

ABSTRACT

The development of noninvasive mHealth techniques for predicting blood biomarkers can significantly improve healthcare and patient monitoring. This dissertation introduces an AI-driven framework that estimates key metabolic and renal biomarkers—creatinine, blood urea nitrogen (BUN), glomerular filtration rate (GFR), creatinine clearance (CrCl), glucose, and glycated hemoglobin (HbA1c)—from fingertip videos collected using a custom hardware device that has been designed and developed as a part of this dissertation. The device uses near-infrared (NIR) spectroscopy and smartphone camera to record ten-second fingertip videos. The system extracts photoplethysmography (PPG) features from the videos and applies machine learning (ML), quantum machine learning (QML), and generative AI (GenAI) for predicting the biomarkers.

The proposed method demonstrates a reliable, low-cost, and portable approach for noninvasive health monitoring without any blood collection. Multiple classical ML models and QML models are developed and compared to assess prediction performance. For BUN estimation, Generative Adversarial Networks (GANs) are used to create synthetic samples as original data was limited, and it led to improve the model's performance. Experimental results using both public data and lab-collected data obtained with the custom-built device confirm that the proposed models can predict multiple biomarkers with high accuracy and reliability.

To extend practical usability, a mHealth application, KDCare, has been designed and implemented. KDCare integrates fingertip video acquisition using the developed hardware, PPG feature extraction, and AI-based biomarker estimation into a single pipeline for real-time health monitoring. This framework shows that combining AI, QML, and GenAI with custom hardware and smartphone technology can support painless, continuous, and affordable monitoring of metabolic and renal health at home and in clinical environments.