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Artificial Intelligence in Wireless Positioning System: Taxonomy and Recent Framework

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ABSTRACT

The diversity of technologies and approaches in Wireless Positioning Systems (WPS) necessitates a structured taxonomy to better understand their capabilities and limitations. Recent advancements in Artificial Intelligence (AI) have significantly enhanced the accuracy and efficiency of WPS by leveraging sophisticated frameworks. The traditional reliance on signal-based metrics, such as received signal strength (RSS), faces significant challenges in adapting to environmental dynamics and mitigating inaccuracies, highlighting the critical role of Artificial Intelligence (AI) in developing more intelligent and adaptive frameworks within Wireless Positioning Systems (WPS). This paper aims to identify and analyze the potential of AI-enhanced WPS frameworks in improving accuracy and robustness, with a specific focus on Wi-Fi and RSS-based methods such as signal fingerprinting technique. The methods taken to characterize the taxonomy include Systematic Literature Review (SLR) and Bibliometric Analysis to identify, categorize, and analyze WPS frameworks that leverage AI to process RSS data and improve position estimation. This study provides a structured taxonomy and highlights the transformative impact of AI in refining WPS based on Wi-Fi and RSS. The findings underscore the potential of AI-driven approaches to address current challenges in wireless positioning, paving the way for more robust and scalable systems. The proposed taxonomy and insights provide a foundation for future research and practical applications, offering pathways to more precise, efficient, and adaptable WPS frameworks.

1. Introduction

Wireless Positioning System (WPS) plays an important role in various applications, including indoor navigation, intelligent transportation systems, Internet of Things (IoT), and location-based asset management. As the need for accurate and efficient positioning systems increases, various approaches have been developed, ranging from signal-based methods such as Received Signal Strength (RSS), Time of Arrival (ToA), and Angle of Arrival (AoA), to machine learning and deep

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learning-based techniques. A study conducted by Yu *et al.,* [1] showed that a hybrid method integrating Wi-Fi FTM, RSSI, and MEMS sensors can improve WPS accuracy.

However, conventional signal-based approaches still face significant challenges, especially signal instability due to multipath fading and environmental noise, which causes accuracy degradation in position estimation. In complex indoor environments, signal fluctuations become a major bottleneck for RSS-based WPS, thus demanding more adaptive and intelligent solutions. According to research conducted by Guo *et al.,* [2], RSS-based systems often suffer from large position errors due to multipath fading, especially in environments with many physical obstacles.

Artificial Intelligence (AI) has emerged as an innovative approach to overcome the limitations of traditional WPS, as discussed in Ratten [3] research. Its ability to extract complex patterns from signal data and dynamically adjust position estimation parameters enables AI to significantly improve the accuracy and robustness of WPS. The study conducted by Almomani and Al-Turjman [4] examined various AI techniques used in IoT-based positioning systems and highlighted the advantages of these methods in optimizing position estimation. Various techniques such as Artificial Neural Networks (ANN) and Long Short-Term Memory (LSTM) have also been applied to optimize signal fingerprinting techniques and improve RSS-based position estimation, as discussed in the study by Wye *et al.,* [5].

Nonetheless, many studies that have explored AI applications in WPS still tend to focus on specific implementations without a thorough analysis of how different AI approaches contribute to addressing the key challenges in Wi-Fi and RSS-based WPS. The study conducted by Kirmaz *et al.,* [6] showed that Convolutional Neural Networks (CNN)-based methods can reduce errors in time-of-arrival (ToA) estimation, but the study did not discuss how these methods compare to other AI approaches in a broader context. Therefore, there is still a need for a systematic mapping that classifies various AI methods in the context of position estimation more comprehensively.

The study conducted by Ma *et al.,* [7] indicates that ANN-based models have great potential in improving positioning accuracy, but there are still challenges in adapting such models to dynamically changing environments. By establishing a clear classification framework, this research is expected to provide deeper insights into how AI can be optimized to improve the performance of positioning systems in dynamic environments. Although various AI techniques have been applied in WPS, there are still some research gaps that have not been fully addressed. In particular, existing research is lacking in systematically analyzing how different AI approaches contribute to improving WPS performance under various dynamic conditions. In addition, there is no comprehensive study on the trade-off between accuracy, computational efficiency, and adaptability of AI systems to changing environments. Therefore, a more systematic mapping is needed to classify various AI methods in the context of position estimation and identify future research challenges and opportunities.

By establishing a clear classification framework, this research is expected to provide deeper insights into how AI can be optimized to improve the performance of positioning systems in dynamic environments. Although significant progress has been made in the application of AI to WPS, there are still challenges in understanding the relationship between signal characteristics, AI parameters, and system performance holistically. The absence of a conceptual framework that links AI techniques with the adaptability and scalability aspects of WPS is one of the main challenges, as identified in the study by Guldner *et al.,* [8]. Therefore, this research contributes by presenting a comprehensive taxonomy, which not only categorizes AI techniques based on their effectiveness in improving position estimation, but also identifies challenges that remain unresolved in the current literature.

The main contribution of this research is the establishment of a systematic classification model to understand the evolution and application of AI in Wi-Fi and RSS-based WPS. This research offers a holistic approach that connects AI techniques with key challenges in RSS-based positioning. As such, this research not only provides a clearer mapping of AI developments in WPS, but also opens up opportunities for further exploration of hybrid methods and deep learning approaches that can improve the efficiency and scalability of positioning systems. The taxonomy and insights generated from this research are expected to be a key reference for academics and practitioners in developing more precise, efficient, and adaptive AI-based WPS solutions for various real-world applications.

