Affective Umbrella – Towards a Novel Sensor Integrated Multimedia Platform Using Electrodermal and Heart Activity in an Umbrella Handle

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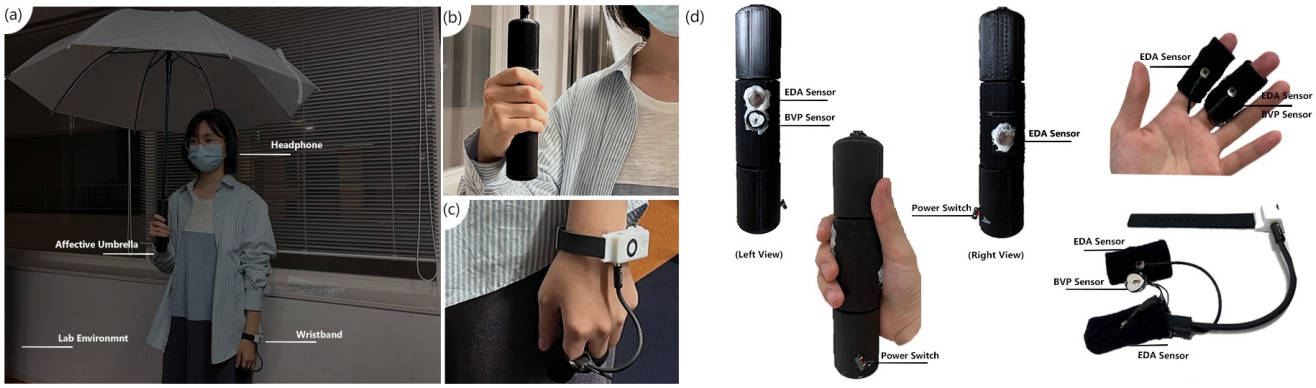

Figure 1: Affective Umbrella to accompany and understand us more deeply. (a) Overview of the experimental environment and devices used (b) the dominant hand holding the umbrella during the experiment (c) Wearing a wristband with the other hand for a baseline recording (d) Comparison of the sensor((blood volume pulse) BVP and (electrodermal activity) EDA sensors) placement design of the umbrella handle with the fingers.

ABSTRACT

We present our first steps towards an umbrella-based novel multimedia platform using physiological data as an integrated feedback loop. In this paper, we demonstrate the viability of using an umbrella handle as a form factor to measure electrodermal activity(EDA) and heart rate(HR) in real-time. We compared the performance of the device with that of a more conventional finger sensor placement. Although the finger sensor placement is more widespread and considered to be more reliable, yet we are able to derive meaningful data from the umbrella handle in both stationary and dynamic contexts in the presented feasibility study.

CCS CONCEPTS

• **Computer systems organization → Sensors and actuators**.

KEYWORDS

umbrella handle, electrodermal activity, heart rate

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1 INTRODUCTION

Umbrellas are one of the most ubiquitous accessories available to us. The motivation of Affective Umbrella is to explore ways of our emotional connection to nature. Affective Umbrella presents opportunities for a novel and unobtrusive means to gather physiological data. Umbrella redesign related research focuses on energy

conversion[7, 9, 13], sound space[7, 8], umbrella surface as an Internet interactive screen[3, 11, 12] , etc. We are unaware of any umbrella redesign embedded with physiological sensors [4, 15, 17].

The main contributions of this paper are: (1) We present an approach to measure EDA and heart rate data from an umbrella handle. We describe an initial design as well a layout of the sensors together with a functional prototype. (2) We present a dataset of 8 participants, which is available under the anonymized google drive link[1], comparing the measured heart rate and EDA to data from the participant's fingers (of the other hand). (3) We show initial insights that the umbrella handle is feasible to collect consistent, accurate physiological signal according to the comparison between the baseline device.

2 PROTOTYPE IMPLEMENTATION AND INITIAL EVALUATION

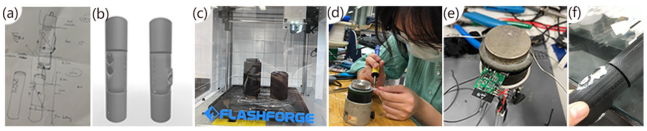

Figure 2: Affective umbrella setup: (a) Original sketch (b) Model and render effect (c) Fabrication in a 3D printer (d,e) Circuit board soldering (f) Using hot melt glue to assemble the umbrella handle

Taking into account the product design that conforms to usage habits, it is also conducive to improving the stability of data collection. We consider of the handle material, weight, and appearance. The prototyping of Affective Umbrella: (a) Sensor placement design -(b) Modeling-(c) Printing-(d,e) Soldering circuit board-(f) Assembling the umbrella (See as figure**??**). The material is made of Polylactic Acid(PLA), a light, hard, and environmentally friendly polymer, which will not bring more burden to users.The handle uses the same (blood volume pulse) BVP and (electrodermal activity) EDA sensors as the wristband used in similar research [2, 6, 10, 16]. Placement of the EDA electrodes was chosen to be in line with our habits of holding umbrella, EDA sensors are placed diagonally on the umbrella handle, matching the position of the palm: under the thumb, and under the pad of the index finger; the BVP plethysmograph is located under the middle finger. To check the rationality of sensor placement and the viability of data collection, we conducted the following feasibility test.

