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SIGNAL DISHA-AUTOMATIC ANTENNA POSITIONING SYSTEM

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Abstract

Antennas are fundamental to every form of wireless communication system. Antenna placement is crucial for successful wireless communication, according to satellites and transmitters. So, to enable the use of IoT for remote antenna deployment, this paper provides an IoT-based antenna placement solution. In this case, this paper examines the transmitted orientation of each antenna over the Internet of Things using a sensor-based system that includes a motor on each antenna. When a satellite's or transmitting station's orientation changes, it is necessary to reposition the antenna. The receiving antennas might be located in different parts of the world, at great distances from each other. So, extremely long-distance antenna placement is within the realm of possibility because of modern technology. Online visibility of antenna sites is available to the operator in charge of the IoT. The antenna monitoring GUI system is utilized by the IoT. With IoT-based antenna placement solution technology, the antenna's orientation can be monitored and updated coordinates provided to the motor, allowing it to position the antenna correctly.

Keywords: Internet of Things (IoT), Antenna Positioning System, Arduino UNO, Servo Motor, IR Sensor, Power Supply, Wi-Fi Module.

Introduction

The need for precise antenna positioning and orientation in contemporary communication systems has grown recently due to the quick development of wireless communication, localization, and sensing technologies. High signal quality, enhanced throughput, and dependable connectivity are all made possible by effective antenna alignment, particularly in applications involving indoor localization, short-range MIMO transmission, and integrated sensing and communication (ISAC). The accuracy and adaptability of traditional antenna positioning and localization methods are frequently limited, especially when working in dynamic environments or when antenna displacement increases.

There are a number of studies that have utilized a number of today's modern techniques to enhance the accuracy of estimating the positions and orientations of antennas by using various types of localization and optimization methods. One of the major techniques used for antenna localization in short-range MIMO systems is the Weighted Centroid Localization

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(WCL); however, as the distance between two antennas increases, the accuracy of WCL decreases. Some of the methods developed from WCL that improve performance by utilizing symmetric coverage or the location of the antenna with the highest received power level result in an accuracy within millimetres of the antenna's true position, allowing for the possible implementation of ultra-high speed communication networks. Communication performance and sensing capabilities have also significantly improved for ISAC systems by using a joint optimization approach that combines beamforming with mobile antenna positioning, even when subject to non-convex optimization constraints. Moreover, the recent advances made in ultra-wideband (UWB) localization systems have produced small (< 12 cm), low-cost, multi-band (both wideband and narrow-band) dielectric resonant antennas, which have high gains and wide bandwidths, that can be used to support localization by measuring angle-of-arrival with very small errors. Additionally, self-aligning antennas that use Direction-of-Arrival (DoA) and Bluetooth Low Energy (BLE) technologies to automatically change the orientation of the antenna to maximize the accuracy of localization have also demonstrated their effectiveness in providing improved accuracy for indoor positioning. However, many existing systems require complex algorithms, expensive hardware, and/or fixed (i.e., non-adjustable) antenna configurations, which all contribute to decreased adaptability in real time and increased expense. Therefore, there is a need for a simple, inexpensive, and automated antenna positioning system that can dynamically align antennas based on direction of arrival. This is the driving force behind the creation of an IoT-based automatically-positioned antenna system to improve the quality of signal reception while minimizing the need for human involvement in positioning antennas and providing real-time monitoring of localization in modern smart wireless communication systems.

1.Literature Survey

In recent years, antenna positioning and orientation optimization have gained significant attention in wireless communication, localization, and sensing systems due to their direct impact on signal strength and communication reliability. Various IEEE research works have addressed the challenges of accurate antenna alignment, dynamic positioning, and performance enhancement in modern communication environments.