2. Methodology

2.1 Research Design

This research uses Bibliometric Analysis and Systematic Literature Review (SLR) approaches to identify, categorize, and analyze research developments and trends related to the application of Artificial Intelligence (AI) in Wireless Positioning System (WPS). The Bibliometric Analysis approach is applied to quantitatively map the research landscape based on publications in reputable databases, while SLR is used to systematically evaluate and synthesize relevant research. This approach aims to compile a comprehensive taxonomy of AI techniques that have been used in Wi-Fi and Received Signal Strength (RSS)-based WPS, and identify future research contributions, challenges, and opportunities.

To understand research trends, a Bibliometric Analysis was conducted using VOSviewer and Biblioshiny software to visualize publication patterns, inter-researcher collaboration, and thematic maps of research in the AI-based WPS domain. The analysis included an evaluation of the number of publications per year, journal distribution, and citation network to identify the most influential research and the evolution of methodologies used. Previous studies, such as the one by Cosh *et al.,* [9], have applied bibliometric approaches to uncover trends in literature review globally. Similarly, the study by Lazarides *et al.,* [10] illustrates how bibliometrics can bridge informatics with science through the analysis of citations and publication trends.

By adopting a similar approach, this research integrates Bibliometric Analysis and SLR to provide a deeper understanding of the development of AI technology in Wi-Fi and RSS-based WPS systems, thereby providing a more systematic insight into the contribution of the research that has been conducted and the direction of future development.

2.2 Search Strategy and Selection Criteria

The search strategy in this study was conducted using a systematic search method using Scopus indexed academic databases. Figure 1 visually depicts the implementation of the PRISMA framework in this review.

At the identification stage, a total of 10,177 articles were found based on keyword combinations covering aspects of artificial intelligence, wireless mapping systems, and signal fingerprinting techniques. Previous studies have shown that this method is effective in capturing literature relevant to a particular research domain. Next, an initial screening was conducted by evaluating relevance based on title, abstract, and keywords, which resulted in the exclusion of 9,127 articles for not meeting the initial eligibility criteria.

After the initial screening stage, 1,050 articles were deemed relevant and searched for in full. However, four articles could not be retrieved. Of the 1,046 articles that were successfully accessed, further selection was made based on more stringent eligibility criteria, including publication year restrictions (≥2021), relevance to the field of study, document type, and publication language. This selection process resulted in the exclusion of an additional 788 articles, with 461 articles published before 2021, 16 articles not matching the targeted field of study, 290 articles not matching the accepted document type, and 21 articles published in languages other than English.

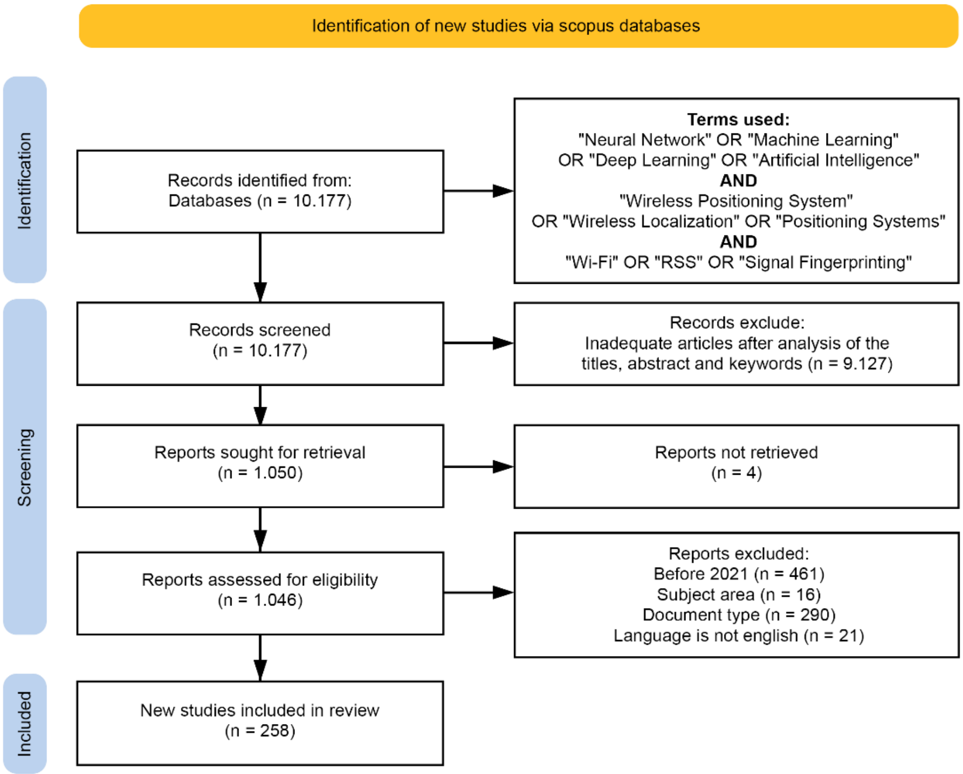

Fig. 1. PRISMA flow diagram

As a final result of this rigorous selection process, a total of 258 new studies were included in the systematic review. The application of the PRISMA method in this literature selection demonstrates a commitment to methodological rigor, ensuring that only studies that meet high standards of quality and relevance are included in the review. As described by Athikarisamy and Patole [11], the PRISMA method enables transparency in study selection and increases replicability and validity in systematic reviews. Thus, the results of this review can provide a comprehensive and evidence-based insight into recent developments in the application of artificial intelligence for Wi-Fi-based wireless mapping and localization systems.

2.3 Eligibility and Inclusion

The validation stage is conducted to ensure that only studies that are truly relevant and have academic significance are included in further analysis. According to Calhoun and Scerbo [12], the validation process aims to select studies that have good methodological quality. Articles that had passed the initial selection stage were examined in more depth by reading the entire content of the study to ensure its suitability for the purpose of this research. The inclusion and exclusion criteria applied in this study are summarized in Table 1.

Based on the rigorous and systematic approach to the study selection process shown in Table 1, this study ensured that only studies that met high academic standards were included in further analysis. Tod [13] emphasized that the application of clear inclusion and exclusion criteria is essential for maintaining the quality of systematic reviews.

