

DTQFL: A NEXT-GENERATION DIGITAL TWIN-DRIVEN QUANTUM FEDERATED LEARNING MODEL FOR 5G-BASED INTELLIGENT DIAGNOSIS

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Abstract

The rapid evolution of 5G mobile networks has enabled real-time healthcare monitoring and intelligent diagnosis through connected medical devices. However, ensuring high diagnostic accuracy while preserving data privacy and minimizing communication overhead remains a significant challenge. This paper proposes DTQFL, a Digital Twin-assisted Quantum Federated Learning algorithm designed to enhance intelligent diagnosis within 5G-enabled healthcare environments. The proposed framework integrates digital twin technology to create virtual replicas of physical devices and patient environments, enabling real-time simulation, monitoring, and optimization. Quantum Federated Learning (QFL) is employed to leverage quantum computing principles for improved model convergence, enhanced computational efficiency, and secure decentralized learning without sharing raw patient data. The DTQFL framework utilizes digital twins to optimize model training parameters, predict network conditions, and dynamically allocate resources in the 5G network. Quantum optimization techniques further accelerate the federated learning process and improve diagnostic accuracy. The proposed approach ensures privacy preservation, reduces communication latency, and enhances scalability across distributed medical systems. Experimental evaluations demonstrate that DTQFL outperforms conventional federated learning methods in terms of diagnostic accuracy, training efficiency, and network utilization. The results highlight the potential of integrating digital twins and quantum federated learning to enable intelligent, secure, and efficient diagnostic systems in next-generation 5G healthcare networks.