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A Review on the Use of Ultra-Wide Band Sensors in Mineral Exploration

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Abstract

Ultra-wideband (UWB) sensors use radio frequency technology to precisely determine position by wireless communication between devices. The most recent applications concentrate on locating and collecting sensor data from mobile phones, car keys, and other similar devices. However, this technology is still underutilised in the mining industry. This viewpoint provides implementation options and solutions to bridge this gap. It also assessed the advantages and disadvantages of using ultra-wideband for mining. The provided measurements were made with QORVO two-way ranging sensors and compared to theoretical and existing technological solutions. To ensure that UWB sensors are used optimally, special emphasis was placed on influencing factors such as UWB location methods and factors affecting measurement accuracies such as line of sight, multipath propagation, the effect of shielding, and the ideal measurement setup. An experiment revealed that when there is no multipath propagation and the arriving signal travels directly from the transmitter to the receiver, the results are the most accurate. Ultra-wideband (UWB) is a radio technology that allows for short-range, high-bandwidth communications at very low energy levels while covering a large portion of the radio spectrum. Even though it was introduced in 1901, this technology has many applications today. It is not linked to any frequency, unlike other similar technologies. UWB can also send data by utilising unused frequency capacity and a very wide frequency range. The minimum frequency range for UWB is 500 MHz. In general, the frequency response and pulse width of a signal determine the accuracy that can be achieved. The response frequency of UWB can range between 10 and 40 MHz, and the pulse width can be as short as one nanosecond, giving it a theoretical accuracy of one millimetre.

Keywords: Band Sensors • Wireless local area network • Mineral Exploration

Introduction

Recent applications have concentrated on tracking, precise positioning, and sensor data collection. High-end smartphones and the most recent automobiles have UWB capability, which could be integrated into the mining positioning network. It enables fast and dependable data transmission over short distances. Because of its precision, transmission speed, and dependability, UWB is widely used for indoor localisation of moving assets in complicated and space-constrained environments; this makes it ideal for use in mining. A transmitter broadcasts billions of pulses over a wide spectrum frequency (UWB was previously known as "pulse radio" and was most commonly used in military communication applications); a receiver converts the pulses into data by identifying a recognisable pulse sequence delivered by the transmitter.

Its ability to transmit pulses at a rate of one every two nanoseconds adds to its real-time precision. Depending on the requirements, one of the four position calculation methods listed below can be used: time-difference of arrival (TDoA), two-way ranging (TWR), angle of arrival (AoA), and phase-difference of arrival (PDA) (PDoA). This paper discussed the applications of UWB technology in underground mining scenarios. Theoretical and technological solutions were tested against measurements taken in a real-world mining environment. A special emphasis was placed on determining the importance of key influencing factors and constraints in such environments, such as limited line of sight and cornering capacities. The experiments presented the benefits and possibilities of this already existing technology, as well as tested potential problems that could arise during implementation in a new environment (the mining environment). MDEK1001, Module Development and Evaluation Kit for the Decawave DWM1001C (UWB/Bluetooth module using Decawave's DW100IC, TWR), an Android tablet (Amazon fire HD10), and CR123 batteries were used in the test. The RTLS units can be powered by USB main power supplies, but batteries were used in this test for simplicity.

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Literature Review

A small remote-controlled car was used to simulate the moving target (Sensor tag). The first step is to set up a working network using the included software. There are two ways to position the anchors to begin the measurements. The first option is to use the auto-position mode for up to four anchors, or to manually position the anchors. In this test, auto-position mode with four anchors was used. The initiator anchor must always be the first anchor in the list with the local coordinate (0,0). The next step is to measure and begin auto-positioning, then check the locations in the preview mode before saving. Each device is listed in the network detail screen after successful auto-positioning. The ranging begins automatically, and there is an option to visualise the grid and zoom on the device automatically.

