-line-of-sight (NLOS) scenarios) [21].

2.3. Distance measurement methods for indoor positioning - geometric methods: There are different methods to determine IP with UWB and other technologies, in this Section we explain some important and major uses, that characterize the accuracy and application. In this Section, we explain the following: Angle-of-arrival (AOA), time-of-arrival (TOA), time difference-of-arrival (TDOA) and received signal strength indication (RSSI).

2.3.1. Angle-of-arrival (AOA): In this method, the distance between the sensors o devices is calculated by intersecting angular lines for each signal emission.

The disadvantage of this method is the greater distance, less accuracy[22], we obtain see Figure 1.

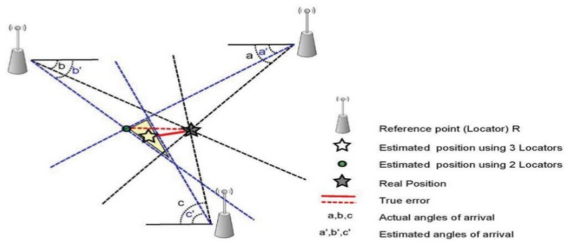


Figure 1. AOA[23]

2.3.2. Time-of-arrival (TOA): The positioning information is obtained from the intersection of the circumferences generated by several transmission sensors, where their radios represent the distances between the anchors and the target. This algorithm requires all the signal emission sensors to be properly synchronized[22], see Figure 2.

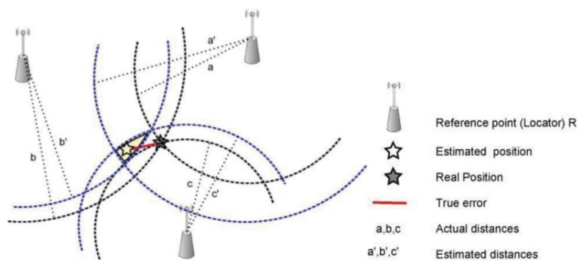


Figure 2. TOA[23]

2.3.3. Time difference-of-arrival (TDOA): With this method, the positioning of a sensor or device is obtained by measuring the difference in the arrival time of a signal sent by it to three o more receiving sensors, for example the anchors[22], see figure 3.

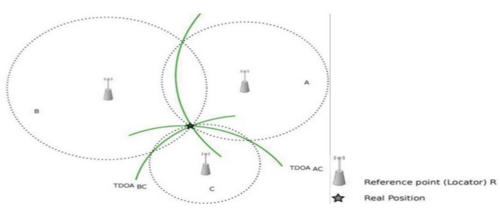


Figure 3. TDOA[23]

2.3.4. Received signal strength indication (RSSI): This is a method with the lower performance and highest precision error. In this method the positioning is obtained by measuring the distance of a sensor or device regarding to the attenuation generated by the propagation of the signal from transmission sensor to the reception sensor. The mobility of the sensors and the unpredictable variability of the communication channel generate large precision errors[22].

2.4. Algorithms of indoor positioning : There are two algorithm that we mention in this paper: trilateration and fingerprinting; the first one refers to the use of IP with geometric method and the second is about the use of RSS with proximity algorithms, such as k-Nearest Neighbor (KNN). We have referred to these algorithms due to the efficiency that has been showed in past applications and the possibility of application in the design that we have proposed.

2.4.1. Trilateration and triangulation: Theses algorithms determine the location of a sensor or device using the geometry of the circles and the measurement of the distances and angles of the sensors that are in the measurement area[24]. It is widely used together with TOA, TDOA and RSSI , see figure 4.

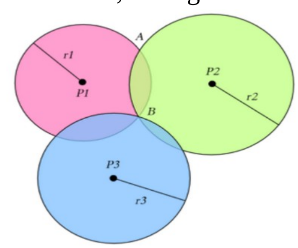


Figure 4. Trilateration[25]

2.4.2. Fingerprinting: This method is based on the creation of a database with the probability distribution of signal strengths in the scenario or application area, and usage of a map of these distributions to locate a given RSS sample[24]. The signals that work with RSS can be WiFi, Bluetooth, UWB, etc. The method has two phases: training and position estimation. In the training phase a map with the received signal strengths (RSS) in different points is used; to define the positioning, the RSS observed in the emission sensor is compared with the map previously building, using proximity algorithms, such as k-Nearest Neighbor (KNN)[26] and then the position of the sensor is estimated, see figure 5.

