Proceedings of the 3rd International Conference on Signal Processing and Machine Learning
DOI: 10.54254/2755-2721/6/20230915

The application of ultrawideband technology in future wireless communications and practical exploration

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Abstract. An innovative form of wireless communication technology is called ultra-wideband technology. By directly modulating impulse pulses with extremely rapid rise and fall times, it is possible to create signals with bandwidths of the order of GHz. It has the benefits of being insensitive to channel fading, low power spectral density of the transmitted signal, low interception capability, low system complexity, and the ability to provide several centimeters of positioning accuracy. It also resolves the main propagation issues that have plagued traditional wireless technology for many years. Early high-speed data transmission in close proximity utilised ultra-wideband; more recently, foreign nations have started using its sub-nanosecond ultra-narrow pulse for close-range indoor positioning. Traditional wireless communication modulates signals to various frequency bands using various carrier frequencies, and within a given range, the carrier wave's frequency and power will change. Ultra-wideband wireless communication does not require a carrier wave, but uses pulsed signals to transmit information, where pulsed signals are those that are generated and disappear in a very short time, from a few hundred microseconds to less than a few nanoseconds. Thirdly, it can be positioned with high accuracy and has good resistance to multipath effects in timing. Ultra-wideband technology wireless communication systems generally work at sub-nanosecond pulse widths, and thus have sub-nanosecond time resolution, and its multipath resolution is correspondingly less than 30 cm, the signal will be received in the formation of a 1-nanosecond time reception window, only receive the signal within the reception window, the multipath interference has very good resistance. Fourthly, it has a greater penetration capability. Ultra-wideband pulses have a low frequency, the lowest of any wireless signal with the same absolute bandwidth, so they have greater penetration capability. Fifthly, the structure is simple, and the cost is low. The wireless communication system of ultra wideband technology does not change the traditional carrier wave to realize information transmission. The wireless communication system uses up conversion circuit, down conversion circuit, intermediate frequency circuit and various filters. The system structure is simple, and communication is relatively tolerant and easy. Therefore, the cost of wireless communication using ultra wideband technology is much lower.

Keywords: Ultrawideband Technology.

1. Introduction

1.1. Application in ultra-wide band

With the application of ultrawideband technology, it is possible to configure short-range wireless communication systems to support high-speed applications and low-speed smart devices. Ultra-

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wideband antenna systems, using a simple regime and coding mechanisms, enable information rates greater than that over short distances. Ultra-wideband can be used in a large number of application scenarios.

1.2. Wireless personal area network

The term "Wireless Personal Area Network" (WPAN) refers to a PAN (Personal Area Network) that consists of interconnected devices that are situated mostly around a person's workspace and are connected via a wireless medium. It is also known as a Person focused on a short-range wireless connection for this reason. The typical range is less than 10 meters, which indicates that it is extremely limited. One of the fundamental ideas of WPAN is "plugging in," as nearby WPAN-equipped devices communicate with one another as if they were physically connected by a cable. WPANs link with little to no infrastructure, in contrast to WLANs (Wireless Local Area Networks), which demand the establishment of infrastructure. In general, if this WPAN offers an energy-saving and affordable solution, it can be applied for a variety of devices over a short distance. Let's use the example of a Wi-Fi connection that allows two people to talk and share documents with each other in a room. Similar to WPAN, most connections between devices occur inside of buildings or in rooms (small distances)[1].

1.3. Wireless ethernet interface link

A wireless Ethernet interface link can extend the data rate of a high-speed wireless personal network to higher data frequencies, for example, up to 1Gb/s. The wireless Ethernet interface link needs to meet the following conditions: firstly, from the computer manufacturer's side, there needs to be an alternative to Ethernet; secondly, from the consumer's point of view, there needs to be a high-quality wireless video transmission capability between the computer and the screen, capable of transmitting wireless digital video.

