Synopsis of Original Research Paper

Quantitative Evaluation and Presentation Methods of Application Techniques to Maximize the Functionality of Cosmetics

Shintaro Izumi

Graduate School of Science, Technology and Innovation, Kobe University

This study aims to develop a system that quantitatively evaluates cosmetic application techniques and provides user feedback, thereby maximizing the functionality of cosmetics, particularly UV protection products. A compact wireless motion-sensing device was embedded into a cosmetic puff to measure hand movements during application. The device captures six-dimensional data including acceleration, angular velocity, and pressure estimations through optical deformation sensing. The data are transmitted in real-time to external devices for analysis.

To validate the system, a series of experiments were conducted using artificial skin embedded with a tri-axial force sensor. UV protection performance was assessed by applying UV-reactive agents and analyzing reflectance under UV camera imaging. Motion and tactile data were synchronized with RGB video using pose estimation algorithms, enabling detailed correlation analysis between user movement and UV protection outcomes.

Results indicated that different application styles (e.g., sliding vs. tapping) led to measurable differences in pressure distribution and UV coverage. However, using motion sensors alone proved insufficient for estimating tactile forces accurately. To address this, an optical tactile sensor was developed that measures force by detecting infrared light reflection changes from the back of the hand, based on the principles of photoplethysmography (PPG). This sensor enables force estimation without obstructing natural tactile sensations.

The integrated system was validated through further experiments, showing the feasibility of simultaneously capturing motion and tactile data without interfering with the user's natural application behavior. These findings provide a foundation for intelligent cosmetic application support systems. Future work includes implementing machine learning models for real-time feedback, and exploring applications in augmented or virtual reality environments for user guidance.