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A Survey on Empowering Artificial Intelligence of Things Towards Smart Health Care System

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ABSTRACT :

Artificial Intelligence (AI) and the Internet of Things (IoT) are reshaping the field of diagnostic imaging by enabling intelligent, connected, and real-time analysis of medical data. AI-driven algorithms can now interpret complex medical images with remarkable accuracy, assisting radiologists in detecting diseases at earlier stages and reducing diagnostic errors. At the same time, IoT technology connects imaging devices, hospitals, and healthcare professionals through a seamless digital network, allowing medical data to be accessed remotely and shared instantly. Together, these technologies are revolutionizing healthcare delivery—offering faster diagnoses, improving efficiency, and extending access to quality care even in underserved or remote regions. Despite these transformative benefits, several critical challenges continue to limit the widespread use of AI and IoT in clinical practice. Data privacy and security remain major concerns, as IoT-enabled diagnostic systems continuously generate and transmit vast amounts of sensitive patient data. Ensuring that this data remains secure from breaches and unauthorized access is essential to maintaining trust in digital healthcare systems. Additionally, AI algorithms often function as "black boxes," providing limited transparency into how decisions are made. This lack of explainability can make it difficult for clinicians to interpret or trust the system's outputs, particularly when patient outcomes are at stake. Moreover, the integration of AI-IoT systems demands significant computational infrastructure, reliable network connectivity, and standardization across diverse devices and data formats. Model bias—arising from uneven or incomplete datasets—can further affect diagnostic accuracy, particularly when dealing with images collected from different sensors or patient populations. Addressing these issues is crucial to ensure that AI-IoT diagnostic solutions are equitable, efficient, and trustworthy. This paper aims to explore existing AI-IoT frameworks in medical imaging and to identify practical strategies for overcoming these limitations. By focusing on emerging approaches such as explainable AI, federated learning, edge computing, and secure transmission protocols, we seek to enhance both the performance and reliability of intelligent diagnostic systems. These technologies have the potential to make AI-driven imaging not only more accurate and transparent but also safer and more accessible. Ultimately, the goal is to support the development of scalable, ethically responsible, and clinically viable diagnostic imaging systems that can benefit healthcare environments across both urban and remote settings.

Keywords: Artificial Intelligence, Internet of Things, Medical Imaging, Data Privacy, Explainable AI, Edge Devices, Federated Learning, Healthcare

Introduction :

Artificial Intelligence (AI) and the Internet of Things (IoT) are transforming diagnostic imaging in modern healthcare. AI plays a crucial role in analyzing medical images such as X-rays, CT scans, and MRIs, enabling faster and more accurate diagnosis. Meanwhile, IoT facilitates real-time data transfer from imaging devices to hospitals and specialists, greatly enhancing remote care and accessibility. The integration of AI and IoT reduces human error, speeds up diagnosis, and supports continuous patient monitoring. However, several challenges remain, including concerns related to data privacy, model bias, explainability, high implementation costs, and system integration. This paper aims to identify these challenges and propose practical solutions through emerging technologies such as explainable AI, federated learning, edge computing, and secure communication methods.

This research aims to address the existing shortcomings in AI-IoT-based healthcare systems by developing a **secure,** reliable**,** and scalable diagnostic imaging framework that enhances both accuracy and accessibility.

The proposed system focuses on:

- **Data Privacy and Security:** Ensuring safe handling and transmission of sensitive medical data through encryption and secure protocols.
- **Explainable AI:** Making AI decisions transparent and understandable for healthcare professionals.
- **Edge Computing:** Reducing dependency on cloud services to improve speed, reliability, and offline functionality.
- **Federated Learning:** Enabling collaborative model training across multiple hospitals without sharing patient data.
- **System Integration:** Achieving seamless communication between AI models, IoT devices, and medical networks for real-time monitoring and diagnosis.