2. Smart antenna system

Antenna arrays or groupings of antennas that have sophisticated processing methods for determining spatial signal fingerprints are known as smart antennas. Smart antennas take advantage of the diversity effect at the transmitter, receiver, or both the source and the destination. The diversity effect uses numerous radio frequency (RF) waves for transmission and/or reception in order to boost data speed and lower error rates. Smart antenna technology can get around these capacity restrictions, boost signal strength, and enable mobile phones to run on less power. Multi-rooted antennas, adaptable array antennas, and MIMO are other names for smart antennas. "AN INTRODUCTION TO SMART ANTENNA SYSTEM," by Bindu Sharma et al. (2015) [2].

2.1. Indoor positioning with Ultra-Wideband

A short-range radio technique called ultrawideband can be utilized for indoor positioning. Positioning is done using a transmission time approach (Time of Flight, ToF) rather than evaluating signal strength, unlike Bluetooth Low Power and Wi-Fi (Received Signal Strength Indicator, RSSI). With this technique, the optical runtime between a target and many receivers is measured (anchor-infsoft locator node 1100). There must be at least three receivers for exact object location (three-digit system). Furthermore, there needs to be a clear line of sight between the transmitter and the receiver. Ultra-wideband indoor positioning offers the following notable benefits: Compared to employing beacons (1-3 m) or Wi-Fi, this method has an accuracy of 10 – 30 cm (5-15 m). Very low latency (up to 100 position requests per second). Height disparities are quantifiable [3].

2.2. Outdoor point to point wireless bridge

Ultra-broadband devices are deployed outdoors, mainly for uplink and information exchange, as well as for downloading news texts, pictures and videos. The standard adopted will determine whether the outdoor peer-to-peer network is structured in a centralised or distributed manner. The ultra-broadband standard used in Europe restricts the deployment of ultra-broadband equipment outdoors. However, this can change at any time as the use of ultra-broadband regulation evolves and improves. The best outdoor point-to-point wireless bridges are bridges that connect two different devices via radio waves.

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It is a communication technology that sends packets of data remotely over an air interface. Wireless bridges are used in many different types of networks, but they are most often found in computer networks and corporate wide area networks (WANs). These bridges allow easy connections between buildings or floors without the need to install cables across the floor or wall[4].

3. Industry applications for ultra- wideband

3.1. Communication

Robot mapping and localization have been accomplished with great success using ultrawideband communications, which differ from the majority of existing radio communication technologies. A very wide range of frequencies are employed simultaneously to facilitate communication rather than employing a single frequency at any given time. The ultra-wideband emission periods are so brief that most radio equipment either cannot detect the signal or, at most, ignores it as normal background noise. This is done to prevent interference and power consumption issues. Obstacles built of materials that will block any specific frequency band are far less likely to impede signals with a very wide spectrum. This aspect of ultra-wideband communications makes time-of-flight computations more precise, especially in congested surroundings. Due to the more complicated transmission and reception requirements compared to traditional radio communication, ultra-wideband is a relatively new method of signaling and communication. Ultrawideband communications were initially employed in the pricey and covert world of military radio communications due to its technological difficulties and lack of visibility. Commercial suites were nearly hard to employ for home service robot navigation tests until recently, but the passage of time and ongoing technology advancement have made it possible to move on with this research.

The main applications of ultrawideband in the communications sector are in the following areas: firstly, intelligent digital home networks. Ultra-wideband technology can be used to connect to a variety of home appliances, such as computers, PDAs, TVs, games, audio and security systems. Secondly, it could become the physical layer standard for the transmission of wireless USB or wireless 1394, as ultra-wideband can provide a wide range of rates, which can enable the rate requirements of wireless USB to be met. Thirdly is the road information service systems. The application of ultra-wideband technology in the road information service system can provide high-speed information services, and can provide users with road information, building information, as well as weather forecasts and other human services. It can also be used in the car collision avoidance system and intelligent toll system. Fourthly, there are military applications. Due to the low interception rate, low detection rate, and low power consumption characteristics of ultra-wideband technology, so the earliest was used in the field, the development has been quite mature, mainly used in the battlefield line-of-sight tactical network radio, non-line-of-sight communication radio, tactical communication radio, ships and aircraft internal communication systems, and man-portable combat systems, etc.

