

Fusion of Multimodal Data for Advanced Intelligent Health Monitoring Systems

Abstract

The fusion of multimodal data represents a transformative paradigm for intelligent health monitoring systems. By integrating heterogeneous sources—ranging from physiological signals (ECG, EEG, blood oxygen), biomedical imaging, and wearable sensor streams to electronic health records and patient reports—multimodal approaches enable comprehensive, individualized assessment beyond traditional single-metric monitoring. Advances in machine learning and deep learning, including CNNs, RNNs, GNNs, and transformer architectures with attention mechanisms, now make large-scale multimodal fusion feasible. Early, late, and hybrid fusion strategies support robust detection of cross-modal patterns, anomaly detection, and predictive analytics in contexts such as chronic illness management, telemedicine, emergency response, and personalized therapeutics. Key challenges remain in interoperability, noise reduction, missing data handling, and model interpretability, underscoring the importance of explainable AI and standardized frameworks.

Overall, multimodal fusion paves the way toward adaptive, patient-centric, and clinically actionable health monitoring systems, with significant implications for precision medicine and value-based healthcare.