In terms of language, only articles published in English were included to ensure accessibility and uniformity of academic terminology. Jemadi *et al.,* [14] explained that the selection of English in scientific publications can improve readability and global dissemination of research results. In terms of publication year, only studies published in the 2021-2025 range were selected, reflecting the focus on recent developments in artificial intelligence for Wireless Positioning System (WPS). Zhan *et al.,* [15] underline that advances in machine learning and deep learning continue to evolve rapidly, so older studies may be less relevant to current technology trends.

Table 1
Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Language	English	Non-English
Year published	2021-2025	Before 2021
Type of article	Article	Conference paper, Book chapter, Conference Review
Subject area	Computer Science, Engineering	Physics and Astronomy, Biochemistry, Genetics and Molecular Biology, Chemistry, Mathematics, Materials Science

This rigorous selection approach ensures that the reviewed studies are of high academic significance and contribute directly to the advancement of AI-based wireless mapping and localization systems. As such, the review results can provide more targeted insights into how AI techniques can improve accuracy, robustness, and scalability in Wi-Fi and RSS-based WPS.

3. Results

3.1 Bibliometric Analysis on AI in Wireless Positioning Systems

3.1.1 Descriptive bibliometric analysis

Table 2 shows that 258 journals by 834 authors over the period 2021-2025. With an average document age of 2.4 years and an average citation count per document of 12.34, this reflects that research in this domain has a high level of relevance and impact within the academic community. In addition, there were 1,524 Keywords Plus (ID) and 725 Author's Keywords (DE), indicating a wide range of research topics and a diversity of methodological approaches. In terms of academic collaboration, there were 834 authors with an average of 4.15 collaborators per document, indicating a trend towards team-based research that encourages multidisciplinary contributions. The international collaboration rate of 28.52% also confirms that research in AI for WPS has a broad global scope, with increasing inter-institutional and cross-country collaboration. These findings confirm that the development of AI in WPS continues to be a major focus across various disciplines, supported by a broad research community and the involvement of academics from various scientific backgrounds.

Table 2
Main Information

Description	Result
Timespan	2021-2025
Sources (Journals)	258
Document Average Age	2,4
Average citations per doc	12,34
Keywords Plus (ID)	1524
Author's Keywords (DE)	725
Authors	834
Co-Authors per Doc	4,15
International co-authorships %	28,52

3.1.2 Document by subject area

Figure 2 is the distribution of publications by subject area which shows that research on Wireless Positioning System based on Artificial Intelligence (AI) is dominated by the fields of Computer Science (33.9%) and Engineering (29.7%), which confirms that the development of intelligent algorithms, system optimization, and implementation of machine learning and deep learning are the main aspects of this research. Physics and Astronomy (12.1%) also made significant contributions, reflecting the role of electromagnetic theory and signal propagation in improving the accuracy of AI-based localization systems. The disciplines of Biochemistry, Genetics and Molecular Biology (6.6%) and Chemistry (6.2%) showed involvement in sensor material development or bio-inspired approaches in algorithm optimization, while Mathematics (5.0%) contributed to probabilistic model formulation, algorithm optimization, and data analysis to improve the performance of the positioning system. Materials Science (3.5%) and Chemical Engineering (1.2%) are likely to play a role in the innovation of more efficient hardware and sensors, while the fields of Business, Management and Accounting (0.3%) and Decision Science (0.3%) have very little representation, indicating that economic, business, and managerial aspects are still rarely studied in depth in the context of developing AI-based Wireless Positioning Systems. Overall, the distribution of publications indicates that research still focuses on technical and computational aspects, opening up opportunities for a broader interdisciplinary approach, especially in exploring the social, economic, and policy impacts of implementing this technology in various sectors of industry and society.

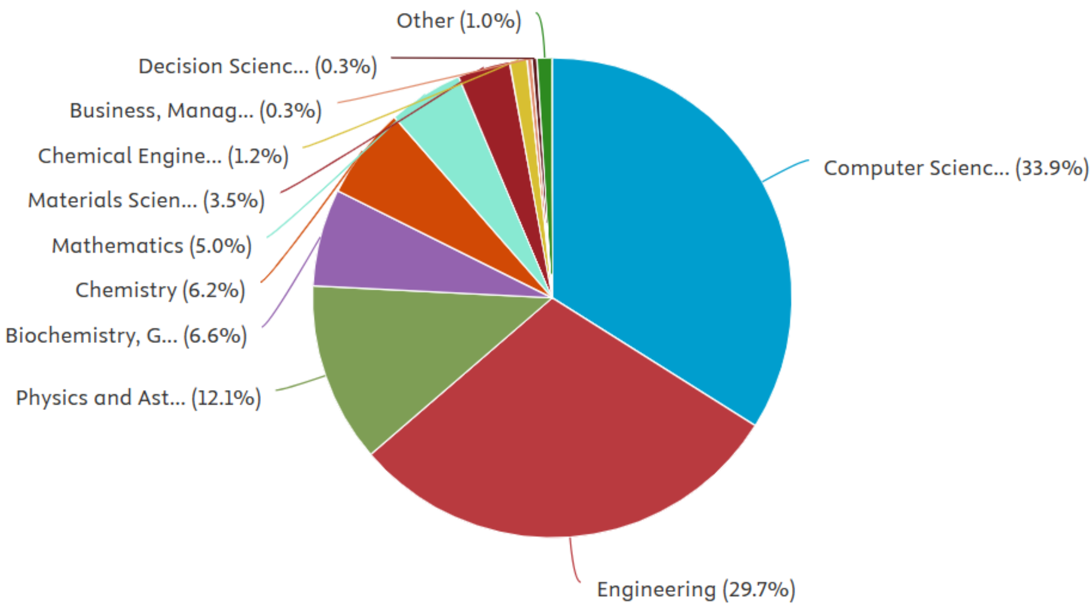

Fig. 2. Distribution of publications by subject area

3.1.3 Most global cited documents

Figure 3 presents the distribution of the most cited scientific documents globally in research related to Artificial Intelligence (AI) for Wireless Positioning System (WPS). The data shows that articles published in highly reputable journals such as IEEE Transactions on Evolutionary Computation, IEEE Sensors Journal, and Expert Systems with Applications have a significant impact on the scientific development in this field. Two key publications, namely Zhou (2021) and Li (2021), received 87 citations each, indicating a wide influence in the academic community.

