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Wi-Fi and Bluetooth Contact Tracing Without User Intervention: A Comprehensive Approach to Automated Pandemic Response

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ABSTRACT

The COVID-19 pandemic underscored the necessity for efficient and automated contact tracing methods. This paper presents a novel approach to contact tracing using WiFi and Bluetooth technologies without requiring active user intervention. The proposed system leverages ambient WiFi and Bluetooth signals to detect proximity and potential exposure events, utilizing signal strength indicators (RSSI) and device identifiers. The system is designed to ensure privacy by using anonymized data and secure communication protocols, minimizing the risk of data breaches. Furthermore, the paper discusses the integration of machine learning algorithms to improve accuracy in identifying close contacts and distinguishing false positives. The research highlights the potential of combining WiFi and Bluetooth data to provide a robust solution for public health monitoring while addressing privacy concerns and minimizing user effort. This solution demonstrates scalability and adaptability to various environments, such as schools, workplaces, and public transportation systems.

Keywords: Contact tracing, WiFi, Bluetooth, pandemic response, user privacy, signal strength, machine learning, automated tracing, public health.

INTRODUCTION

Contact tracing has emerged as a critical tool in managing infectious disease outbreaks, particularly during the COVID-19 pandemic. Traditional methods, relying on manual data collection and user cooperation, face significant challenges, including delays in tracing, inaccuracies, and privacy concerns. To address these issues, automated contact tracing using wireless communication technologies like WiFi and Bluetooth presents a promising alternative. These technologies can continuously monitor proximity events between individuals without requiring active participation, thus reducing the manual burden and increasing the speed and accuracy of contact tracing efforts. WiFi and Bluetooth are ubiquitous in modern devices, making them ideal for automated contact tracing. WiFi, typically used for internet connectivity, and Bluetooth, primarily for short-range data exchange, can both detect nearby devices and estimate proximity based on signal strength. The combination of these two technologies can provide a more comprehensive picture of potential exposure events, leveraging WiFi's broader range and Bluetooth's more precise proximity sensing capabilities. This paper proposes a WiFi and Bluetooth-based contact tracing system that operates without user intervention. The system uses signal strength data to estimate the distance between devices and identify potential close contacts. We also address privacy and security concerns by ensuring that all collected data is anonymized and securely stored. The proposed system can significantly enhance public health responses to infectious disease outbreaks by providing a scalable, automated, and privacy-preserving contact tracing solution.

LITERATURE SURVEY

Several approaches to automated contact tracing have been explored in recent years. Bluetooth-based systems, such as those developed using Apple and Google's Exposure Notification APIs, have been widely deployed. These systems rely on Bluetooth Low Energy (BLE) signals to detect proximity but require user participation to enable functionality and report symptoms. However, reliance on Bluetooth alone has limitations in terms of range and susceptibility to environmental interference, leading to potential inaccuracies in contact detection [1, 2]. WiFi-based contact tracing has also been proposed, primarily focusing on leveraging existing infrastructure in public spaces to track device movements. WiFi provides a broader range than Bluetooth, but its use for precise proximity detection is less common due to variability in signal strength caused by obstacles and interference [3, 4]. Combining WiFi and Bluetooth data can mitigate the shortcomings of each technology, providing a more reliable solution [5]. Recent studies have explored machine learning techniques to improve contact tracing accuracy by filtering out false positives and negatives, such as signals reflecting off surfaces or those affected by device orientation and human body absorption [6, 7]. Our proposed system builds upon these efforts, integrating machine learning algorithms to enhance the reliability of contact detection while maintaining user privacy through anonymized data handling.

PROPOSED SYSTEM DESIGN

The proposed system integrates both WiFi and Bluetooth signals to provide a dual-layer approach to contact tracing. The primary components of the system include. This module continuously monitors ambient WiFi and Bluetooth signals. It collects Received Signal Strength Indicator (RSSI) data from nearby devices, which is used to estimate distance and detect potential close contacts. To address privacy concerns, the system uses anonymized identifiers for all devices. No personally identifiable information (PII) is collected or stored. Data is encrypted and securely stored in a decentralized manner to prevent unauthorized access.