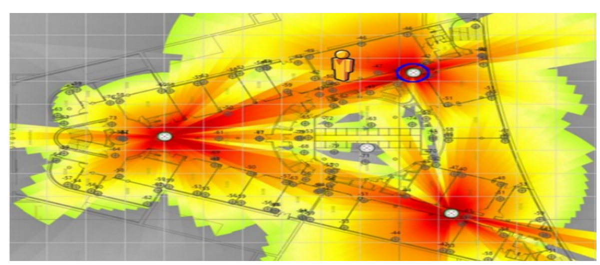


Figure 5. Fingerprinting[25]

2.4.3. Hybrid Techniques: In order to produce a more robust estimate of position, a combination of position related parameters can be utilized. A hybrid location estimation scheme provides heterogeneity of sensor networks, in terms of time synchronization, routing capabilities of network devices and communication range[27]. Moreover, in short-range wide-band communication, hybrid techniques provide significantly the smallest possible positioning error[23].

3. Literature Survey

There are previous several works related with the topic about this document, especially those that explain the methods and techniques used for the IP. A mosaic of approaches are involved, where the most used protocols are: WiFi and Bluetooth together with methods[28] that help to the determine the positioning, as, triangulation, scene analysis or fingerprinting, proximity based localization, vision analysis and dead reckoning, that we will explain later in this paper. We have identified that the subjects on the IP with Ultra Wide Band (UWB) with IEEE 802.15.4a are relatively new subjects; however, the works that explain their operation are scarce. This is the aim why we present a review on this theme. In this Section a review of the works that were taken into account in the development of the proposed solution is carried out, the selection of the mentioned works was made taking into account three elements: first, that the works were published maximum in the last five years; second that the papers relate UWB technology for positioning and third that the papers show some type of application with UWP or IPS. According to the above, this section is divided into: works on positioning indoors at a general level; papers that relate UWB technology and related papers that use UWB with IEEE 802.15.4a.

3.1 Works about general Indoor Positioning: As mentioned above, several works in the scientific world explain the functioning about the indoor positioning. For example, Tariq et al[28], authors focuses on Non-GPS position systems, where it is presented a survey about the indoor localization techniques and the hybrid indoor localization techniques. The work presented is general, explaining the advantages and disadvantages of each technique and technology studied. In the same way, there is a similar work of Alvarado and Delgado[29], which explains the systems and technologies that facilitate the indoor positioning. The work of Zafari et al[18], focuses on the evaluation of different systems for indoor positioning, but, from the perspective of energy efficiency, availability, cost, reception range, latency, scalability and tracking accuracy. Correa et al[30], talk about the development of indoor positioning systems is studied in term of the infrastructure and methodology employed. Mainly, the related document talks about network based systems, inertial based systems and hybrid positioning systems. On other hand, Bagaric[24], focuses on improving the estimation of the positioning of mobile devices within closed spaces, the novelty with respect to others similar works, is the study on indoor positioning with the use of technologies such as Raspberry Pi and FM (Frequency Modular) receiver Module in the process. Into general studies, we note other works that explain the situations related to specific cases and contexts such as a specific technique or some emphasis in a specific technology. Regarding these works we have highlight several[31-33], which are based on the analysis of the error of the localization measurement with WiFi and inertial positioning[31], where the most relevant is the conclusion about the common error in these systems, which are: i) for WiFi the received signal variability, and ii) in inertial systems the accuracy error in the time. Basiri et al[32], focuses mainly on the inertial system, concluding that the accuracy is low, which means that it is still an open problem. A web site that deals with the positioning error is that of POZYX[34], where this situation is explained with devices (tag), which are sensors that work with UWB technology and determine the position on 3D or 2D, according the configuration of the same, the most important conclusion reached was that it is possible to reduce the positioning error to approximately 10 cm.