Serup, Pedersen and Zhang (2022) proposed a combined single-layer K-band transmit array and beamforming S-band antenna array for satellite communication applications. The design integrates a low-frequency phased patch array with a high-frequency transmit array sharing the same aperture, enabling compact dual-band operation. The transmit array is electrically transparent to the S-band array, allowing efficient beamforming without interference. The antenna achieved gains of about 15.4 dBi at S-band and 23.5 dBi at K-band with a wide scanning range of nearly 60°, demonstrating high aperture efficiency and dual-band performance. Their work mainly focuses on shared-aperture architecture, high gain, and efficient beam steering for nano-satellite and Satcom systems. [1]Trzebiatowski, Kalista, Rzymowski, Kulas and Nyka (2022) developed a multibeam antenna for Ka-band CubeSat connectivity using a 3-D printed lens integrated with an antenna array. The proposed system enhances satellite communication by generating multiple beams with improved directivity and coverage. The use of additive manufacturing reduces weight, cost, and fabrication

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complexity while maintaining high radiation performance. Their design is particularly suitable for small satellites where size, weight, and power constraints are critical. However, the study primarily emphasizes multibeam generation and high-frequency connectivity rather than automatic antenna alignment or intelligent positioning systems.[2]Ma et al. (2024) proposed a simple and low-cost shared-aperture antenna module designed for 5G N78 and N257 band applications. The antenna integrates sub-6 GHz and millimetre-wave frequencies into a single compact structure, improving space efficiency and reducing hardware complexity. Their design achieves dual-band operation with good radiation performance, high efficiency, and cost-effective fabrication, making it suitable for modern 5G communication systems. The study mainly focuses on aperture sharing, compactness, and multi-band functionality for advanced wireless networks. [3] He et al. (2021) designed a broadband double-ridge horn antenna for millimetre-wave applications. The proposed antenna provides wide bandwidth, stable gain, and excellent impedance matching across high-frequency ranges. The structure enhances radiation efficiency and directional characteristics, making it suitable for 5G, radar, and high-speed communication systems. Their work emphasizes broadband performance and high-frequency signal transmission, but it does not address automatic antenna alignment or intelligent positioning mechanisms. [4] Motevasselian and W. G. Whittow (2017) proposed a miniaturization technique for a circular patch microstrip antenna using an arc projection method. The design significantly reduces the physical size of the antenna while maintaining its resonant frequency and acceptable radiation characteristics. This approach is suitable for compact wireless devices where space constraints are critical. The study mainly focuses on antenna size reduction without compromising performance and efficiency. [5] Jia, Ji, Lu, Pan and Zhu (2021) presented a dual-resonant high-gain wideband Yagi-Uda antenna using full-wavelength sectorial dipoles. The proposed antenna achieves enhanced gain, wide bandwidth, and improved directional radiation performance. Their design is effective for high-frequency and long-range communication applications requiring stable and high-gain transmission. The research emphasizes wideband operation and directional characteristics for advanced wireless communication systems. [6]Zetterstrom, Petek, Castillo-Tapia, Palomares-Caballero, Fonseca and Quevedo-Teruel (2023) presented a V-band fully metallic geodesic Luneburg lens antenna for high-frequency applications. The proposed antenna offers high gain, wide scanning capability, and low loss due to its fully metallic structure, making it suitable for millimeter-wave and satellite communication systems. The geodesic lens design improves beam steering performance and enhances radiation efficiency at V-band frequencies.[7]Kähkönen, Ala-Laurinaho and Viikari (2022) proposed a modular dual-polarized Ka-band Vivaldi antenna array for high-data-rate communication systems. The antenna array provides wide bandwidth, dual polarization, and high directivity, which are essential for advanced satellite and 5G applications. Their modular design allows easy scalability and integration while maintaining stable radiation characteristics and efficient beamforming performance.[8]Choi and Dagefu (2023) proposed a compact three-port antenna with enhanced inter-port isolation to achieve polarization and pattern diversity. The antenna design improves isolation between ports, reducing mutual coupling and enhancing overall communication reliability. Their work focuses on compact structure, diversity performance, and stable radiation characteristics, making it suitable for modern wireless and multi-antenna communication systems. [9]Varheenmaa, Lehtovuori, Ylä-Oijala and Viikari