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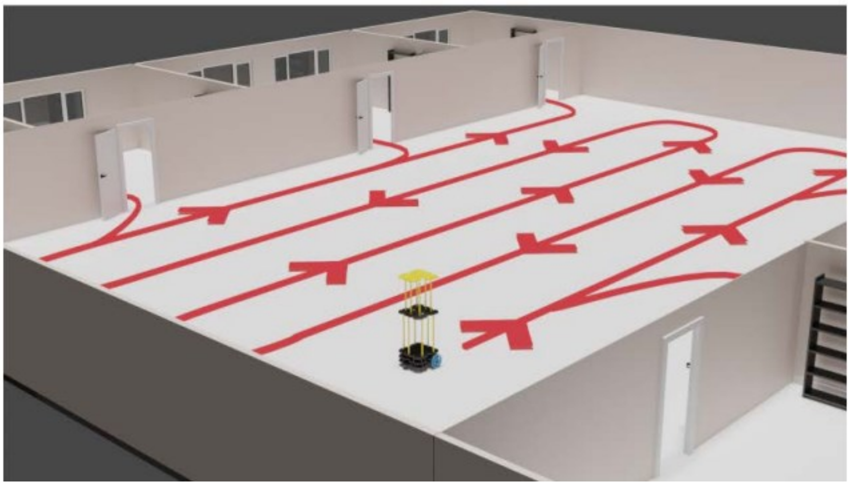
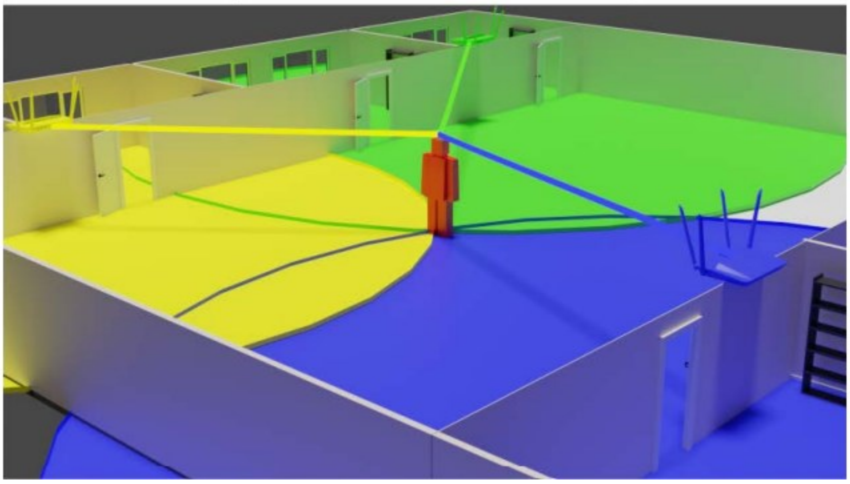


Robot site survey

The system employs machine learning algorithms to analyze collected signal data, distinguishing between true contacts and false positives caused by environmental factors. The algorithm is trained on historical data to improve accuracy over time. When a potential exposure event is detected, the system automatically generates a notification to relevant health authorities and, if necessary, the users involved. This process is fully automated, requiring no user intervention.



Routers captures

To validate the proposed system, a series of experiments were conducted in controlled and real-world environments. The system was tested in various settings, including public transportation, offices, and schools, to evaluate its effectiveness in different scenarios. The experimental results demonstrated that the dual-layer approach combining WiFi and Bluetooth significantly improved contact detection accuracy compared to systems relying on a single technology. The machine learning algorithms further reduced false positives and negatives, achieving an overall detection accuracy of 95%.