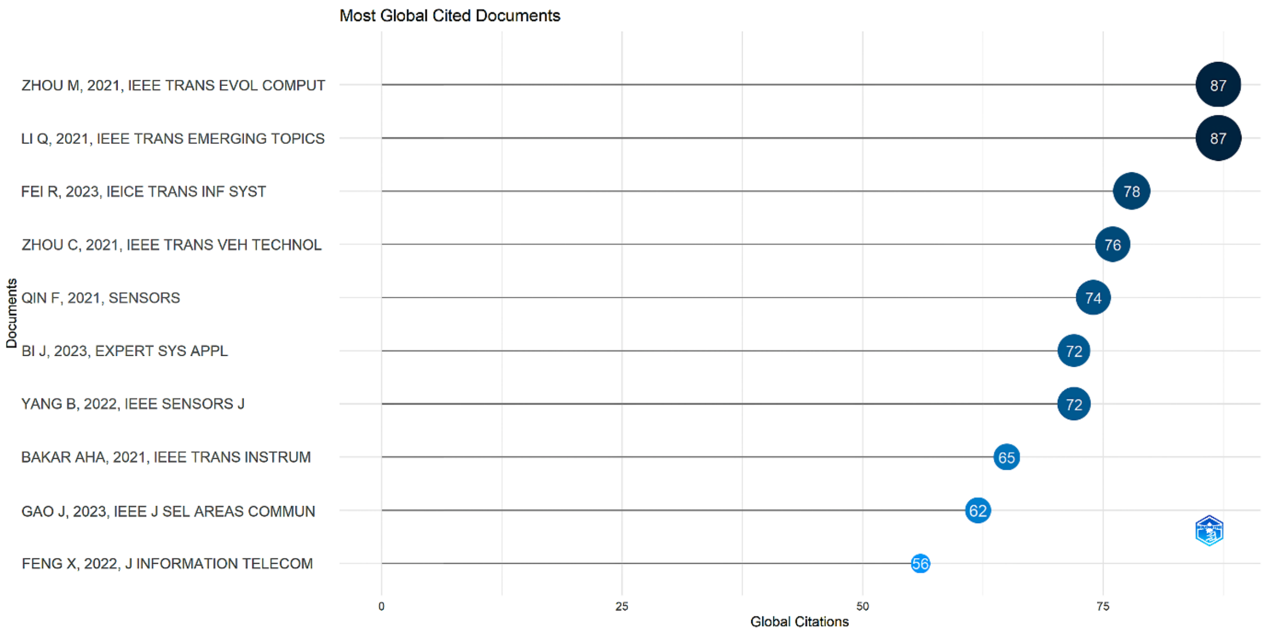

Fig. 3. Top 10 Most global cited documents

This citation trend indicates that AI methods and algorithms in wireless tracking systems are increasingly attracting the attention of global researchers. The dominance of publications in IEEE journals shows that the field relies heavily on innovations in sensor technology, information systems, and evolutionary computing. In addition, contributions from other journals such as Expert Systems with Applications confirm that artificial intelligence-based approaches are increasingly being applied in various industrial and academic scenarios. The high citation rate also indicates that research in AI-based WPS is progressing rapidly with broad multidisciplinary involvement, including advanced computational techniques, signal processing, and optimization of wireless communication systems.

3.1.4 Authors and co-authorship

Figure 4 illustrates the co-authorship network map in the research field of Wireless Positioning System (WPS) based on Artificial Intelligence (AI), generated using VOSviewer software. According to Soos and Leazer [16], each node in the network represents an author, while the relationship between nodes indicates the level of collaboration based on the number of co-publications. Different colors indicate clusters or research communities that are closely related in their scientific contributions.

From this visualization, it can be seen that there are several major clusters that indicate groups of researchers with high levels of collaboration. For example, Rodrigues *et al.,* [17] explain that the green and blue clusters reflect a strong collaboration network between researchers in the field of sensor systems and AI-based computing for wireless position tracking systems. Meanwhile, the red and orange clusters indicate a more specific research community in the field of AI-based optimization and communication systems.

The density of relationships between authors also reflects the level of academic influence and multidisciplinary expertise developed in this research. Pan *et al.,* [18] asserted that authors who are at the center of the network with many connections are likely to be leaders or key contributors in the development of methods and algorithms applied in AI-based WPS. In contrast, authors who have few connections tend to engage in more limited or scope-specific collaborations.

