Smartphone Camera Oximetry for Hypoxemia Screening

This application harnesses a convolutional neural network to analyze blood-oxygen saturation data captured by smartphone cameras, achieving clinical-grade accuracy in blood-oxygen saturation monitoring. It represents a significant advancement in mobile health diagnostics, enabling precise, non-invasive respiratory screening.

Technology ID

BDP 8391

Category

Software/Healthcare IT

Selection of Available Technologies

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What is the Problem?

Blood-oxygen saturation (SpO2) is an essential health metric indicating how well oxygen is distributed throughout the body. Optimal SpO2 levels hover around 96-98%, reflecting efficient oxygen transport and utilization. However, when SpO2 levels fall more than 5% below an individual's baseline, it may signal underlying respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), pneumonia, or COVID-19. These conditions can precipitate a decline in SpO2, leading to hypoxemia—a state of diminished oxygen in the blood. If unaddressed, hypoxemia can escalate to hypoxia, where tissues are deprived of oxygen, causing irreversible damage.

Traditionally, SpO2 is measured using pulse oximeters, non-invasive devices that estimate SpO2 levels by transmitting light through the skin. Recognizing the potential for broader health monitoring, researchers have explored smartphone technology as an alternative. Smartphones could theoretically replicate the function of pulse oximeters, but existing attempts have faced challenges in accuracy, user experience, and lack of clinical validation. There is a pressing need for a smartphone-based application capable of reliably screening SpO2 levels. Such an app would harness the widespread availability of smartphones, offering a convenient and non-invasive tool for early detection of respiratory issues, potentially saving lives by prompting timely medical intervention.

What is the Solution?

The solution couples a wider range of clinically relevant SpO2 data with modern advances in data analysis techniques to not only make a more accurate tool, but extend it to predicting hypoxemia. The software's foundation is a dataset derived from a Varied Fractional Inspired Oxygen (Varied FiO2) study, conducted by a clinical validation laboratory. This dataset is pivotal as it provides a wider range of training data in clinically relevant regimes, distinguishing this software from previous attempts.

To capture SpO2 data, the app utilizes the smartphone's camera and flashlight. The data undergoes optimization via predefined camera settings, including color gain and white balance

adjustments, to ensure precision before analysis. At the core of the technology is a convolutional neural network (CNN) meticulously crafted to replicate the mathematical principles underlying traditional pulse oximeters, mitigate the influence of heartbeat variability on measurements, and effectively manage the inherent noise in smartphone camera signals. The app achieves an overall mean absolute error (MAE) of 5% in SpO2 readings. It also demonstrates commendable performance in detecting low SpO2 levels—those below 90%—with 81% sensitivity and 79% specificity. These metrics are indicative of the app's reliability and its potential to serve as a valuable tool for early detection of respiratory issues.

What is the Competitive Advantage?

The competitive edge of this smartphone application lies in its ability to accurately measure blood-oxygen saturation (SpO2) levels in clinically relevant lower ranges using just the phone's camera and flashlight. Notably, it is the first model to perform below the 85% SpO2 threshold, and overall has an error margin only 2% greater than FDA-cleared pulse oximeters.

The app's deep learning model is fine-tuned with clinical data obtained from the Varied FiO2 procedure. This extensive training enables the app not only to provide precise SpO2 readings but also to offer guidance on when to seek medical care if low levels are detected. Such functionality is particularly beneficial given the widespread incidence of respiratory ailments, including asthma, pneumonia, and COVID-19. As a result, this technology is poised to make a significant impact in the expanding field of smartphone-based health diagnostics, offering a practical solution for continuous respiratory health monitoring.

References

1. Jason S. Hoffman, Varun K. Viswanath, Caiwei Tian, Xinyi Ding, Matthew J. Thompson, Eric C. Larson, Shwetak N. Patel, Edward J. Wang(2022-09-19) , https://www.nature.com/articles/s41746-022-00665-y, https://www.nature.com/npjdigitalmed/, 5, 146