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(2022) developed a low-SAR back cover mobile antenna aimed at reducing the specific absorption rate in handheld devices. The proposed antenna is integrated into the mobile back cover, ensuring user safety while maintaining good radiation efficiency and impedance matching. The design emphasizes compactness, low electromagnetic exposure, and efficient performance for mobile and portable communication applications. Kowalewski, Eisenbeis, Jauch, Mayer, Kretschmann and Zwick (2020) proposed a millimeter-wave broadband dual-polarized dielectric resonator antenna based on hybrid modes. The antenna achieves wide bandwidth, high radiation efficiency, and stable dual-polarization performance, making it suitable for mmWave and high-data-rate communication systems. Their design mainly focuses on broadband operation and improved polarization diversity for advanced wireless applications.[10]Crocker and Scott (2020) presented an unbalanced sinuous antenna designed for near-surface polarimetric ground-penetrating radar applications. The proposed antenna provides ultra-wideband performance, stable polarization characteristics, and effective subsurface detection capability. Their work emphasizes broadband radiation, polarization purity, and reliable performance in radar and sensing applications, particularly for ground-penetrating radar systems.[11]

2. Problem Statement

Accurate antenna alignment is essential for reliable connectivity, strong signals, and the efficient transfer of data in wireless communication systems. Manual methods of positioning antennas are slow, prone to errors, and not practical in dynamic or remote settings causing signal loss and decreased performance. In addition, static antenna systems have difficulty adjusting to obstacles or changing environmental conditions when the signal direction changes and require manual adjustment frequently. Typically advanced solutions are expensive with complexity in processing the signal direction determining the position of the antenna. Conversely, an IoT-based automatic antenna positioning system offers a cost-effective solution that utilizes sensors, RF, and microcontroller to detect the signal direction automatically and position the antenna to provide optimal signal reception and better communication efficiency.

3. Literature Review (Existing system & Proposed system)

3.1 Existing System

In traditional wireless communication systems, antenna alignment is mainly performed manually using fixed directional antennas and basic signal strength indicators. Technicians adjust the antenna position through trial-and-error methods to obtain maximum signal reception, which is time-consuming and prone to human error. Some existing systems use motorized antennas controlled by predefined algorithms, but they often require complex hardware, high computational power, and expensive signal processing units.

Moreover, many conventional antenna systems are static and cannot automatically adapt to changes in signal direction due to environmental obstacles, mobility of transmitters, or weather conditions. Advanced automatic tracking systems such as radar-based and GPS-

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based alignment solutions provide better accuracy but are costly and unsuitable for low-cost IoT applications. These limitations result in reduced signal quality, inefficient communication, and increased maintenance effort, highlighting the need for an intelligent and automated antenna positioning system.

3.2 Proposed System

Signal Disha is an Internet of Things (IoT)-based automatic antenna positioning system that aims to improve signal strength and make sure that wireless communication is reliable by smartly aligning the antenna in the best direction. In traditional wireless systems, antenna alignment is done by hand, which takes a lot of time, isn't very accurate, and isn't very efficient, especially in places where the signal direction changes a lot. To get around these problems, the proposed system combines infrared (IR) sensors, RF transmitter and receiver modules, an Arduino microcontroller, a servo motor with motor driver, a Wi-Fi module, and an LCD display to make antenna control automatic and smart. The RF transmitter sends signals without wires, and the RF receiver picks up on changes in signal strength. The IR sensors keep track of changes in the signal's direction and strength, which lets the system know which way is best. The Arduino microcontroller is the brain of the system. It gets data from the sensors and analyses it to find the direction with the best signal reception. The microcontroller makes the right control signals based on this analysis and sends them to the servo motor through a motor driver circuit. The servo motor then turns the antenna exactly in the right direction, which improves signal reception and communication stability. At the same time, the LCD screen shows the current antenna angle and signal strength, giving the user real-time information about the system. The Wi-Fi module gives the system IoT capabilities by letting users check on the performance of the antenna from anywhere and get status updates over the internet. This prototype reduces the need for human input, increases the accuracy of alignment, and keeps the connection going even when the signal environment changes. The system is also cost-effective, scalable, and flexible enough to be used in a wide range of situations, such as communication towers, satellite communication systems, smart wireless networks, and remote monitoring stations. The proposed system greatly improves the efficiency, reliability, and performance of wireless communication systems by using automation, sensor integration, and IoT technology.

