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EDITORIAL

Federated Learning: The Monobloc of Artificial Intelligence & Machine Learning (AI-ML) Applications in Health Care

Minu Bajpai[1,]* and Abhijat Sheth[2]
[1]*Vice President, National Board of Examinations in Medical Sciences, Medical Enclave, Ansari Nagar, Mahatma Gandhi Marg, Ring Road, New Delhi, Delhi – 110029*
[2]*Senior Consultant, Cardiothoracic Surgeon & C.E.O., Apollo Hospital, Ahmedabad & President, National Board of Examinations in Medical Sciences, Medical Enclave, Ansari Nagar, Mahatma Gandhi Marg, Ring Road, New Delhi, Delhi – 110029*

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In this current issue, the article by Khanna et al. [1], highlights the role of AI-ML in healthcare. A significant bottleneck in realizing this nature of data mining, viz., patient related sensitive information, is data security concern. The latter pertains to the hospitals from where this information is to be procured. Federated learning has the necessary mechanism to overcome this significantly - M. Bajpai and A. Sheth

Recent breakthroughs in **Deep Learning (DL)** have been used in current medical data processes, which **include automatic disease diagnosis, classification, biomedical data analysis, Question Answering in the medical domain, and segmentation.**

AI-ML utilizes datasets distributed across data centers such as hospitals, clinical research labs, and mobile devices. In order for AI models to be effective, they often require large amounts of data to be trained on. Transmission & usage of information and the usage of stored medical data & its transmission are central to patient rights. Training AI models on a broader range of data (across different hospitals, regions, or countries) helps improve **model generalization.**

The **EHR (Electronic Health Records)** in hospitals are sensitive and widespread in nature. If learning from individual datasets could be utilized without exposure to the seat of data generation, the privacy issue could be circumvented. Federated learning allows institutions to share model parameters without compromising data privacy, making the resulting models more **robust** and **generalizable** to real-world scenarios. This exclusiveness becomes the boon of Federated Learning (FL).

*Corresponding Author: Minu Bajpai
Email: bajpai2b@gmail.com

The General Data Protection Regulation (GDPR) and the **Health Insurance Portability and Accountability Act (HIPAA)**, have passed new laws that control data shared while preserving user security and privacy.

Healthcare data often resides in **isolated silos**, such as individual hospitals, clinics, and research institutions, making it difficult to create comprehensive models. Federated learning helps unify these fragmented datasets by allowing institutions to train their local models and only share updates (like gradients or model weights). This **decentralized approach** fosters collaboration across institutions while maintaining each institution's data privacy. With federated learning, it becomes feasible to scale AI/ML models for precision medicine. Models trained using federated learning can take into account diverse, multi-institutional data to make more **personalized and equitable predictions**, minimizing biases that might arise when training models with data from only a single institution. This scalability is especially crucial in healthcare, where **rare diseases** and **patient heterogeneity** require models that can generalize across various populations.

Federated learning doesn't just benefit one subset of healthcare (e.g., radiology, genomics, or pathology). Instead, it enables the development of **cross-disciplinary models** that leverage data across specialties. For example, models that combine radiology, genomics, and patient history could deliver more comprehensive clinical insights, improving diagnosis and treatment recommendations. By keeping data within the institution's firewall, federated learning can help address healthcare's stringent regulatory and ethical standards. **Patients and regulators** can trust that their sensitive medical data is not being shared indiscriminately, while still benefiting from the advancements in AI/ML that improve patient outcomes.

Precision Medicine at Scale

- Federated learning can enable **precision medicine** by leveraging data from multiple institutions to train models that account for individual patient variations (e.g., genomics, medical history, lifestyle factors). This ensures that AI-driven solutions are tailored to the specific needs of patients, offering more **personalized treatment options** and improving patient outcomes.
- By facilitating access to a broader range of data without compromising privacy, FL creates an **opportunity for large-scale precision medicine** that can serve diverse populations and rare conditions.

Supporting a Wide Range of Healthcare Applications

- Federated learning enables **AI/ML applications** across a broad range of healthcare areas, such as:
  - **Medical imaging (radiology, pathology)**
  - **Genomic data analysis**
  - **Clinical decision support systems**

- **Predictive models for patient outcomes (e.g., sepsis, COVID-19 risk)**
- **Drug discovery**

- FL supports these applications by providing a platform for collaborative, cross-disciplinary efforts where data privacy and compliance are non-negotiable. This collaborative ecosystem nurtures continuous innovation in healthcare AI.

Thus, **FL** is the process of developing machine learning models over datasets distributed across data centers such as hospitals, clinical research labs, and mobile devices while preventing data leakage. FL is used to train other machine learning algorithms, thereby allowing companies to create a 'shared global model' without having to centralize data. As healthcare data becomes increasingly important for machine learning models, federated learning acts as the **fundamental building block** (the "monobloc") to enable secure, large-scale, and collaborative AI-driven innovations in the healthcare industry. Through FL, healthcare AI can evolve, scale, and provide more accurate, equitable, and personalized solutions across a wide range of applications—from medical imaging to precision medicine—ultimately improving patient care globally.

Reference

1. Khanna S, Siddiqui MH, Bhushan S, Saxena R. Deciphering the Role of Artificial Intelligence in Medical Sciences: An Update. Natl. Board Exam. J. Med. Sci. 2025;3(1):56-66. doi: 10.61770/NBEJMS.2025.v03.i01.008

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