The main purpose of the experiment is to test the effectiveness of biometric sensors placement and feasibility of the data acquisition, and to further explore the response of physiological data to different audio effects (rain sound and jump-scare effects) and different states (imitating the actual scenarios of an umbrella: stationary or walking around), so as to understand the potential value of Affective Umbrella as the ubiquitous multimedia platform.

There were 8 participants in total, four male and four female, ranging from 23 to 32 years old. The experiment included two 7-minute sessions, before and after each resting and experimental period, participants were asked to fill out the SAM (Self Assessment Manikin) questionnaire, finally received an 8-minutes interview. During the experiment, participants were required to hold the affective umbrella with their dominant hand and wear the wristband on the other hand (Figure1), being exposed to audio stimuli listed to over wireless blue-tooth headphones. Both the umbrella and wristband device used the same analog front-end PCB circuitry, with a wheatstone bridge connected to a differential ADC that communicates to an ESP32 chip over I2C. The resulting data is streamed wirelessly to a nearby computer running in-house software as a data receptacle.

[1]https://drive.google.com/file/d/1CfrYq4YySX6ctSjNVFvawRrUWN0PRkN_/view

3 INITIAL DATA ANALYSIS, DISCUSSION AND FUTURE WORK

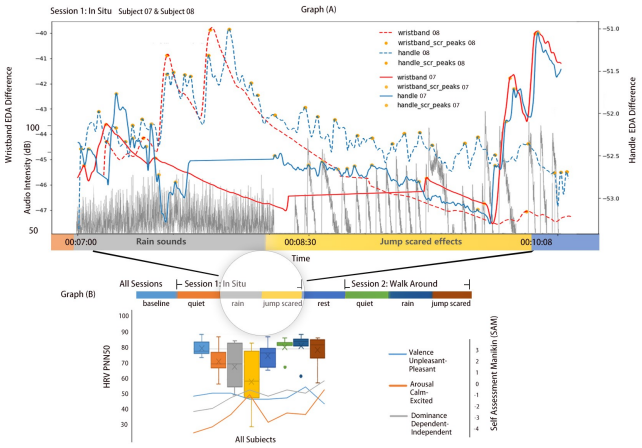

Figure 3: Graph(A) EDA changes with EDA extrema counts,EDA extrema peaks (highlighted in orange), trends in subject07 and subject08 from wristband(Left Y scale) and handle(Right Y scale), corresponding with audio effects; Graph(B) Trends in all subjects of HRV PNN50 (Left Y scale) and value from Self Assessment Manikin(SAM) (Right Y scale).

During the study we recorded EDA (4.54 Hz) and BVP (50 Hz) data alongside the SAM questionnaire. For EDA data analysis, we mainly focus on the fast changes in EDA response (see Figure **??**). The different patterns of EDA across different sessions of experiment are expected. And we picked (subject07) sub07 and (subject08) sub08's EDA as an example to show the difference(See Figure 3 (Graph A)). Graph(A) shows the extreme values of EDA located under the sound effect stimulus in session 1. Through the audio decibel peak corresponding to the extreme EDA peak, we found that **the overall accuracy of the data collected from the umbrella handle is higher than data from the fingers,** (sum amounts of peaks with jump scared effects from sub07 and sub08) 25 > 6 (peaks from sub07 + sub08 with jump scared effects).**This can potentially be explained by stronger gripping force participants use to hold the umbrella.**

HRV features were extracted from BVP data. For simplicity(See Graph(B) from Figure**??**), the changes in PNN50 (strongly related to PSNS, less affected by SNS (related to excitement)[1, 5, 14],) and

SAM arousal were used to analyze the average changes of all subjects. It is not difficult to find that the two verify each other. Therefore, **the sensor placement and the physiological sensing of Affective Umbrella are both reasonable and effective, that is, the umbrella handle can be used as an functional prototype measuring EDA and HR data.**

We propose a method to measure physiological data (EDA, HR data) using Affective Umbrella, briefly describe and analyze the recorded data, and provide a complete dataset for download. In addition, we also found that the space created by the rain and the umbrella can affect emotions to a certain extent. Future work includes: (1) Real-time detection of the effects of umbrella space and weather (like rain) on our physiology (2) Exploring the reasons behind different mapping relationships, such as the loudness and frequency of rain; the intensity of ultraviolet radiation and the physiological response relation.

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