Baroesque Barometric Skirt

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Abstract
The Baroesque Barometric Skirt visualises data from the wearer's environment alongside physiological data of the wearer. The skirt changes visually as the wearer moves around environments and also as the body reacts to its present situation. This garment-device starts a conversation around the connections between the environmental and physiological data of the wearer. This short paper charts the evolution of the Baroesque Barometric Skirt from purpose to design, to making the skirt and constructing the electronics and code that become integral to it. The Baroesque Barometric skirt contributes a new way of sensing and presenting environmental and physiological data together.

Author Keywords
Barometric; data; visualization; physiological; environmental; wearable; technology; computing; e-textiles;

ACM Classification Keywords
HCI; algorithms; design

Introduction
The Baroesque Barometric Skirt is a responsive, functional wearable that uses data from four sensors to create unique visuals upon the skirt as the wearer moves around and visits different environments. The

skirt incorporates four pieces of RGB (Red Green Blue) LED (Light Emitting Diode) strip [1], which change colour independently of each other depending on the environmental conditions and the wearer's physiological temperature [Fig. 1]. The environmental data is pulled in from a barometric printed circuit board (PCB) [7] on the outside of the skirt, containing three sensors: temperature (Celsius °C), pressure (pascal Pa) and altitude (meter m). The forth sensor is a compact temperature sensor that sits on the inside of the skirt and pulls in the wearer's body temperature. The skirt changes colour as the wearer moves from room to room, upstairs and downstairs, reflecting changes in temperature indoors and outside.

Motivation, audience and functionality

The skirt was developed to answer the question of how one can display their physical data alongside that of the 'bigger picture' of elements that we are surrounded by. Also, to bridge the gap between what can become an enclosed capsule of only capturing and visualising one's own physiological data when using wearable computing devices, and instead, entwining personal physiological data with that from the environment around the wearer. The aim is to create a functional and useful piece of wearable technology, which also fulfills a design aesthetic that would be attractive to the wearer [3].

This skirt was created to accompany the wearer as a new way of experiencing environments and to give a sense of how their surroundings change whether they stay still or move around, plus a means of reflecting on how environmental conditions may affect their physiological state. It is envisaged that the skirt will appeal to those who appreciate interactive wearable technology that raises mindfulness towards aspects of their surroundings that may often be missed. It is aimed at those who are interested in wearable technology that uses live data to give feedback in the form of a colourful visualisation or capture the sensor readings as they come in from the barometric sensor, by linking the garmet-device to a computer. The data may be used to compare and contrast patterns, and significances, such as the effect of environmental factors such as weather on moods and health.

Figure 1. Baroesque Barometric Skirt.

Figure 2. Painting the skirt's Ōkami inspired motif.

Development and execution of concept

The Baroesque Barometric Skirt is made up of three distinct components, and each of these had their own demands and challenges. These elements are: the skirt itself, secondly the electronics, thirdly the code and algorithms that drive the electronics. The initial idea for the project was based around the skirt design, but research and development of hardware and code soon became important in order for the project to develop.

Skirt

To embed electronics within a skirt required a carefully chosen shape and cut, and after some research a pattern for a paneled A-line skirt with a dropped waist was chosen. The panels also provided a good canvas area for the painted motif on the skirt, plus could be aligned with and give support to the electronic components. To research the most suitable fabric for the skirt, various kinds of satin and organza fabrics were painted and washed to test for practical concerns such as washability, shrinking, ironing, and to test the reliability of fabric paints. A Japanese brush technique was selected to reflect movement and the fan art style imagery of characters from the console game Ōkami [4], which were chosen to depict the opposing states of low and high pressure weather. The sun god *Amaterasu*, a wolf, is pictured advancing through precipitation and the cat deity, *Kabegami*, is shown bathing in the sun [Fig. 2].

The electronic components, including the RGB LED strips, are sewn into a removable substrate apron. This has been designed to allow easy release from the main skirt for washing and so that the electronics can be worn in other and differently designed skirts.

Four RGB LED strips are used to display sensor data from inside the skirt and align with the skirt's painted sun motif. The satin fabric diffuses the coloured light to give a softer feel. The apron also allows the electronics to be displayed as a standalone piece of e-textile design. The electronics apron is positioned between the outer layer of the skirt's fabric and lining layer and is held securely with Velcro, ensuring that the wearer is shielded from the components and battery pack, which is held in a fitted pocket [Fig. 3].

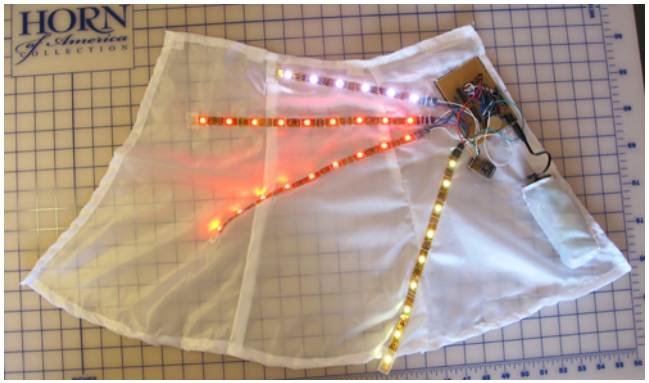

Figure 3. The electronics apron that sits inside the Baroesque Skirt.