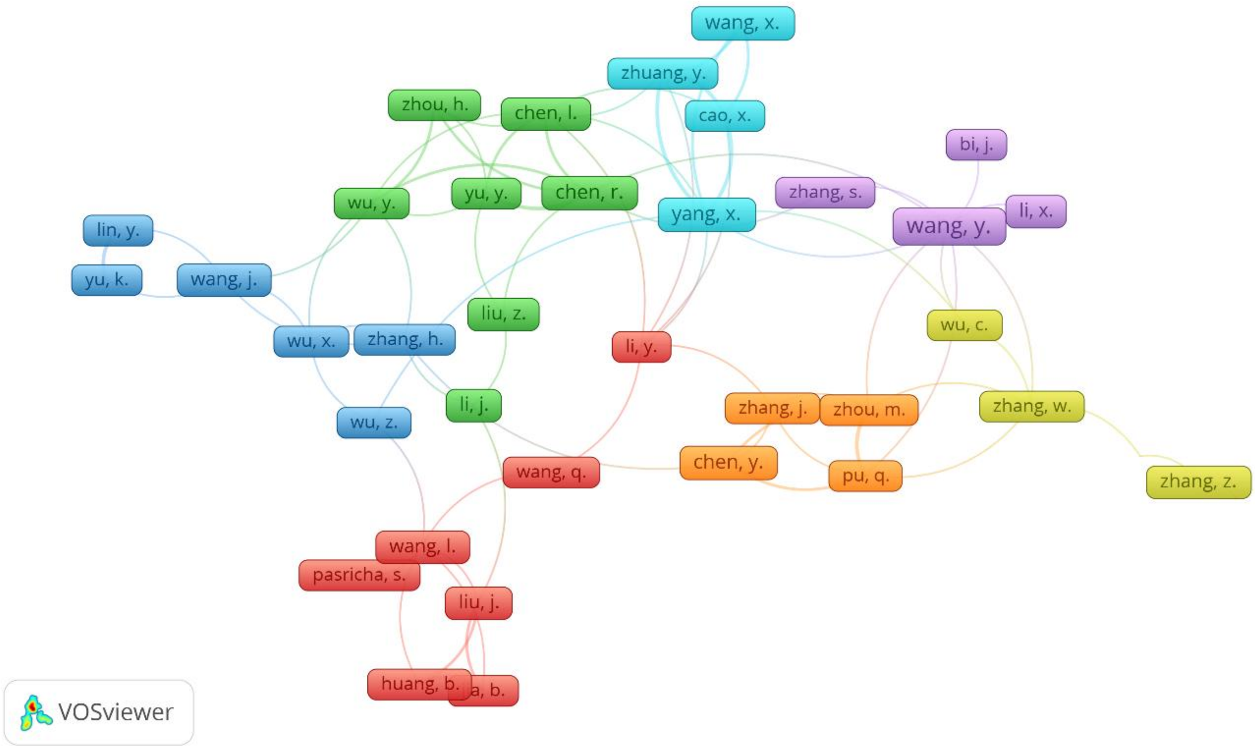

Fig. 4. Co-authorship network map

This analysis confirms that research in AI for WPS relies heavily on global and cross-disciplinary collaborations. Liu *et al.,* [19] stated that the network structure shows the importance of synergies between researchers from different institutions and areas of expertise to foster innovation and increase the academic impact of the studies. Therefore, understanding these collaboration patterns can help in identifying further research opportunities and strengthening academic networks to improve the productivity and quality of scientific publications in this domain.

3.1.5 Countries collaboration map

A map of country collaboration in Artificial Intelligence (AI) research for Wireless Positioning System (WPS) shows that China is a major center of global academic cooperation. China has extensive partnerships with countries in Asia, Europe and North America. The high intensity of collaboration with countries such as the United States, United Kingdom, Germany, and Australia indicates that research in this field has significant global appeal, supported by large investments in AI research and development infrastructure.

Jia [20] stated that the distribution of collaborations involving developing countries indicates a real effort to expand the reach of research to an international scale, thereby accelerating the innovation and adoption of AI technology in wireless-based navigation and tracking systems in various industrial sectors. Figure 5 shows the distribution and intensity of country collaborations in this study. Thus, understanding the pattern of collaboration between countries can help identify the potential for broader academic cooperation and improve the efficiency of technology development in this field.

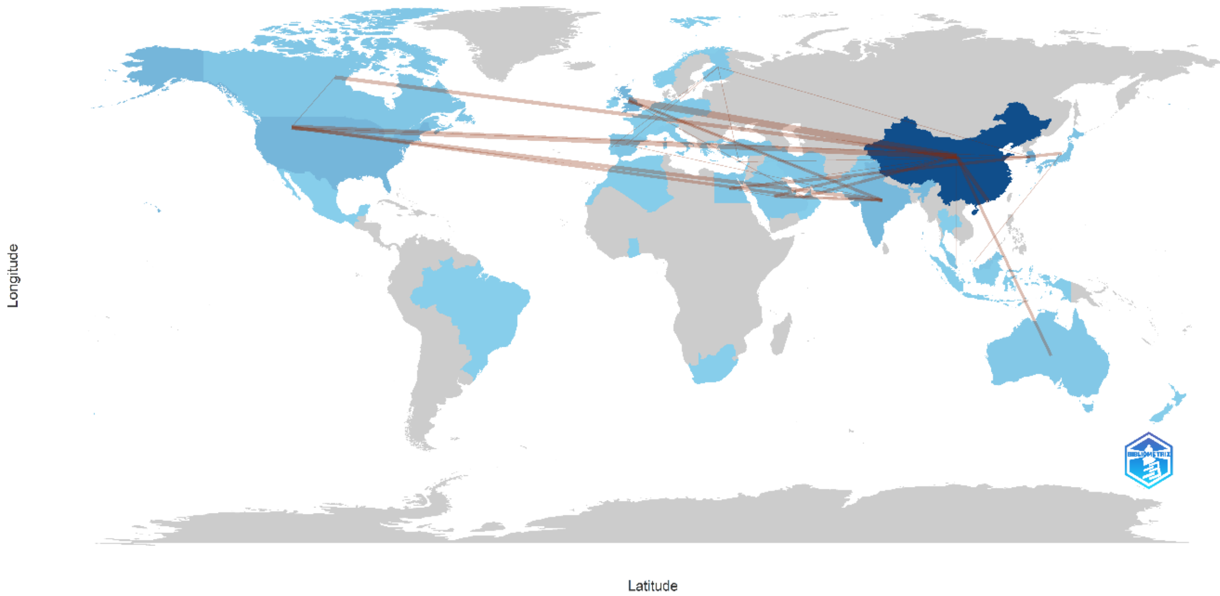

Fig. 5. Collaboration world map

3.2 Taxonomy of AI-Based Wireless Positioning Systems

3.2.1 Co-occurrence analysis

The keyword co-occurrence network map in Figure 6 provides deep insights into the major trends and interconnections between concepts in Artificial Intelligence (AI)-based Wireless Positioning System (WPS)-related research. Based on this analysis, “indoor positioning systems” emerges as a major center of research with close links to various AI approaches such as “deep learning”, “machine learning”, and “neural networks”.