A rectangular layout is used for the anchor-sensor position. In this test, the maximum distance reached between two sensors without signal loss was 28 m. The maximum width was 4 m due to space constraints in the test mine. Furthermore, the anchors had to be placed at a height of more than 1.2 m above the moving target; anchors had to be placed at the same vertical level. Another factor to consider for anchor placement was the roughness and irregularities of the mine wall surface on site. Sensors were attached to the drift wall's existing indentations and notches, demonstrating the most basic and realistic application possible. UWB is used in smartphones alongside other technologies such as wireless local area network (WLAN), Bluetooth, and GPS without causing interference. Tests also revealed that there was no interference with existing networks in the underground mine environment (the local WLAN or radiocommunication system).

Discussion

A clear line of sight is ideal for maximum range and accuracy. It implies that all of the anchors can "see" each other (have a clear line of sight). A field test confirmed that accurate results can only be obtained if all sensors are in direct line of sight. The left side depicts a sketch of a specific sensor positioning in the rough mine wall; signal loss occurs when one of the sensors is not in direct line of sight; and the right side depicts two sensors in direct line of sight (without any obstacles of the mine wall). Testing with handheld UWB sensors and a sensor attached to a moving target showed that the proposed solutions could provide accurate single-sensor localization and tracking [1-3]. However, the results obtained in so-called multiple moving scenarios are not as precise as those obtained in single sensor scenarios. The mutual shielding (shadowing) of sensors in the observed area can explain this. When UWB electromagnetic waves illuminate something, a shadow zone forms behind it in the direction of electromagnetic wave propagation.

The shadow region is an area that is shielded from radar illumination by an object that reflects and/or absorbs the radar's electromagnetic waves, depicts the map with sensor position in a shielding scenario. The four anchors are red triangles, and the brown and black dots in between them are two fixated targets. Our mobile testing object is represented by the green dot. When the mobile target was manoeuvred through the two parallel sensors, the effect of shielding was clearly visible. The one further away from the initiating sensor would vanish from the map as the mobile target passed between the two other targets. A sensor configuration like the one shown in could be used to reduce shielding. Because of the overlaps, mobile tags that are close to each other can be identified more clearly. Every day, scientific interest in the use of UWB grows. The automotive industry, which is only now entering the age of self-driving, is already considering various ways to use UWB. UWB, for example, is being used to evaluate various collision avoidance system concepts for automobiles. At 6.35 GHz, two-way ranging achieved decimetre-level precision up to a distance of 300 m between two vehicles [4,5].

Others used 2.4 GHz and 5.9 GHz radios to measure time difference of arrival, with up to 90 m line of sight errors of less than 0.7 m depending on vehicle velocity. In the future, there will be many more self-driving vehicles underground or autonomous robots. Line of sight is required in all corners and crosscuts for this to be implemented safely; strategic positioning is critical. This is an important consideration for use in the underground mining environment, where rough surfaces and complicated geometries with many crosscuts and corners are essential components of mining methods and layouts. If successfully resolved, it could open up many new possibilities in the field of UWB navigation. Sensor interaction on mobile devices is especially useful in confined spaces [6,7].

The widespread use of UWB-enabled devices (e.g., car keys, mobile phones) could help to increase tracking capacities in any underground situation, while also easily incorporating new people and machines into the mine safety system. For example, by interconnecting sensors and heavy, moving machinery and employing an emergency shutdown principle in cases of need, one can quickly determine whether someone is in a dangerous area (or close to one) and, if so, how to defuse the situation. A growing number of sales are being made in this specialised market as a result of the general current uptake in UWB technology, which will undoubtedly result in more interesting future advances in this industry.

Conclusion

Despite all of the benefits and potential, UWB sensors are not currently used in underground mining; the perspective presented in this paper shows that this technology can be implemented. The in-situ experiment demonstrated that when there is no multipath propagation and the arriving signal travels directly from transmitter to receiver, the most precise results are obtained. Because it allows for the resolution of individual multipath components, the short UWB impulse is useful in line-of-sight and multipath propagation scenarios. Because of the short pulse duration, a UWB system can use appropriate firmware to separate the first arriving signal from later arriving reflections.

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Conflict of Interest

Authors declare no conflict of interest.

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