Electronics

The design of the electronics circuit schematic was given much consideration as it is integral in the visualisation of data output from the four sensors: ambient temperature, pressure and altitude from the barometric sensor, and also the wearer's temperature. The RGB LED strip was chosen as it is flexible and easier to sew into the fabric than multiple RGB LEDs with conductive thread. Also, because the RGB LEDs require a 12 V battery pack, conductive thread was rejected due to resistivity and possible overheating issues, such as singeing of fabric.

Due to each of the four RGB LED strips requiring four input / outputs, the original prototyping was conducted on three breadboards and connected to an Arduino Uno [2]. This complicated mass of wires needed simplifying as it would have been very complicated to reproduce and solder onto stripboard [5], so was simplified into a much neater circuit by using two Darlington Pair ICs (integrated circuits), which incorporated their own transistors and resistors. This elegant solution meant that all the components would fit on one breadboard instead of three. A second temperature sensor (the first being on the barometric sensor on the outside of the skirt) was positioned on the stripboard circuit so it would be nearer to the body to record its temperature. To scale down the overall size of the circuit, the Arduino Uno was replaced by Shrimp microcontroller kit, which is comparable to the Arduino Uno and also uses the Atmel 328 microcontroller. The Shrimp kit is a low-cost alternative to pre-assembled microcontrollers and comes as a bag of components, which can be constructed in a much smaller area, thus can be used to save space [6].

The barometric sensor (sensing ambient temperature, pressure and altitude), the temperature sensor (sensing physiological temperature) and the Shrimp microcontroller are powered by a 3.3 V coin cell battery, the RGB LEDs need a larger power source and run off a 12 V battery pack. Once the new Shrimp driven circuit was tested, the components were transferred from the breadboard and soldered onto stripboard.

Code

The code that drives the hardware is written in the C programming language, with the addition of the Wiring library and the example code library for the barometric sensor, which carries out calculations to convert readings from the sensors on the barometric sensor board to °C (Celsius), Pa (Pascal) and m (meter).

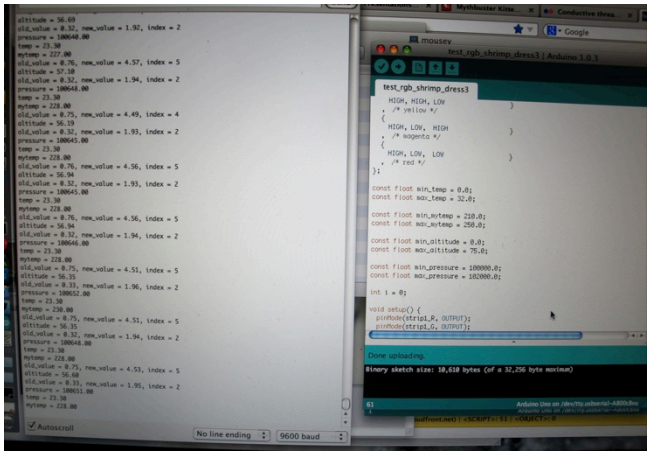

Figure 4. Celsius (°C), pascal (Pa) and meters (m) data viewed in real time coming from the skirt in the Arduino IDE serial monitor, shown next to sensor algorithm.

To get an area specific reading for altitude, it is required to input the local mean sea level reading that can be obtained from weather information websites. Based on expected ranges of data coming in from the sensors an algorithm is used to reflect the data in colours on the RGB LED strips [Fig. 4]. The RGB LED strip indicates changes in incoming data from a low reading, shown as blue, changing to cyan, green, yellow, white, magenta, to the highest reading indicated as red [Fig. 5].

Usability

The Baroesque Barometric Skirt is an easy to use interface between the wearer and their environment. In terms of usability, one need only insert the batteries into the holder for the system to begin polling the environment for barometric and physiological data. If the batteries begin to fade, then the LEDs will pulse informing the wearer to change them. To access or record the numerical values of the data when on the move, the wearer can simply connect the skirt directly or remove the electronics apron from the main skirt and connect it via USB to a laptop or tablet device. If required, periods of data could be recorded onto the microcontroller's EEPROM memory and retrieved later.

Figure 5. RGB LED strip was chosen as a flexible component for bending to the wearer's body.

Figure 6. side view of the skirt

Conclusion

The Baroesque Barometric Skirt offers a way to connect our physiology to the environment for both the wearer and the viewer [Fig. 6]. In the future, ambient systems will be integrated into our clothing and will monitor everything from our physiological to environmental data and also help us manage aspects of our daily lives, such as health, meetings, location, transport, etc, by carrying out multiple monitoring tasks in the background and providing data updates as we need them. We already do much more monitoring of ourselves that we realise through our smart phones, which are familiarising us with the concept of data driven lives, plus apps and devices such as fitness trackers that manage and do so much for us already. One could imagine the concept of the Baroesque Barometric Skirt being integrated in such a system as we start to look at new ways to interface with our devices as computing becomes more important and ubiquitous to our lifestyles.

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