Regarding to the works that relate the analysis on specific techniques of IP, we find to Diaz[25], and others[35-37]. López[35], focuses on the RF fingerprinting with WiFi, whose technique requires the calibration and evaluation of the indoor space. Moreover, with the aim of reducing the error, an algorithm called: dynamic space warping (DSW) which calculates the position of devices, was designed. A disadvantage of this work is the positioning error obtained, which was 2 meters. In the same line, with the technique of fingerprints, we have the work of Trevisan[36], which deals with the analysis of affecting the presence of several people in the calculation of the indoor positioning, using WiFi technology in comparison with a system based on the magnetic field. In this work the main conclusion is that none of the studied technologies offers the minimum error guarantees, nevertheless it concludes that the systems with WiFi are better with respect to the system based on magnetic field. But the error is still high, even with WIFI, in the cases studied the estimated error was approximately 2 meters. On the other hand, Díaz [25], focuses on indoor positioning with Bluetooth and trilateration. In this work, it is concluded that trilateration is better that fingerprinting, because if reduces the error, but it does not present an approximate measurement. Pereira and Polo[37], propose a solution with a localization prototype, which works with Bluetooth Low Energy, RSSI and triangulation, these technologies have been used before, it are good, but the accuracy error is still big. To finish this first part, we detail other works that relate different options for indoor positioning. For example Jimenez and Seco[38], focuses on systems for indoor positioning with cell phones, where, the authors presented an experimental evaluation of different approaches for finding an object of interest respect to the pose of a user's phone. Islam et al[39], propose the design of an internal positioning scheme using two algorithms: i) an Artificial Neural Networks (ANN), and ii) a fuzzy logic algorithm. ANN works with the Euclidean distance and trains the information obtained with the optimization of the retro-propagation technique by neural networks, generating positioning results for the fuzzy logic algorithm. Islam et al[39], claim that the results obtained were almost 99% accurate for positioning. Pabón[40], propose a work on an indoor navigation network, where the objective is the optimization of internal roads for any type of person. The work is mainly about navigation routes to helps persons in locating in the building they are located but in this work does not delve into the techniques or technologies in this regard.

3.2 Works about indoor positioning with UWB: UWB is a technology that are characterized by very wide bandwidths and the commensurate fine range resolution[41], which makes it attractive for IP applications[42]. In this Section, we have compiled some works on indoor positioning using UWB. We start with the works that related a comparison or evaluate the performance of UWB. For example, Caso et al[43], focus on the comparison of UWB with WiFi, using fingerprinting, where the authors found that UWB outperforms WIFI. Barral et al[44], talk about UWB and a platform called PLUS RTLS, where the techniques of RSS and TDOA are mainly used, seeking to improve the positioning algorithm; the published result are very good and UWB shows that accuracy it handles is superior to other technologies. An interesting document of the analysis of the UWB channel is presented by Martínez[45], where the evolution of this technology, its characteristics and its uses are explained, we also find different applications on UWB and the difference with other technologies, evidencing once again that UWB is a excellent option for IP. On the other hand, we have the works with specific application. For example, Gutiérrez[22], explain the use of the UWB with the POZYX system, where it mainly uses the TOA technique; the results in this work were satisfactory, but the author express that this technology still needs more in-depth studies. Kocur et al[46], propose a work about multiple moving person tracking by UWB sensors, where the mutual shielding effect and its relation with IP using UWB sensors is analyzed, the presented results are very good, but the authors say that there is still space for more improvements and closer to real-life conditions and applications or real life. Yao et al[47], focuses on the IP with UWB and the inertial measurement unit (IMU) technique, also, it work with the Kalman filter to improve the accuracy and reduce the interference that people generate in IPS; in the different tests and simulations carried out, the authors showed improvements by using the methods and technologies mentioned. A work on monitoring people in real time with IPS is presented by Drutarovsky et al[48], where the authors discuss the modular architecture of UWB-SN that they affirm can be used for fast development and testing of new real-time people tracking applications.

Regarding the works with UWB that deals with precision, we find as relevant papers those mentioned by Mazhar et al[27] and Tiemann and Wietfeld[49]. These works mainly explain how UWB systems can be more accuracate. In the work of Mazhar et al[27], the different methods, algorithms and implementations with UWB are reviewed, mainly to guarantee accuracy and its comparison with other technologies such as WiFi, Bluetooth and ZigBee. Finally, Tiemann and Wietfeld[49], focuses on accuracy with UWB using TDOA with Multi-rotor unmanned aerial vehicle (UAV), this latest work is novel and interesting because of the aims on performance with UWB and accuracy they are handled.

