Technical Summary : Self-Sustaining Cost-Effective Wearable for Monitoring Sun Exposure

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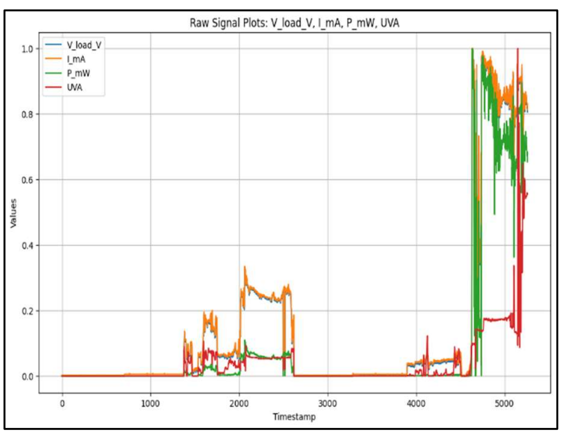
This project describes the development of a Self-Sustaining Cost-Effective Wearable for Monitoring Sun Exposure to address the issue of UV over-exposure and skin cancer, specifically melanoma. The core innovation is the use of a self-sustainable solar panel instead of a specialized UV sensor that requires a battery, aiming to overcome the limitations of current costly, bulky, or imprecise UV wearables. The device components include a Seeed Studio XIAO ESP32-S3 microcontroller, an INA219 current sensor, a 1-inch solar panel, a 100 Ohm resistor, and a PKCELL LiPo Battery. The system also includes a Sparkfun Spectral UV Sensor (AS7331) to provide the ground truth UVA/UVB/UVC data for training.

Data Collection and Processing

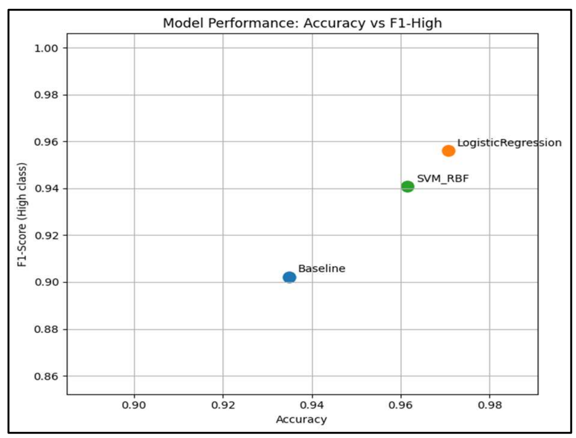
Sensor readings, including time, voltage, current, power, and UVA/UVB/UVC values, were recorded at 10 Hz while the device was worn on the wrist. Data collection occurred across eight sessions under four main conditions: indoors, indoors near a window, outdoor shade, and outdoors under direct sunlight, each measured at 1:30 PM and 4:00 PM. The raw data underwent a preprocessing pipeline involving trimming and smoothing. For model training, the UV exposure was classified into a binary label: High or Normal, where the High label corresponds to the upper 33% of UV values, signifying significant exposure where a user alert would be necessary.

Machine Learning Approach and Evaluation

The project's specific aim was to train and compare machine-learning models to classify UV exposure levels using engineered solar-based features, rather than estimating exact UV values. The dataset was split into 70% training, 15% validation, and 15% testing sets. Three models were trained and compared: Logistic Regression, SVM, and a Baseline Threshold Model. The models were evaluated using metrics critical for health monitoring, including Accuracy, Precision (to reduce false alarms), Recall (to reduce missed risks), and the F1 score (useful for imbalanced classes).



Trend of the Overall Data



Performance of Models

Key Findings and Future Work

The Logistic Regression model demonstrated the best performance among the tested classifiers, achieving high scores in both accuracy and F1-High (the F1 score for the crucial 'High' UV class). The project successfully confirmed that the solar panel integrates UV detection capabilities, offering a cost-cutting, self-sustaining, and lightweight solution. Future work will focus on turning the prototype into a well-finished, end-to-end usable device. Additionally, there are plans to add the feature of measuring the hydration level of the person.