Guest Editorial Distributed Big Data Intelligence in Instantaneous E-Healthcare Services

IN AN era where technology advances at an unprecedented pace, the healthcare sector stands at the cusp of a transformative revolution. The confluence of distributed Big Data intelligence with instantaneous e-healthcare services heralds a new paradigm, where the boundaries between medicine, artificial intelligence, and data science are blurred, giving rise to innovative solutions that redefine patient care. The emergence of personalized medicine, bolstered by the power of machine learning, graph-based techniques, and real-time analysis, is not merely a technological triumph but a testament to human ingenuity. It's a response to a world grappling with complex diseases, burgeoning healthcare costs, and an ever-increasing demand for precision and efficiency.

Recent reports and state-of-the-art work have only reinforced this trajectory, showcasing groundbreaking successes in medical imaging, genomics, and healthcare IoT [1]. Whether it's the application of federated learning to preserve patient privacy or the utilization of transformer models to enhance medical image quality, the landscape is ripe with innovation. Yet, this thrilling frontier is not without its challenges. Issues related to data privacy, model explainability, integration of multimodal data, and real-time responsiveness present intricate problems demanding meticulous research and development.

Highlighting the complexity of Big Data in healthcare, including the diverse sources of data such as clinical details, laboratory data, CT pictures, insurance files, MRI images, Electronic Medical Records (EMRs), Electronic Health Records (EHRs), and more. This complexity underscores the need for innovative solutions like ML, AI, and IoT to manage, analyze, and derive insights from this data. This special issue, titled "Distributed Big Data Intelligence in Instantaneous E-healthcare Services," serves as a beacon in this exciting journey. It brings together pioneering research from across the globe, shedding light on cutting-edge methodologies, findings, and implications. From low-latency federated learning to insight extraction using hypergraphs, the articles encapsulate the essence of modern healthcare research—an interdisciplinary endeavor that seeks to harness the power of data to heal, empower, and innovate.

The first article by Shudong Wang et al. [A1] presents a novel approach related to graph attention networks (GANs) and their application in predicting miRNA-disease associations. The work seems to focus on the use of meta-subgraphs and heterogeneous graph attention networks (MSH GANMDA) to improve the prediction accuracy of miRNA-disease associations.

The authors propose a novel heterogeneous graph attention network that leverages meta-subgraphs to capture complex relationships between miRNAs and diseases. The architecture of MSH GANMDA consists of embedding layers, attention mechanisms, and prediction layers, allowing for the effective representation of heterogeneous information. MSH GANMDA demonstrates promising results in predicting miRNA-disease associations. The model outperforms existing methods in terms of accuracy and computational efficiency. The utilization of meta-subgraphs enhances the model's ability to capture intricate relationships between entities, contributing to its superior performance. The proposed method offers a more efficient and accurate way to predict miRNA-disease associations, potentially revolutionizing the way researchers approach this critical area in biomedical science. By leveraging Big Data and graph attention networks, the article showcases the potential of distributed intelligence in healthcare.

The second article by Vincenzo Schiano di Cola et al. [A2], authors introduce a novel approach to extracting insights from e-health bookings by employing hypergraph techniques and machine learning. The article emphasizes the structuring of e-health data through a Knowledge Graph (KG) approach, combining Big Data technologies with healthcare services. Key concepts include embedding techniques, enterprise knowledge graphs, and electronic medical records. The study successfully demonstrates the ability to derive insights from healthcare booking centers managed by local health authorities. By utilizing hypergraph techniques, the authors can represent and analyze complex relationships within the data. The application of machine learning further enables precise insight extraction, significantly improving the understanding of e-health bookings and their dynamics. The article's methodology presents an innovative way to harness Big Data in healthcare, particularly in managing and interpreting e-health bookings. By offering a robust method for insight extraction, this work contributes to the optimization of healthcare services, planning, and decision-making. It highlights the potential for machine learning and graph technologies to transform healthcare data management and analytics.

The third article in the special issue introduces a novel methodology named "Transformer with Double Enhancement"

Date of current version 5 October 2023.
Digital Object Identifier 10.1109/JBHI.2023.3311649

aimed at denoising low-dose CT (Computed Tomography) images. The authors Haoran Li et al. [A3], propose a new architecture that combines the advantages of transformer models with specific enhancement techniques. They focus on the application of this method in the biomedical domain, particularly for improving the quality of low-dose CT images. The transformer model with double enhancement demonstrates significant success in reducing noise from low-dose CT images. The method outperforms existing denoising techniques, showing higher efficiency and accuracy. The double enhancement strategy appears to be a key factor in the model's superior performance, enabling more nuanced noise reduction without losing essential details. This article's contribution lies in its potential to revolutionize the quality and reliability of low-dose CT images. By implementing a novel denoising method, it can lead to more accurate diagnoses and treatment planning. It also emphasizes the integration of advanced machine learning techniques with medical imaging, showcasing the transformative potential of distributed Big Data intelligence in healthcare.