3.3 Works about IP with UWB and IEEE 802.15.4a: In this Section we have included some works on a technology that supports UWB, called IEEE 802.15.4a; which is a standard of the group "802.15" of the IEEE, where two additional physical levels have been included regarding original standard called IEEE 802.15.4, one of these levels contains UWB. De Rivaz et al[50] and Karapistoli et al[51], being explained the operation and performance. The first work related to UWB+IEEE 802.15.4a is that of Súarez and Llano[52], where present a review about this technology, focusing on describing the technical characteristics and operation of UWB with IEEE 802.15.4a, with emphasis on describing the operation of the IR-UWB channel (Impulsive Radio Ultra Wide Band). With regard to IP with UWB and IEEE 802.15.4a, there are several works[53-54], that analyze the different general techniques of this process. In other similar papers[55-56], the authors propose an time of arrival (TOA) based approach using both UWB+IEEE 802.15.4a at 2.4 GHz technologies to achieve an enhanced localization accuracy. On the other hand, Benini et al[4] explain the use of UWB+IEEE 802.15.4a making reference to the Kalman's filter[57] and to the IMU's system (Inertial measurement unit) with these technologies. Tiemann[58], relates the indoor positioning with UWB and IEEE 802.15.4a using TDOA (Time-difference of arrival). The main conclusion about this work according to the author is: "Although the system accuracy is sufficient for most applications, multi-path rejection might be improved in future work, to allow for robust operation in crowded environments".

Figure 6 CEATIC Lab – UJAEN

4. Proposal Indoor Positioning with UWB

4.1. Context: The University of Jaén -Spain (UJAEN), has an environmental intelligence lab (see Figure 6), which is equipped with different electronic devices (sensors and actuators), furniture and appliances, which simulate a person's home. Currently the lab has some devices for indoor positioning, for example an electronic floor (Sensfloor Technology of Future-Shape, see figure 7), which it sends the position of a person to the system when monitored, also the lab has some sensors that works with BLE, but UWB technology has not yet been implemented. Another possible place for the implementation of UWB technology will be a center for the elderly, mainly a residential center, such as the "Residencia Ángeles Cobo", which is a center managed by Macrosad in Spain, specifically in the region of Alcaudete in Andalucia. This center was visited in the REMIND project activities in the secondment held at Ageing Lab in 2017, and we hope to collaborate in the future with an IPS. The description of the areas of this center is shown in table 1.

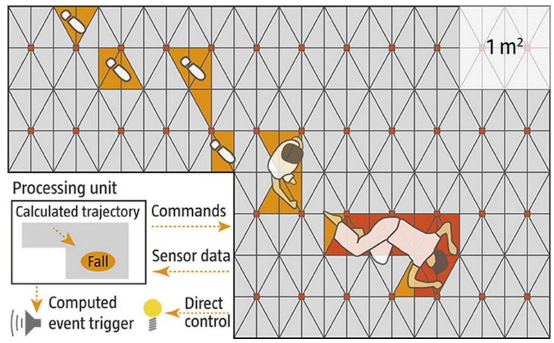
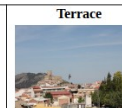


Figure 7. Sensfloor of Future-Shape

Table 1. Description Angeles Cobo Residence[59]

Areas			
Reception 	Dining Room 	Living Room 	Terrace 
Kitchen 	Double Rooms 	Common Recreational areas 	

The residential center that is listed in table 1, is an example of a place with different areas for the elderly, where the localization of a person is very important, mainly due to the possible risks or dangers that the elderly may suffer when they walk in the same. Before implementing the sensors in the places described in the context, we carried out an initial test in a laboratory of the UNAD Colombia, where the UWB technology was implemented, to verify the accuracy of the same. In figure 8, we can see the UNAD Laboratory.

4.2. Technological Proposal: According to the selected places for the development of the IPS with UWB, the proposed technology has the following characteristics, see Table 2. The main benefits of the technology proposed in Table 2 are: Precise location of tagged objects (a precision of 10 cm indoors); Long

LOS and NLOS range reduces amount of infrastructure required to deploy systems; Low chip cost allows cost-effective implementation of solutions; Low power consumption reduces the need to replace batteries and lowers system lifetime costs; Standards based solution (IEEE802.15.4-2011), eases proliferation. The kits proposed in the Table 2, are necessary for the implementation of the indoor positioning system with UWB, these devices are elements in development, but with great projection in this field. Our goal is to make several tests to assess the accuracy of the technology and its possible applications in localization this kind people inside. Next we explain the model design and the way of implementation of this technology in the proposed places.