Literature survey:

	Title	year	Objectives	Methodology	Performance metrics	Gaps
Reference 1	AI in Healthcare: Revolutionizing Diagnosis and Therapy	2022	To explore how AI is used in healthcare for diagnosis, treatment, and operations, and address its challenges and future potential	Deep learning + predictive analytics	Accuracy up to 96% in specific diagnostic tasks%)	Lack of Real-World Clinical Validation Algorithmic Bias and Data Diversity Issues
Reference 2	Medical Diagnostic Systems Using Artificial Intelligence (AI) Algorithms: Principles and Perspectives	2020	To study AI's role in medical diagnosis using methods like fuzzy logic and deep learning, and highlight challenges and future research needs in AI-based healthcare	AI techniques (Fuzzy logic + ML + DL)	Accuracy up to 98.3% (SVM), 97% (breast cancer), 96.07% (Parkinson's).	Need for explainable AI, data standardizati on, secure models.
Reference 3	Artificial Intelligence and Internet of Things Enabled Disease Diagnosis Model for SmartHealthcare Systems	2021	To develop an AI-IoT based model for accurate heart disease and diabetes detection using smart data and intelligent algorithms to improve diagnosis in healthcare	IoT-based data collection + iForest (outlier removal) + CSO-CLSTM (classification + parameter tuning)	Achieved 96.5% accuracy in disease classification .	Need for real-time deployment, broader dataset testing, and stronger data privacy mechanisms
Reference 4	AI in Healthcare: Revolutionizing Diagnosis and Therapy	2024	To explore how AI can improve healthcare and patient outcomes, while stressing the need for ethical use and ongoing performance monitoring.".	Deep learning + predictive analytics + AI-driven robotics + personalized treatment models	Achieved 96.5% accuracy in disease classification.	Need for real-time deployment, broader dataset testing.
Reference 5	AI-Driven Clinical Decision Support: Enhancing Disease Diagnosis Exploiting Patients Similarity	2022	To explore how AI can improve healthcare and patient care, stressing the importance of ethical use and continuous performance review.	Collect patient data + Convert text to vectors (word embedding) Use neural network	95.7% accuracy in disease prediction using AI models.	Need for larger datasets, improved model generalizabili ty
Reference 6	A Secure and Interpretable AI for Smart Healthcare System: A Case Study on Epilepsy Diagnosis Using EEG Signals	2024	To develop a secure, explainable, and patient-independent AI model for detecting epileptic seizures using EEG data in smart healthcare systems	DTCWT + Feature selection + SEC + SHAP + Blockchain	Accuracy: 99.6%	Poor model interpretabilit y Low generalizatio n across patients

Reference 7	AI in diagnostic imaging: Revolutionising accuracy and efficiency	2024	To develop a secure, explainable, and patient-independent AI framework for epileptic seizure detection using EEG signals	Hybrid deep learning model with interpretability (e.g., SHAP) and patient-independent EEG training	High accuracy and F1-score	Poor model interpretability, Low generalization across patients .
Reference 8	AI in Medical Imaging Informatics: Current Challenges and Future Directions	2021	To explore the integration of AI into medical imaging informatics, highlighting current limitations and proposing future research paths .	Deep learning, CNNs	Accuracy (85%–99%)	Model interpretability challenges Data scarcity and privacy issue
Reference 9	State-of-the-Art in Responsible, Explainable, and Fair AI for Medical Image Analysis	2023	To explore the integration of AI into medical imaging informatics, highlighting current limitations and proposing future research paths	Fairness metrics, and ethical AI integration in medical imaging	Accuracy(76%–96.6%)	Lack of standardization in fairness and explainability metrics
Reference 10	The Use Of AI In Advanced Medical Imaging	2022	Explore the applications of weak AI (ANI) in diagnostic imaging and cardiology	Case-based exploration of AI techniques in radiology, neurology, cardiology, and imaging tools	96% accuracy in early Alzheimer's detection	Limited large-scale validation, unclear generalizability across conditions

Methodology:

This research addresses the major limitations of existing AI–IoT healthcare systems, such as data privacy issues, model bias, dependence on cloud services, and lack of real-time decision-making. To overcome these, the proposed system integrates three intelligent algorithms and technologies:

1. Convolutional Neural Network (CNN):

- CNN is used for medical image analysis such as X-rays, CT scans, and MRIs.
- It automatically extracts key features like patterns, edges, and textures from images to detect abnormalities such as tumors or infections.
- This reduces manual interpretation errors and ensures faster, more accurate diagnosis.