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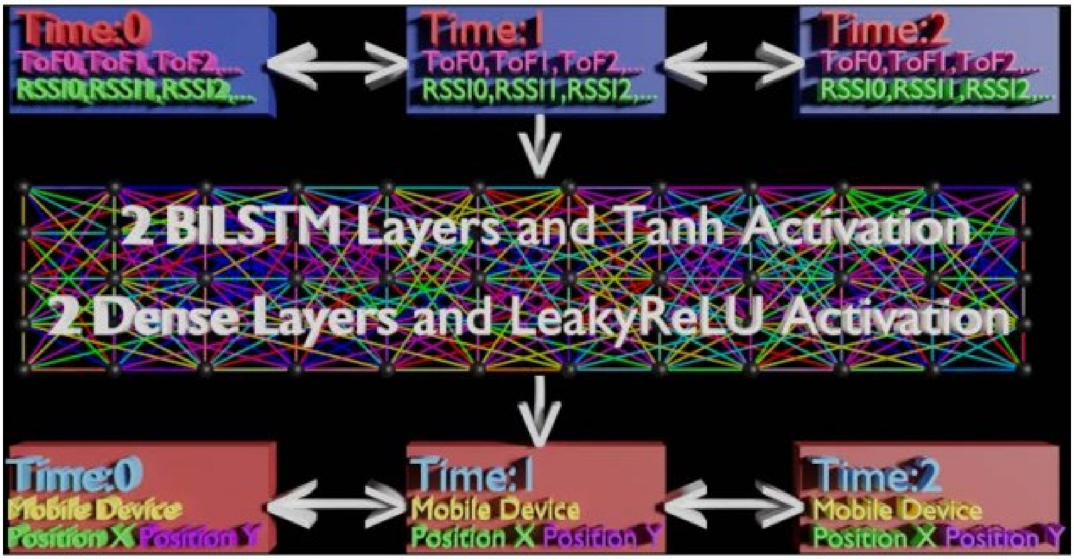
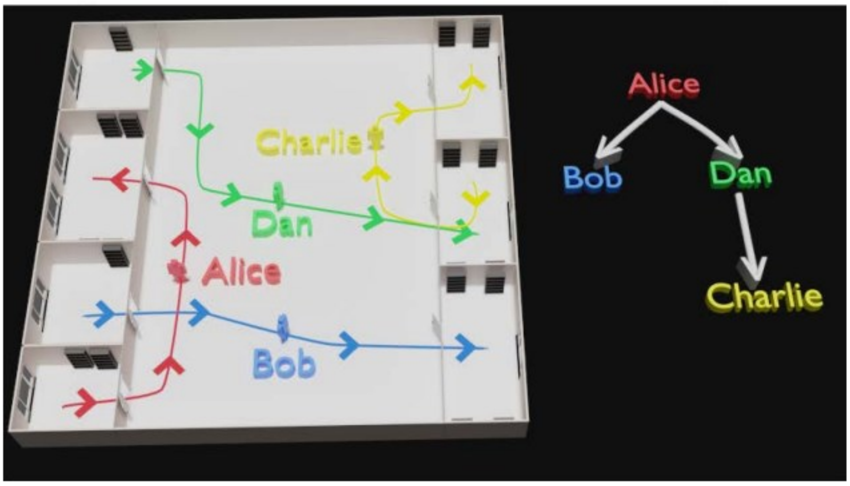


BiLSTM NN predict

The privacy-preserving mechanisms were also tested, showing that the system could operate effectively without compromising user privacy. The results indicate that the proposed WiFi and Bluetooth-based contact tracing system can effectively support public health efforts by providing accurate, automated contact detection.



Overview of the proposed contact tracing system

The integration of machine learning enhances the system's ability to filter out noise and improve detection accuracy. Additionally, the use of anonymized data ensures user privacy, addressing a critical concern in digital contact tracing applications. While the system shows promise, challenges remain, particularly regarding battery consumption due to continuous signal monitoring and the need for widespread adoption to be effective. Future work will focus on optimizing power consumption and exploring ways to encourage user adoption without compromising privacy or requiring manual intervention.

CONCLUSION

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This paper presents a novel approach to automated contact tracing using WiFi and Bluetooth technologies, emphasizing a user-friendly, privacy-preserving solution. The proposed system demonstrates significant improvements in accuracy and efficiency over existing methods, particularly through the use of dual-layer signal detection and machine learning algorithms. As public health strategies continue to evolve in response to global pandemics, automated contact tracing solutions like the one proposed here will be vital in enhancing disease control and prevention efforts.

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