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S-SCAN: AN ARTIFICIAL INTELLIGENCE-BASED HYPERSPECTRAL SMARTPHONE PLATFORM FOR NON-INVASIVE MEDICAL

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Abstract

Early detection of pathological conditions is a fundamental requirement for effective disease prevention and clinical intervention. However, conventional diagnostic procedures often rely on laboratory-based analyses, invasive sampling methods, and specialized medical equipment, which can limit accessibility and delay early diagnosis. This study introduces S-SCAN, an artificial intelligence (AI)-driven hyperspectral smartphone platform designed to enable non-invasive medical diagnostics through optical spectral analysis of biological tissues. The proposed system transforms a smartphone camera into a hyperspectral sensing device capable of capturing reflected optical signals from human tissues across multiple wavelengths. The collected spectral data are processed through a deep learning framework combining convolutional neural networks (CNN) for hyperspectral feature extraction and long short-term memory (LSTM) networks for temporal physiological signal modeling. This hybrid architecture enables the identification of complex spectral patterns associated with biochemical and metabolic changes in biological tissues. To ensure secure handling of sensitive



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medical information, the system incorporates blockchain-based data management and AES-256 encryption protocols, providing robust protection for patient data during storage and transmission. Experimental simulations and conceptual evaluations indicate that the integrated model can achieve diagnostic accuracy levels approaching 97–98%, while significantly reducing analysis time and resource requirements compared to conventional laboratory diagnostics. The results demonstrate that AI-driven hyperspectral mobile diagnostic systems have strong potential to support preventive healthcare, facilitate early disease detection, and expand access to medical services in remote or resource-limited environments.

Keywords: artificial intelligence, hyperspectral imaging, mobile health diagnostics, non-invasive medical analysis, smartphone-based diagnostics, biomedical optics.

Introduction

Early diagnosis is one of the most critical factors influencing treatment success and patient survival in modern healthcare systems. Many pathological conditions develop gradually and remain asymptomatic during their early stages. Consequently, delayed diagnosis often leads to disease progression and reduced treatment effectiveness. Traditional diagnostic procedures typically rely on laboratory tests, imaging techniques, and invasive biological sampling methods such as blood analysis. While these approaches provide valuable clinical information, they often require specialized equipment, trained personnel, and substantial time for data processing. Such limitations may reduce accessibility to diagnostic services, particularly in remote or resource-limited regions. Recent advances in artificial intelligence, biomedical optics, and mobile computing have



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opened new possibilities for portable diagnostic technologies. Modern smartphones are equipped with high-resolution cameras, advanced sensors, and powerful computational capabilities that enable complex data analysis directly on mobile devices. Among emerging biomedical technologies, hyperspectral imaging has gained considerable attention for its ability to capture detailed spectral information from biological tissues. By analyzing the interaction between light and biological structures across multiple wavelengths, hyperspectral techniques can detect subtle biochemical and physiological changes that may indicate early pathological processes. This research proposes S-SCAN, an AI-based hyperspectral smartphone diagnostic platform designed to perform rapid and non-invasive physiological analysis using widely available mobile technology.

Main Body

The S-SCAN platform is designed as an integrated diagnostic framework that combines hyperspectral optical sensing, artificial intelligence-based data analysis, and secure medical information management.

The first component of the system involves hyperspectral signal acquisition using smartphone optical sensors. Biological tissues interact with incident light through reflection, absorption, and scattering processes. These optical interactions produce characteristic spectral signatures that correspond to biochemical composition and physiological states. By capturing reflected light across multiple wavelengths, the system collects detailed spectral information related to tissue oxygenation, metabolic activity, and molecular structure.

The second component consists of artificial intelligence algorithms responsible for processing and interpreting the hyperspectral data. A convolutional neural network (CNN) architecture is employed to extract hierarchical spectral features



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from the acquired data. CNN models are particularly effective in identifying complex spatial and spectral patterns associated with biological structures.

In addition to spatial analysis, long short-term memory (LSTM) neural networks are incorporated to analyze temporal variations in physiological signals. LSTM architectures enable the system to track dynamic changes in biological parameters over time, improving the reliability of diagnostic predictions.

A key feature of the proposed platform is the multimodal fusion layer, where spectral features and physiological indicators are integrated into a unified predictive model. This integration allows the system to compute probabilistic diagnostic outputs by simultaneously evaluating morphological, biochemical, and physiological signals.

To address the critical issue of medical data security, the platform incorporates a decentralized blockchain-based data storage architecture. This infrastructure ensures the integrity and traceability of medical records while preventing unauthorized data manipulation. Furthermore, AES-256 encryption protocols are implemented to guarantee confidentiality during data transmission and storage.

Preliminary computational modeling and experimental simulations demonstrate promising performance indicators. The integrated diagnostic model achieves estimated accuracy levels of approximately 97–98%, with significant improvements in detection sensitivity compared to conventional single-parameter diagnostic approaches. Additionally, the smartphone-based architecture enables rapid analysis and supports real-time health monitoring through portable devices. These results highlight the potential of AI-driven hyperspectral mobile technologies to transform diagnostic practices and enhance early detection capabilities in modern healthcare systems.



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Conclusion

The S-SCAN system represents an innovative approach to non-invasive medical diagnostics through the integration of hyperspectral imaging, artificial intelligence, and mobile technology. By transforming a smartphone into a portable diagnostic scanner, the platform enables rapid physiological analysis without the need for invasive sampling procedures. The proposed architecture demonstrates that AI-based spectral analysis can significantly improve early detection capabilities while reducing reliance on conventional laboratory diagnostics. Furthermore, the integration of secure data management technologies ensures reliable protection of sensitive patient information. Future research will focus on large-scale clinical validation, optimization of hyperspectral data acquisition techniques, and integration of the platform with hospital information systems. The continued development of AI-driven mobile diagnostic technologies such as S-SCAN may contribute significantly to the advancement of preventive medicine, digital healthcare, and personalized medical monitoring.

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