Development of a Detachable UV Monitoring Wappen Patch: Real-Time Sun Exposure Management

Lidiia Khleborodova[1], EungTae Kim[1,]

[1]Department of Clothing & Textiles, Chungnam National University, Republic of Korea

Introduction

Research Problem
Excessive exposure to **ultraviolet (UV)** radiation is a growing health concern, linked to risks such as skin cancer and sunburn. While various UV monitoring devices exist, most require active user engagement and lack convenient integration into everyday clothing, limiting their practical utility. There is a need for a user-friendly, wearable UV monitoring solution that enables continuous, passive monitoring and encourages proactive sun safety without interrupting daily routines.

Research Question
How effective is a detachable, wearable UV monitoring patch in providing real-time UV exposure information and promoting sun safety behaviors compared to conventional UV monitoring methods?

Research Objective
Development and evaluation of detachable UV monitoring patch, integrated with a user-friendly mobile app, that provides real-time UV exposure feedback, encouraging proactive sun safety behaviors in everyday life.

Methods

Hardware design

Components

1. Photodiode UV Sensor (GUVA-S12SD)
2. Microcontroller (Arduino Nano 33 BLE Sense Rev2)
3. Bluetooth Low Energy (BLE) Module
4. Rechargeable Lithium-Polymer Battery

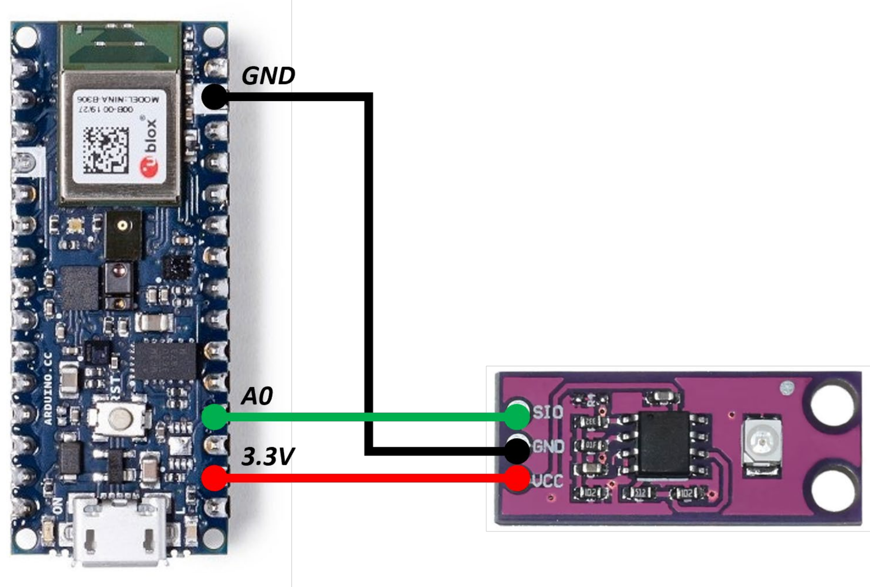


Figure 1. Components connection scheme

Components of the monitoring patch were carefully selected for accuracy, energy efficiency, and user convenience. The **GUVA-S12SD photodiode UV sensor** provides precise, real-time UV index assessments while consuming minimal power, making it ideal for long-term wear. Paired with the compact **Arduino Nano 33 BLE Sense microcontroller**, which includes a **Bluetooth Low Energy (BLE) module**, the device can process and wirelessly transmit UV data to a mobile app with low energy consumption. Powered by a **rechargeable lithium-polymer battery**, the patch maintains compactness and sustainability, minimizing the need for frequent recharges. This design maximizes both functionality and comfort, enabling unobtrusive UV monitoring in daily life.

Software design

To complement the hardware, an **Android-based mobile application** was developed with Android Studio to provide a user-friendly interface for monitoring UV radiation levels.

Application workflow

1. Data Collection
The UV sensor in the patch continuously measures UV intensity, with the microcontroller assessing UV index levels in real-time.

2. Data Transmission
The processed UV data is sent to the app via Bluetooth Low Energy (BLE), establishing a secure, energy-efficient connection.

3. Data Reception
The mobile application, built in Android Studio, includes a BLE communication module that automatically connects to the patch once it is within range. As data is received, the app updates the UV index display in real time, ensuring users see the latest UV exposure level.

4. Data Categorization
The app categorizes the UV index into levels (Low to Extreme) with WHO color codes for immediate risk assessment.

UV Index	0	1	2	3	4	5
Vout(mV)	<50	227	318	408	503	606
Analog Value	<10	46	65	83	103	124
UV Index	**6**	**7**	**8**	**9**	**10**	**11+**
Vout(mV)	696	795	881	976	1079	1170+
Analog Value	142	162	180	200	221	240

Figure 2. UV radiation exposure categories and WHO color codes

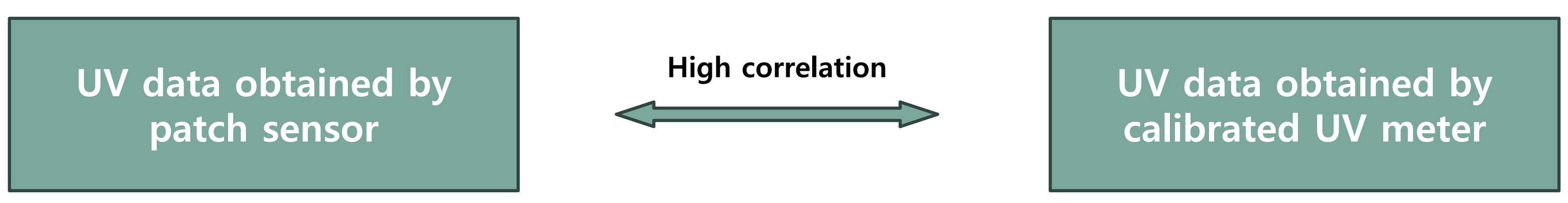
5. Notifications
At high or extreme UV levels, the app sends alerts, recommending actions like applying sunscreen or seeking shade.

6. Customization
Users can personalize notification settings and data-sharing preferences within the app.

7. Real-time Updates
The app continuously updates as long as it's within Bluetooth range, providing constant UV exposure feedback.

Experiments

For performance evaluation of the UV monitoring patch under varying environmental conditions multiple field trials were conducted. Measurements were taken at different times of the day to assess the sensor's accuracy in detecting changes in UV intensity. The results were compared to standard readings obtained from a **calibrated UV meter** to validate the system's accuracy.



The data obtained from these trials demonstrated a high level of correlation between the patch readings and the calibrated UV meter, indicating the reliability of the system in real-world conditions.

Results

- The patch's flexible attachment and detachment mechanism was extensively tested on various items of clothing and accessories, such as hats, shirts, and bags, demonstrating its versatility and ease of use.
- This extensive testing confirmed that the patch could be reliably used in everyday life without frequent maintenance or recharging, enhancing user compliance and satisfaction.

Discussion

- **Effective UV Management**

The patch and app together provide real-time UV monitoring that is convenient and promotes proactive sun safety.

- **Seamless Daily Integration**

The patch is designed for easy wear without active user input, making UV safety an effortless part of daily life.

- **Advancement in Wearable Health Tech**

This solution highlights the importance of user-friendly, accessible health monitoring in wearable technology development.