In the Deep Learning category, techniques such as deep neural networks (DNN), multilayer neural networks, backpropagation neural networks, convolutional neural networks (CNN) and neural network models are the main methods applied in this research. These techniques are used to improve the accuracy of wireless sensor data-based positioning systems, especially in indoor scenarios.

One of the dominant methods in this research is “Wi-Fi fingerprinting”, which is often combined with “received signal strength (RSS)” and “channel state information (CSI)” to improve the accuracy of indoor localization systems. CSI offers higher granularity than RSS, so it has become a major focus in recent research, especially those adopting deep learning techniques such as convolutional neural networks (CNN) and long short-term memory (LSTM).

Furthermore, the Artificial Intelligence and Machine Learning category includes techniques such as “support vector machines (SVM)”, “decision trees”, “random forest”, “genetic algorithms”, “adaptive boosting (AdaBoost)”, “clustering algorithms”, “regression analysis”, and “transfer learning”. These methods are used in various studies to improve the accuracy of location mapping as well as overcome challenges in environments with complex signal dynamics.

Network analysis also showed a close relationship between “location awareness”, “wireless local area networks (WLAN)”, and “Internet of Things (IoT)”, indicating that WPS research is increasingly correlated with the development of the IoT ecosystem. In addition, the application of “data augmentation” methods is increasingly used to improve the generalizability of models in various indoor environments.

In the aspect of performance evaluation, terms such as "positioning accuracy", "localization accuracy", and "mean square error (MSE)" are becoming key metrics in AI-based WPS research.

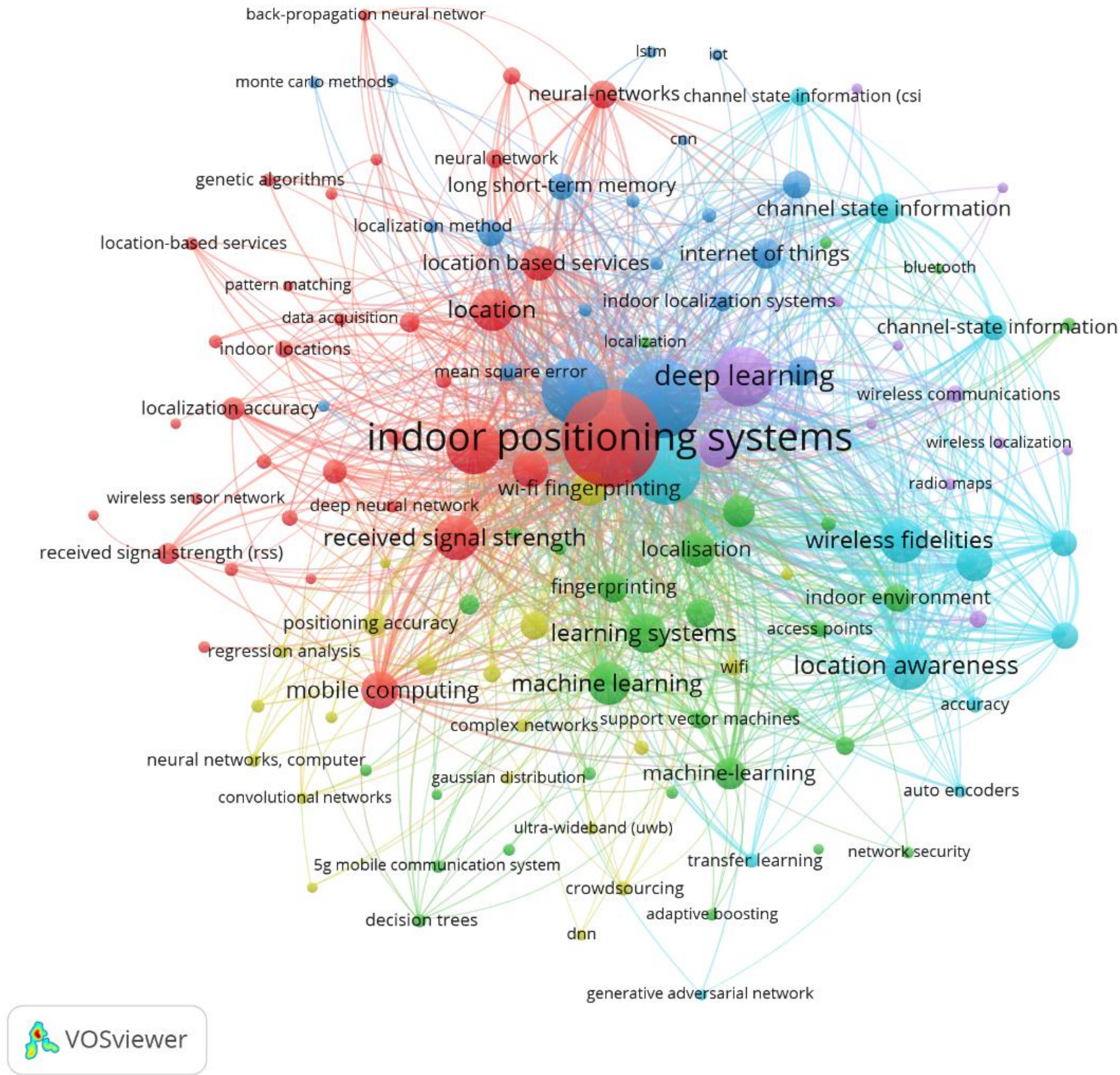

Fig. 6. Keyword co-occurrence network map

Based on the analysis in this journal, the main trend of AI-based WPS research continues to evolve towards the utilization of more complex deep learning techniques as well as integration with various data sources, including “wireless sensor networks (WSN)” and “global positioning system (GPS)”. This visualization provides a clearer picture of the current research landscape and future development directions that can be further explored in future studies.