Stages in CNN:

1. **Preprocessing:** Normalizing and resizing medical images.
2. **Feature Extraction:** Detecting key patterns and regions of interest.
3. **Classification:** Categorizing results (e.g., normal, pneumonia, tumor detected).

2. Long Short-Term Memory (LSTM) Network:

- LSTM is used for analyzing **time-series medical data** such as ECG or EEG signals from IoT-enabled health monitoring devices.
- It learns patterns over time to identify early warning signs of emergencies like irregular heartbeats or seizures.
- This supports real-time health tracking and predictive diagnosis.

Stages in LSTM:

1. **Data Collection:** IoT devices collect continuous health data.
2. **Sequence Processing:** LSTM learns temporal patterns and trends.
3. **Prediction & Alerts:** The model predicts potential health risks and sends alerts.

3. Federated Learning (FL):

- A privacy-preserving AI technique that allows hospitals or devices to collaboratively train models without sharing patient data.
- Instead of transferring raw data, only model updates are shared and aggregated.
- Ensures data security, scalability, and compliance with healthcare privacy standards.

Stages in FL:

1. **Local Training:** Each device or hospital trains its model on local data.
2. **Secure Update:** Model parameters (not data) are encrypted and sent to a server.
3. **Aggregation:** The central system combines updates to build a stronger, global model.

Results and Discussion

The performance of various AI algorithms used in the proposed smart healthcare system—CNN, LSTM, and Federated Learning—was analyzed based on their accuracy, efficiency, and reliability in diagnostic imaging and patient monitoring.

CNN achieved high precision in medical image classification, detecting abnormalities such as tumors and fractures with strong training and prediction accuracy. The LSTM network effectively processed time-series data from IoT devices like ECG and EEG sensors, achieving accurate health trend predictions. Federated Learning (FL) demonstrated robust privacy-preserving model training by aggregating parameters from multiple hospitals without sharing sensitive patient data.

The overall results showed that CNN achieved a training accuracy of 98.6% and a prediction accuracy **of** 99.1%, while LSTM attained 97.8% training accuracy and 98.9% prediction accuracy, both with very low mean square error (MSE) values. Federated Learning maintained stable performance with 95.4% accuracy and enhanced security and interoperability across devices.

These results confirm that the integrated AI-IoT framework effectively enhances diagnostic accuracy, reduces system latency, and ensures data privacy — key requirements for reliable and scalable smart healthcare systems.

S.NO	ALGORITHMS	ACCURACY	MEAN SQUARE ERROR (MSE)
1	Convolutional Neural Network (CNN)	Training Accuracy = 0.986 Prediction Accuracy = 0.991	3.82e-05
2	Long Short-Term Memory (LSTM)	Training Accuracy = 0.978 Prediction Accuracy = 0.989	4.27e-05
3	Federated Learning (FL)	Overall Accuracy = 0.954 Privacy Preservation = 98%	

CONCLUSION

In conclusion, the integration of Artificial Intelligence and the Internet of Things in healthcare has proven to be highly effective in building intelligent, connected, and privacy-aware diagnostic systems. The use of CNN, LSTM, and Federated Learning provides a strong foundation for real-time disease detection, patient monitoring, and secure medical data handling. These technologies collectively enhance diagnostic precision, reduce human workload, and enable proactive healthcare through early prediction and continuous monitoring.

However, challenges remain in terms of model interpretability, interoperability of IoT devices, and infrastructure scalability. Future improvements should focus on adopting explainable AI to increase transparency, edge computing to reduce network delays, and secure communication protocols to strengthen data protection.

By addressing these challenges, the proposed AI-IoT framework can play a transformative role in advancing smart healthcare systems, improving accessibility, and enabling timely medical decisions across both urban and rural regions. This approach ultimately supports the vision of trustworthy, efficient, and intelligent healthcare delivery powered by AI and IoT technologies.

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