4. Block Diagram of Automatic Antenna Positioning System

The block diagram shows how the Signal Disha IoT-based automatic antenna positioning system is set up. The architecture is made so that it can automatically find the direction of the signal and turn the antenna toward the strongest signal source to make sure that communication is reliable. The first part of the system is the sensing section, which has two IR sensors and an RF transmitter (RF TX). The IR sensors are used to find changes in the direction and strength of signals. These sensors keep an eye on the environment around them all the time to find changes in signal strength. The RF transmitter sends wireless signals that act like or stand in for the source of the communication signal. A separate power supply powers this section to make sure it works properly. The signals are then received by the RF receiver, which then sends the information to the Arduino microcontroller. The Wi-Fi module is connected to the Arduino microcontroller to facilitate the Internet of Things. This allows real-time monitoring and access to system information via the internet. The core of this architecture is the Arduino microcontroller, which is used to process the information. This microcontroller receives the input information from the RF receiver and analyzes the signal strength. Based on this information, the Arduino microcontroller then decides which direction has the maximum signal intensity. The output section consists of a motor driver, a servo motor, and an LCD display. The motor driver receives the signals from the Arduino and provides them to the servo motor. The servo motor rotates the antenna in the desired direction. The LCD display shows the angle of the antenna and the signal status.

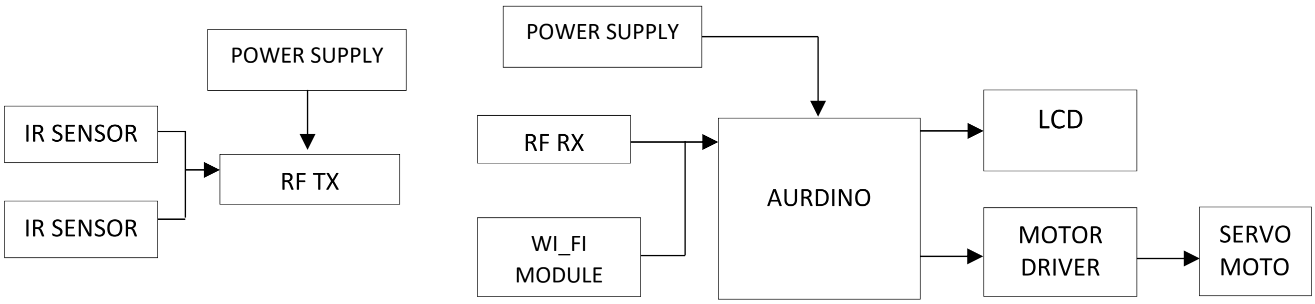

Figure 1. Block Diagram of Automatic Antenna Positioning System

5. Conclusion

The Signal Disha system successfully demonstrates an intelligent and automated solution for antenna alignment using Internet of Things technology. The prototype effectively detects signal direction changes and automatically adjusts the antenna toward the direction of maximum signal strength. By integrating IR sensors, RF transmitter-receiver modules, an Arduino microcontroller, a servo motor, and a Wi-Fi module, the system achieves accurate positioning with minimal human intervention. The experimental results confirm that the system improves signal strength, reduces communication interruptions, and ensures stable connectivity in dynamic environments. The automatic alignment mechanism eliminates the limitations of manual antenna adjustment, which is often time-consuming and less precise. The inclusion of an LCD displays and IoT-based remote monitoring enhances usability and real-time system tracking. Overall, it is found that Signal Disha acts as a cost-effective, scalable, and reliable solution for the needs of modern wireless communication. This system can be used in communication towers, satellite systems, remote monitoring systems, and smart wireless networks. For future developments, advanced signal processing techniques and AI-based optimizations could be considered.

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