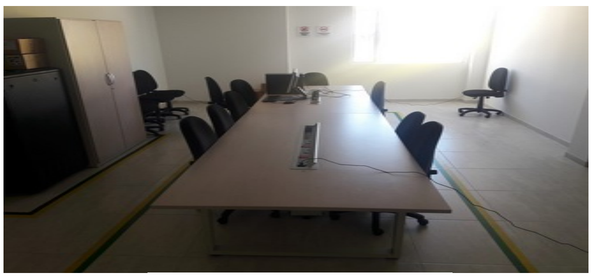


Figure 8. UNAD Laboratory

Table 2. Hardware proposal UWB

Hardware	Description	Quatity	Place of implementation
Kit RTLS1000 UWB	Development kit: Wireless positioning indoor real-time positioning and navigation tracking, 3 base stations and 1 label.	1	CEATIC Laboratory UJAEN
Tag or Label DWM1000	**DWM1000 UWB indoor positioning and ranging station label development board communication module**	3	CEATIC Laboratory UJAEN
Kit UWB: DWM1000	UWB indoor positioning system of high power DWM1000, 3 base stations and 2 labels	10	Residential Center Angeles Cobo
Kit Pozyx IPS UWB	Development kit: Wireless positioning indoor real-time positioning and navigation tracking, 4 base stations (anchors) and 2 tags.	1	UNAD Laboratory

4.2.1 CEATIC LAB Proposal: According to figure 9, the proposal for CEATIC consists of a sensors kit for indoor positioning, where three anchors and three labels or tags will be install; the anchors will be located in the corners of the lab and the tags or labels will be for free use and positioning tests. The technique or method we will use is TDOA with Fingerprinting.

4.2.2. Residential Center Angeles Cobo Proposal: In this place, the proposal consists in locating 10 sensors kits in different areas, mainly in zones where the size of the area is large, for example, the terrace, common recreational areas, living room, dinning room, kitchen, double room, physiotherapy room, multiple-purpose room and the reception. Each kit will have three anchors, which it will be located in the corners of each selected area, in total we will have 30 anchors for whole center and 10 tags or labels for tests. The method for the indoor positioning in this center will be TDOA and fingerprinting.

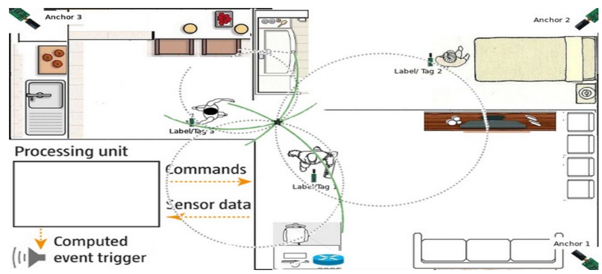


Figure 9. CEATIC Laboratory with sensors indoor positioning

4.2.4. UNAD Laboratory: This was the initial test, the aim of which was to evaluate the accuracy of the UWB technology. We can observe the proposed design in figure 10.

4.3. Procedure and implementation: The description that we have made about the implementation of indoor positioning system in three different places (CEATIC Laboratory, Residential Center Angeles Cobo and UNAD Laboratory), its have the following procedure: a. Acquisition and purchase of the sensor kits and the hardware required; b.Use or development of a software application for IPS; c. Localization of the devices: Anchors and routers WSN and WiFi; d. Devices configuration; e. Zone calibration – Fingerprinting off-line and on-line techniques; f. Saving localization data of zones identified in the database of the software developed or used; g. Performance tests with the positioning algorithm; h. Analysis of data and reports. In this paper, we explain the implementation of UWB technology in the UNAD Laboratory, the other places we hope to be able to implement them in the near future.

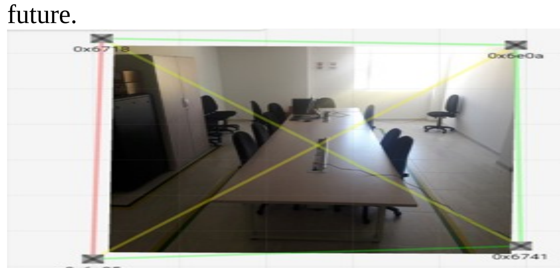


Figure 10. Implementation UNAD Laboratory

4.4. Initial Implementation Test: UNAD Laboratory

a. Acquisition of the sensor kit: for this test, we acquired the POZYX Kit, which is a set of sensors for indoor positioning, composed of: four (4) anchors and two (2) tags.

b. Use or development of a software application for IPS: for the implementation of the Pozyx kit in the UNAD Laboratory, we used the "Pozyx Cloud" software, which allowed us to calibrate and configure the anchors and tags for the test (figure 11).

c. Localization of the devices: in this test, we place the anchors in the corners of the UNAD laboratory and we connect these devices to the University's WiFi network in order to send the positioning data to the Pozyx software cloud. The tags were used movable to test the UWB technology and we were located in different places in the laboratory (figure 12).

