ABSTRACT

Recent advancements in dermatological engineering have fostered the development of innovative, non-invasive approaches for rapid and efficient skin condition assessment. This research proposes the design and implementation of a portable non-contact skin analysis system employing a Raspberry Pi 5 integrated with a 12 MP high-resolution camera. The system leverages image processing techniques within the HSV (Hue, Saturation, Value) color space, enhanced with *auto-calibrate* and *auto-recalibrate* algorithms, enabling adaptive thresholding to accommodate variations in skin tone and illumination. The device is engineered to detect and classify oily, dry, and normal skin regions, with analytical focus on the *T-Zone*, which exhibits higher sebaceous activity. The hardware architecture incorporates a Raspberry Pi 5 for on-device computation, an optical imaging module for high-fidelity image acquisition, and an LED Ring Light to ensure homogenous illumination and reduce ambient light interference. The *software* framework, developed in Python utilizing OpenCV and NumPy libraries, integrates facial detection, ROI segmentation, and adaptive classification models. Performance evaluation was conducted with 10 human subjects of varying skin types under controlled lighting conditions. Ground-truth validation was performed against a commercial Digital Skin Analyzer through comparative statistical analysis. Experimental results indicate that the proposed system achieves an average detection accuracy of 93.9% relative to the reference instrument. The integrated auto-calibration mechanism effectively stabilizes performance across high, moderate, and low lighting intensities, with minor degradation under low-light scenarios. Given its non-contact, real-time operation, and cost-efficient design, the system demonstrates significant potential for integration in clinical dermatology, cosmetic product diagnostics, and personalized home-based skin health monitoring.

KeyWord: Non-contact Skin Analysis, Raspberry Pi 5, HSV Color Space, Adaptive Thresholding, Image Processing, Sebum Measurement