3.2.2 Taxonomy of AI techniques

The taxonomy developed in this research aims to provide a systematic classification of various AI approaches in Wireless Positioning System (WPS). Based on a comprehensive literature review, AI methods in WPS can be categorized into several main groups based on the types of techniques used, position estimation approaches, and performance evaluation metrics.

In terms of AI techniques, this study found that Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and hybrid models are the most widely used methods in improving the accuracy of Wi-Fi and Received Signal Strength (RSS)-based position estimation. ANN and CNN techniques are proven to excel in feature extraction from signal data, while LSTM-based models show effectiveness in handling the dynamics of signal changes in varying environments. In addition, the combination of multiple techniques in hybrid models is growing to improve the computational efficiency and adaptability of positioning systems, as outlined in the research conducted by Guo *et al.*, [21]. Details of the taxonomy of AI approaches in WPS can be seen in Table 3.

Table 3
Taxonomy of AI Approaches

Category	Main Methods	Pros	Disadvantages
Neural Networks	DNN, CNN, LSTM, Multilayer Neural Networks, Backpropagation	High accuracy, capable of handling complex data	Need large computing power
Machine Learning	SVM, Decision Trees, Random Forest	Easy to implement, faster than deep learning	Less accurate in complex data
Ensemble Learning	AdaBoost, Random Forest	Improve prediction accuracy	May experience overfitting
Evolutionary Algorithms	Genetic Algorithms	Optimal in global solution search	Long iterative process
Transfer Learning	Transfer Learning	Can use models that have been trained	Need a large initial dataset
Wi-Fi Fingerprinting-based	Wi-Fi Fingerprinting, RSSI, CSI	Widely used in indoor positioning	Accuracy can be affected by the environment

The most commonly used position estimation approaches in AI and WPS related studies include Signal Fingerprinting, Probabilistic Models, and Regression-Based Localization. Signal Fingerprinting remains the dominant method due to its ability to capture the unique patterns of RSS in various locations. Meanwhile, probabilistic model-based approaches are increasingly being applied to handle uncertainty in signal propagation, as discussed by Bhatti *et al.*, [22]. On the other hand, deep learning-based regression is used to predict locations with higher accuracy.

The performance evaluation is done by considering the aspects of position estimation accuracy, computational efficiency, and robustness to environmental changes, as discussed by Sivarasa *et al.,* [23]. The analysis results show that more complex AI models such as CNN and LSTM perform better in dynamic environments, although they require more computational power. Therefore, future research needs to consider model optimization to improve system efficiency without sacrificing position estimation accuracy.

3.3 Recent AI Frameworks for Wireless Positioning Systems

In recent years, research on AI in WPS has resulted in increasingly sophisticated frameworks. An analysis of recent frameworks shows that CNN and LSTM-based models dominate the development of Wi-Fi and RSS-based positioning systems. CNN is widely used in spatial feature extraction from RSS signals, while LSTM is effective in handling temporal changes of dynamic signal data.

Some recent frameworks also incorporate Hybrid AI techniques, which combine CNN with probabilistic models to improve the stability of position estimation. This approach has shown significant improvement in accuracy over conventional methods. In addition, recent research has also begun to explore the use of Graph Neural Networks (GNN) to handle spatial dependencies between access points in Wi-Fi network-based positioning systems.

The use of datasets in AI frameworks is also an important aspect. This study found that most research still relies on experimental or simulated datasets, which may limit the generalization of the model to real-world scenarios. Therefore, further efforts are needed in developing more representative and comprehensive datasets, which include environmental variations and signal interference factors.

3.3.1 Practical applications of AI in wireless positioning systems

Artificial Intelligence (AI) has shown great potential in improving Wireless Positioning Systems (WPS) in various real-world applications. While theoretical advancements in AI-based WPS have been widely documented, practical implementation in various industries remains an important aspect that needs to be discussed. The integration of AI in WPS has improved accuracy, adaptability, and real-time processing, providing benefits to various sectors, including indoor navigation, transportation systems, smart cities, and logistics management.

i. Indoor navigation is one of the main applications of AI-based WPS, especially in environments where GPS-based solutions are not effective. AI-based models such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) have been applied in hospitals, shopping malls, and large office buildings to provide accurate location tracking, as discussed in previous research by Ngamakeur *et al.,* [24]. For example, AI-based WPS enables real-time positioning in hospitals, assisting medical personnel in locating equipment, staff, and patients more efficiently, thus improving operational efficiency and emergency response, as shown in the study by Senapati *et al.,* [25]. In addition, AI-based navigation in shopping malls has improved user experience by helping visitors locate specific stores or facilities based on real-time position data, as reviewed in a previous study by Yasufuku *et al.,* [26]. Wi-Fi Fingerprinting method is also widely used in indoor navigation due to its ability to capture unique signal patterns from RSS in various locations, as mentioned in Ali *et al.,* [27] research.
ii. The transportation industry has benefited greatly from AI-based WPS, especially in the development of intelligent transportation systems (ITS). AI models improve traffic monitoring, route optimization, and vehicle navigation systems by utilizing real-time wireless signal data, as reviewed by Zhu *et al.,* [28]. In urban environments, AI-based positioning systems support vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications, which contribute to traffic flow optimization as well as congestion reduction, as reported in a study by Maity *et al.,* [29]. In addition, ride-sharing services have leveraged AI-based localization to improve driver allocation efficiency, ensure faster response times, and optimal travel routes, as described by Li *et al.,* [30]. In terms of location prediction optimization in dynamic environments, regression-based models and Random Forest have been widely used to improve estimation accuracy, as discussed in Arora *et al.,* [31].
iii. The integration of AI-based WPS in smart cities has enabled a variety of smarter location-based services, including environmental monitoring, energy optimization, and enhanced public safety. AI models have been used to analyze wireless signal data from IoT sensors spread across the city to provide insights into pedestrian movement, infrastructure usage, and air quality, as described in a study by Kataria and Puri [32]. In security applications, AI-based WPS has been applied in geofencing and unauthorized access detection to strengthen surveillance systems and emergency response mechanisms in metropolitan areas, as reported