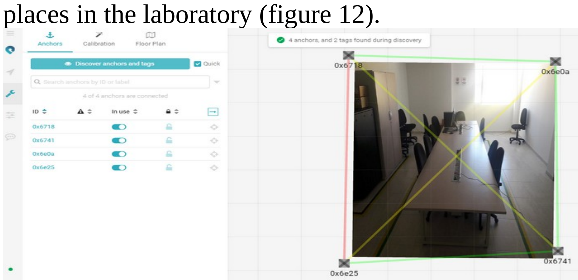


Figure 11. Pozyx software screen

d. Devices configuration: this procedure was performed with the Pozyx cloud software. We configured the general features of UWB technology, the localization of devices and their calibration.

e. Zone calibration: this procedure was carried out with the software in the Pozyx cloud, the first thing that was done was to determine the area of the UNAD Laboratory and the identification of the space of the elements that were in this place. Once this was done, we did some tests with the sensors, tags and anchors, to then perform the accuracy test (figure 13).

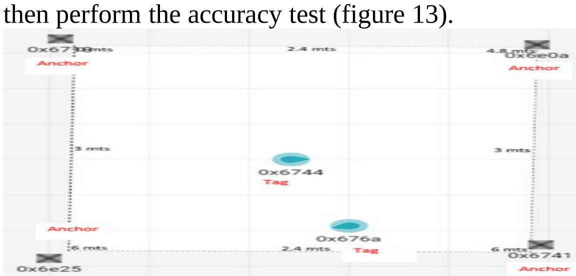


Figure 12. Localization of the devices

f. Analysis of data and reports: in this first implementation the aim was probe the accuracy of UWB technology, so we used the tags in different places of UNAD laboratory and after we verified the localization that save the Pozyx system and the real localization of the sensor. In figure 14 we can see the information that save the Pozyx system and in figure 15 the real localization of the sensors in the laboratory.

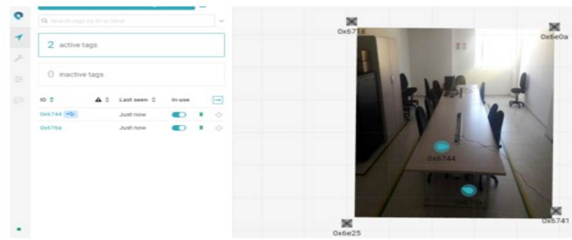
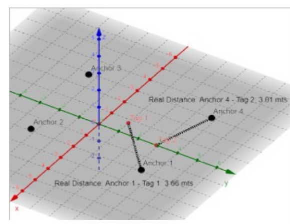


Figure 13. Zone calibration



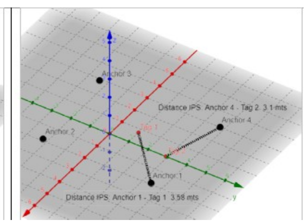


Figure 14. Real Distance and Figure 15. Distance IPS

With the coordinates of the anchor sensors and the label sensors, we obtained the position of the Pozyx system and compared it with the actual position measured with one meter. The results obtained were: with respect to tag 1 that was measured in relation to anchor 1, the difference of the real system versus the pozyx system was 12 centimeters; with respect to label 2, the distance was measured in relation to anchor 4 and the difference was 9.9 centimeters. These differences are within the expected parameters, which confirms the accuracy of UWB in an indoor positioning system.

5. Conclusions

The IPS are a necessary tool for different kinds of population, for example for the elderly people, where there are many situations that its must be monitored and controlled in real time, mainly when its working with persons who have important pathologies such as dementia and other similar. Currently there are many works about IPS, most use mainly WiFi and BLE, but there is a new possibility, which is UWB, where the accuracy according to previous studies is the best. In this paper we have proposed a design with this technology, and we hope to implement in a lab and a center for elderly people. There are many methods for implement IPS, some are very good, but only the works that have implemented UWB have achieved a better accuracy and significantly reduce the precision error. In addition, another way to improve the performance of IPS applications according to some previous studies has been the mix of several methods, in our design we have proposed a hybrid IPS with TDOA and Fingerprint. According to the context test in the UNAD laboratory, we were able to verify the accuracy of UWB technology, so in our next project we will implement this technology with some variations to obtain greater benefits in the design of IPS.

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