3.2. Ultra-wideband for radar and surveillance applications

It mimics the electromagnetic pulse of nuclear explosions under the control of radar and communication equipment. Ultra wideband sensing also creates new opportunities for radar applications. This radar technology will find new uses in industry, non-destructive testing, medical engineering and healthcare, surveillance, search and rescue, etc. thanks to small, affordable equipment, high resolution and sensitivity, as well as low light exposure of radio waves[5].

3.3. Radar

In the field of radar, the application of ultrawideband technology has been studied for more than 50 years and the field of radar is also the earliest application area for ultrawideband technology. The development of ultra-wideband radar technology has become very mature by now. When sub-nanosecond signals are used, the spatial range resolution can be very high and when combined with the high perpendicular resolution and the frequency spectrum, the radar has a more accurate target recognition capability and can capture the subtle features of complex targets. The signals from ultra-wideband radar systems are highly penetrating and can penetrate through foliage, ground and cloud

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cover, allowing very hidden targets to be detected and distinguished. Specific applications include ground penetrating radar, wall penetrating radar and security surveillance[6].

3.4. Helping to digitize industry

Noccela has been working on micro-positioning technology for industrial applications since 2014. Sub-metre to centimetre micro-positioning is crucial when digitising industrial operations through Industry 4.0, smart factories and lean initiatives. Process optimisation and safety are the two primary considerations in most factories. By linking people, events, time and location information with people, tools, materials, goods and machines in real time, both parties are kept informed. In short, one of the best ways to improve efficiency is to first identify where the bottlenecks are. The most effective way to retrieve misplaced tools, pallets or vehicles is to first identify exactly where they are currently located. And the best way to keep workers and machines at a safe distance from each other is to know exactly where they are in real time. UWB-based micro-location services can provide this information in real time, allowing systems to measure, analyse and alert in real time. Noccela has deep expertise in this area. To build an industrial-grade solution, Noccela's engineers looked at Bluetooth® low energy (LE) and UWB, and found that Bluetooth LE has limitations in its ability to locate with high accuracy, primarily due to Bluetooth LE's Received Signal Strength Indicator (RSSI) method. It is subject to multiple paths and interference from objects and metal machines, and cannot provide reliable, accurate object ranging and positioning in industrial and other environments. But UWB can[7].

3.5. Robots

Robot mapping and localization have made excellent use of ultrawideband communication, which differs from most other radio communication systems. A very wide range of frequencies are employed simultaneously to facilitate communication rather than employing a single frequency at any given time. The ultra-wideband emission periods are so brief that most radio equipment either cannot detect the signal or, at most, ignores it as normal background noise. This is done to prevent interference and power consumption issues. Obstacles built of materials that will block any specific frequency band are far less likely to impede signals with a very wide spectrum. This aspect of ultra-wideband communications makes time-of-flight computations more precise, especially in congested surroundings. Due to the more complicated transmission and reception requirements compared to traditional radio communication, ultra-wideband is a relatively new method of signaling and communication. Ultrawideband communications were initially employed in the pricey and covert world of military radio communications due to its technological difficulties and lack of visibility. Commercial suites were nearly hard to employ for home service robot navigation tests until recently, but the passage of time and ongoing technology advancement have made it possible to move on with this research[8].

4. The advantages of ultrawideband technology in wireless communications

Applications of UWB technology include wireless data transmission, support for Internet of Things implementations, support for augmented reality, digital contactless keys for use in security systems, real-time positioning systems for locating devices, and automatic target identification in military communications and synthetic aperture radar technology.

1. Due to its low power consumption, it is perfect for settings or circumstances where radio frequencies are sensitive, such as hospitals.
2. Radar system processing technology, which has the ability to penetrate things, conduct high-resolution scanning, and identify dangers like buried explosives and covert enemies from a safe distance.
3. Compared to Wi-Fi and Bluetooth, ultra-wideband technology is intrinsically more accurate at locating objects or devices, broadening the range of applications for smart devices and facilitating the development of networked smart systems and the Internet of Things.
4. Accuracy is due to its ability to update positions roughly 10 times per second and locate objects with margins as tiny as 5 mm as opposed to the Bluetooth technology's 1 meter margin.