The fourth article introduces a federated semi-supervised learning approach specifically tailored for medical image segmentation. The authors Liang Qiu et al. [A4], propose a method that incorporates pseudo-label denoising to enhance the performance of the model. The article emphasizes the application of federated learning in the context of healthcare, addressing challenges related to data privacy and distributed learning environments. The proposed method demonstrates remarkable success in medical image segmentation tasks. By employing pseudo-label denoising within a federated learning framework, the model achieves higher segmentation accuracy compared to traditional techniques. The article also highlights the benefits of federated learning in preserving data privacy and enabling collaborative learning across different institutions. This work has profound implications for medical imaging, particularly in scenarios where collaboration and data privacy are paramount. The federated semi-supervised learning approach provides a new pathway to enhance medical image segmentation while respecting privacy constraints. The integration of pseudo-label denoising further underscores the innovation in handling complex medical imaging tasks.

The article reflects the broader theme of distributed Big Data intelligence by showcasing how federated learning can be effectively applied in healthcare to create robust and privacy-preserving solutions.

The fifth article in this special issue presents a method for low-latency federated learning, specifically focusing on the healthcare Internet of Things (IoT) domain. The authors Peng He et al. [A5], propose a dynamic model partitioning approach that facilitates efficient and real-time learning across distributed IoT devices. The article explores the challenges and opportunities in implementing federated learning within the constraints of healthcare IoT systems. The article demonstrates that the dynamic model partitioning technique significantly reduces latency in federated learning scenarios. This reduction in latency enables more timely and responsive learning across healthcare IoT devices. The method's effectiveness is validated through extensive experiments and comparisons with existing approaches, revealing its superiority in handling real-time learning requirements. The novel approach to low-latency federated learning opens new possibilities for real-time data analysis and decision-making within the healthcare IoT ecosystem. By addressing the latency challenges inherent in distributed learning environments, this article contributes to the advancement of instantaneous e-healthcare services. The utilization of dynamic model partitioning underscores the potential for innovative solutions in managing complex, distributed learning tasks.

The article aligns with the overarching theme of distributed Big Data intelligence, emphasizing the role of federated learning in enhancing the responsiveness and efficiency of healthcare IoT systems.

The articles reveal the complexity of healthcare data and the need for sophisticated models like graph attention networks and transformers to capture intricate relationships. Federated learning emerges as a powerful paradigm, enabling collaboration across institutions while preserving privacy, as evidenced by various methodologies presented. Low-latency learning techniques, as explored in some articles, highlight the importance of real-time solutions in healthcare, emphasizing the need for dynamic and responsive models. The convergence of machine learning, Big Data, graph theory, and medical expertise showcases the interdisciplinary nature of modern healthcare research. While not explicitly addressed in all articles, the underlying theme of privacy preservation and ethical handling of healthcare data is an essential consideration that pervades this field.

Future Directions:

Enhancing Federated Learning: Several articles in this issue focus on federated learning and its applications in healthcare. Future work may explore advanced optimization techniques to reduce computational burdens, improve model convergence, and further enhance privacy-preserving mechanisms. *Integrating Multimodal Data*: The integration of various data types, such as genomics, electronic health records, and imaging data, remains a challenge. Research towards a unified framework that can effectively combine multimodal data will pave the way for more comprehensive healthcare analytics. *Real-time Analysis in IoT*: The application of low-latency learning in healthcare IoT presents vast opportunities. Developing algorithms that can adapt to the dynamic nature of IoT devices and network conditions will be crucial in delivering real-time healthcare services.

Explainable AI Models: As AI models become more complex, the need for explainability grows. Future research could focus on developing transparent and interpretable models that healthcare professionals can trust and understand.

Personalized Healthcare: The trend towards personalized medicine is evident in these articles. Tailoring algorithms to individual patient needs, considering genetic, lifestyle, and environmental factors, will be an essential direction for future research.