by S *et al.,* [33]. In addition, Transfer Learning is increasingly used in smart city applications to enable AI models to adapt quickly to environmental changes without requiring retraining from scratch, as described in the study by Fang *et al.,* [34].

iv. AI-based WPS has revolutionized the logistics and supply chain industry by improving asset tracking, inventory management, and fleet monitoring. AI-based models have contributed to warehouse automation by providing real-time location information of goods and equipment, thereby reducing operational delays and optimizing storage management, as reviewed in the study by Hristov *et al.,* [35]. AI-based WPS has revolutionized the logistics and supply chain industry by improving asset tracking, inventory management, and fleet monitoring. AI-based models have contributed to warehouse automation by providing real-time location information of goods and equipment, thereby reducing operational delays and optimizing storage management, as reviewed in the study by Boute and Udenio [36]. In addition, algorithms such as Genetic Algorithm and Adaptive Boosting (AdaBoost) have been frequently applied in delivery route optimization to improve efficiency in fleet management, as discussed in the study by Li *et al.,* [37].

3.3.2 Challenges and limitations of datasets in AI-based wireless positioning systems

Datasets play a crucial role in the development and evaluation of AI models for Wireless Positioning Systems (WPS). However, there are several challenges in using datasets that may affect the effectiveness and generalizability of AI models in real-world scenarios.

i. Most AI-based WPS research still relies on experimental or simulated datasets that may not reflect real-world conditions thoroughly. Environmental factors such as building layout changes, signal interference, and hardware differences can lead to significant model performance differences between laboratory testing and field implementation.

ii. Variation in Environmental Conditions and Data Quality is also a limiting factor. Datasets used in research are often collected under limited environmental conditions, making it difficult for AI models to generalize to different scenarios. High signal variability, multipath fading, and changes in spectrum frequency are major challenges in AI-based localization. In addition, poor data quality, including distorted or inconsistent signals, can degrade model accuracy.

iii. The absence of widely accepted dataset standards for the evaluation of AI models in WPS makes comparison of study results difficult. Individual studies often use different datasets with non-uniform evaluation metrics, hindering effective replication and validation of results.

iv. To face the challenges of dataset development in the future, a more representative and realistic approach is needed. One method that can be used is crowdsourced datasets, which collect data from various users to increase data diversity as well as generalization of AI models. This approach allows the dataset to cover a wide range of environmental conditions and different devices, making it more representative of real-world scenarios. Xu *et al.,* [38] stated that the use of crowdsourcing in data collection can improve the model's ability to generalize to various conditions. In addition, augmented datasets are an effective strategy in enriching existing datasets. Data augmentation techniques such as signal simulation, interpolation, and synthetic data can help AI models become more adaptive to environmental variations that may not be fully covered in the original dataset. Guo *et al.,* [39] explained that data augmentation can increase the model's robustness to unexpected changes in conditions and expand the scope of the dataset used. Finally, dataset benchmarking is an important aspect of AI research for wireless positioning systems (WPS). The development of standardized datasets that cover a wide range of environmental conditions enables objective comparisons between different AI methods as well as accelerates the replication of research results. Azzini and Rosati [40] emphasized the importance of dataset standardization in improving the validity and reproducibility of research in this area. This standardization allows for more objective comparisons between different AI methods and accelerates replication of research results. Develop standardized datasets that cover various environmental conditions and can be widely used in AI research for WPS.

With a more comprehensive dataset, AI models can more accurately address real-world challenges and improve the performance of Wireless Positioning Systems in various application scenarios.

4. Conclusion

This research presents a comprehensive taxonomy and up-to-date framework on the application of Artificial Intelligence (AI) in Wireless Positioning Systems (WPS), with a particular focus on Wi-Fi and Received Signal Strength (RSS) based techniques. The analysis conducted shows that AI techniques, particularly Artificial Neural Networks (ANN) and Long Short-Term Memory (LSTM), are able to improve the accuracy as well as the robustness of positioning systems by overcoming key challenges such as multipath fading and environmental variability. Moreover, a bibliometric approach and systematic literature review confirmed that AI developments in WPS continue to experience significant growth, characterized by an increasing number of publications as well as multidisciplinary collaborations. Furthermore, this research highlights the practical application of AI in various fields, including indoor navigation, intelligent transportation, smart cities, and supply chain logistics. Although various techniques have shown improved performance in WPS, challenges related to limited datasets, computational efficiency, and adaptability to dynamic environments are still major obstacles in real-world implementation. To overcome these challenges, future research needs to focus on developing more representative datasets, improving hybrid AI-based models to increase generalization, and optimizing transfer learning techniques to reduce dependence on limited datasets. In addition, the exploration of edge computing methods and more advanced data security techniques will also play a role in improving the effectiveness and adoption of AI-based WPS systems in the real world. Thus, this study not only provides theoretical insights into the evolution of AI in WPS but also offers future development directions that are more precise, efficient, and adaptive. The implications of this study can serve as a foundation for academics and practitioners in developing more accurate and robust AI-based positioning systems for various industrial applications, including indoor navigation, Internet of Things (IoT), and intelligent transportation systems.

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