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5. Research demonstrates that by supporting time-of-flight measurements, better reach angel implementation, and increased safety, this technology enables more accuracy in both line-of-sight and non-line-of-sight conditions.

6. It is less prone to interference than other communications systems because it uses higher frequencies and a wider bandwidth, which are less congested.

5. Disadvantages and limitations of ultrawideband technology for wireless communications

The use of surplus bandwidth, along with low system power consumption, straightforward architecture or operating principles, and affordable implementation costs, are the main benefits of ultrawideband technology. It has been incorporated into consumer electronics like Apple's iPhone devices and Samsung's Galaxy smartphones due to its potential applications. But it has clear shortcomings and restrictions.

1. Tags for UWB-based pairing and location systems are more expensive than those for Bluetooth and RFID

2. Due to its slow data transfer rates, it cannot replace Bluetooth and Wi-Fi, which are used to transmit large amounts of data, hence it is not appropriate for streaming massive data.

3. The system is capable of carrier-free transmission. The following drawbacks, however, come with delivering data or signals without a carrier: intricate signal processing, inapplicability of super-resolution beamforming, and antenna profile

4. Due to the fact that it utilizes spectrum that is already designated for a variety of military, civilian, and commercial applications, it still poses a risk of interfering with already-installed devices.

6. Challenges and prospects for ultra-wide band technology

One is that today's market requires short-range wireless systems that can be modulated on narrowband carriers and can provide high-speed data rates to transmit video or accurate location information to support location-sensitive applications. Thus, this is a new research target for ultrawideband. Secondly, there are still many issues regarding mutual interference in the support of ultra-wideband devices and the achievable Qos levels. Thirdly, there are also challenges in the area of modulation and coding techniques for ultrawideband technology. When UWB technology was first applied to the military, obtaining high capacity was not the main goal of military communications. However, when applying UWB technology in commercial systems, user capacity is the first thing to be considered. Coding and modulation is one of the most effective ways to improve the capacity of a system with multiple users, which requires the design of adaptive modulation methods and channel coding mechanisms to increase system capacity. Although the average effective omnidirectional radiated power is very low in ultra-wideband technology, the peak power in a short period of time can be very high. This requires optimization of the transmission technology to suit the different signal propagation environments and to provide the high reliability and adaptive capability required. Fourthly, although UWB systems are highly resistant to multipath effects, system performance can also be affected by multipath effects. Fifthly, the complexity of the system is such that ultra-wideband blood medicine can be used with multiple parallel detectors or higher-order modulation. Sixth, the design and implementation of antennas for ultra-wideband devices at the physical layer, and the design and implementation of effective antennas, is a huge challenge for ultra-wideband systems. Seventh, the in-band interference brought by other wireless signals to the ultra-wideband receiver. The extremely small transmit power spectral density of ultra-wideband devices makes ultra-wideband receivers vulnerable to noise interference and impact. Eighth, new semiconductor technologies need to be investigated for application in ultra-wideband systems to end the problems of speed and synchronization delay and power consumption. Ultra-wideband technology is facing these challenges, will indicate the development direction of ultra-wideband technology, when ultra-wideband technology will now face challenges to overcome one by one, then the development prospects of ultra-wideband technology will be brighter, the application of the range will be more and more extensive, ultra-wideband technology in wireless communications will also be more perfect, to provide more effective services for people's lives.

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7. Conclusion

Although UWB technology is currently in the research and development stage and the transmission theory need further study, the potential applications are numerous. The widespread deployment of wireless local area networks (WLANs) and their natural integration with wireless mobile cellular networks suggest that the future of UWB technology will be very broad. As electronic devices become more intelligent, the need for high-speed data transmission over short distances is becoming more and more urgent.

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