This special issue offers a panoramic view of the state-of-the-art methodologies and applications in the realm of distributed Big Data intelligence for instantaneous e-healthcare services. It

provides a glimpse into the future, where technology and healthcare converge to create robust, personalized, and responsive medical systems. The insights drawn from these articles lay the groundwork for future innovations, emphasizing the synergistic relationship between data science and healthcare. Together, they paint a promising picture of a future where data-driven insights fuel the continual evolution of healthcare practice, shaping a new era of medical excellence [2].

As we reflect on the current state of the art and the promising directions illuminated by this collection, we must recognize the collaborative spirit that underpins these advancements. The interdisciplinary nature of these works symbolizes the convergence of different fields, united by a common goal to enhance human well-being. In a world where new reports continually unveil technological breakthroughs, this special issue serves as both a milestone and a compass. It captures a moment in time where possibilities are boundless and challenges are stepping stones to innovation. We invite readers to explore, ponder, and engage with these works, not merely as academic pursuits but as catalysts for change. May this special issue inspire further exploration, collaboration, and creativity, fostering a future where healthcare is not just a practice but a continually evolving art.

In the final reflections of this momentous endeavor, our gratitude extends profoundly to the authors, the minds behind the trailblazing research submitted to this special issue. Their intellectual rigor and innovative pursuits have shaped the very essence of this collection. Our acknowledgment further reaches the distinguished experts in the field, whose participation in the review process has been nothing short of instrumental. Their insightful critiques and thoughtful guidance have refined the content and presentation, elevating the articles to their highest potential.

We reserve special commendation for Professor Dimitrios I. Fotiadis, the Editor-in-Chief, whose wisdom and leadership have been an unwavering beacon throughout the intricate stages of this project. Together with the dedicated publishing team, they have provided invaluable support, insights, and direction, transforming challenges into triumphs. Their collaborative spirit and meticulous attention have not only concluded this special issue but have left an indelible mark on the academic landscape. This collaboration of minds and efforts resonates as a testament to what collective pursuit of excellence can achieve, encapsulating the core of what makes this special issue not just a publication but a milestone in the field of e-healthcare.

ANAND PAUL
Kyungpook National University
Sangju-si 37224, South Korea
anandpaul@ieee.org

NAVEEN CHILAMKURTI
La Trobe University
Melbourne, VIC 3086, Australia
n.chilamkurti@latrobe.edu.au

AWAIS AHMAD
Università Degli Studi di Milano
20122 Milan, Italy
awais.editor@gmail.com

SYED HASSAN AHMED
California State University
Fullerton, CA 90032 USA
sh.ahmed@ieee.org

APPENDIX
RELATED ARTICLES

[A1] S. Wang et al., "MSHGANMDA: Meta-subgraphs heterogeneous graph attention network for miRNA-disease association prediction," *IEEE J. Biomed. Health Inform.*, early access, Jun. 27, 2022, doi: 10.1109/JBHI.2022.3186534.

[A2] V. S. D. Cola, D. Chiaro, E. Prezioso, S. Izzo, and F. Giampaolo, "Insight extraction from e-Health bookings by means of hypergraph and machine learning," *IEEE J. Biomed. Health Inform.*, early access, Jan. 02, 2023, doi: 10.1109/JBHI.2022.3233498.

[A3] H. Li, X. Yang, S. Yang, D. Wang, and G. Jeon, "Transformer with double enhancement for low-dose CT denoising," *IEEE J. Biomed. Health Inform.*, early access, Oct. 25, 2022, doi: 10.1109/JBHI.2022.3216887.

[A4] L. Qiu, J. Cheng, H. Gao, W. Xiong, and H. Ren, "Federated semi-supervised learning for medical image segmentation via pseudo-label denoising," *IEEE J. Biomed. Health Inform.*, early access, May 08, 2023, doi: 10.1109/JBHI.2023.3274498.

[A5] P. He et al., "Low-latency federated learning via dynamic model partitioning for healthcare IoT," *IEEE J. Biomed. Health Inform.*, early access, Jul. 24, 2023, doi: 10.1109/JBHI.2023.3298446.

REFERENCES

[1] A. Paul, A. Ahmad, M. M. Rathore, and S. Jabbar, "Smartbuddy: Defining human behaviors using big data analytics in social Internet of Things," *IEEE Wireless Commun.*, vol. 23, no. 5, pp. 68–74, Oct. 2016.

[2] G. Pugalendhi, M. M. Rathore, D. Shukla, and A. Paul, "Handling big microarray data: A novel approach to design accurate fuzzy-based medical expert system," *IEEE Access*, vol. 11, pp. 35182–35196, 2023.