Æffect

A Prototype for a Contemplative Wearable

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Abstract

In our fast-paced society and beset by the challenges of pandemic facial coverings, our connection to both our own emotional condition and the condition of others has seemingly never been further from our conscious awareness. A portmanteau of visual effect and psychological affect, Æffect presents a prototype model for a physically dynamic, emotionally responsive wearable garment providing haptic feedback to its wearer to encourage greater introspection.

Project Repository:
https://github.com/CLimeburner/CART360/tree/main/Everywhere%3DNowhere%3DNow

Introduction

Faced with the facelessness of our currently masked society, we as a design team originally set out to explore novel ways of conveying implicit emotional context in social situations. The notion of wearable technology that serves as an extension, not only of the wearer's physical body, but also their internal state of mind, is by no means a unique idea, preceded by many examples all the way back to the Mood Ring, but whereas many of these articles are chiefly visual displays of emotional state, our's took a twist into the exploration of modalities that, while visible, carried with them an additional tactile element. This feedback loop from wearer, to garment, and back to wear via tactile cues, leads us to believe such applications have potential as reflective articles, helping individuals come to understand the dynamics of their own emotions as much as express that state to others.

Background

Since the debut of the Mood Ring in the 1970s [1], wearable technology that responds to its wearer's emotional state has enchanted the broader populace. Quite understandably, the outward manifestation of these otherwise inward thoughts and feelings carries with it a certain "magic" that resonates strongly across demographics. As the form factor of various sensors and microcontrollers has reduced over time, new tech has been brought to bear, allowing for a greater diversity, both in the biometric signals that serve as input, and the kinds of outward expression a garment can effect.

At the same time, we find ourselves in an uniquely challenging moment regarding the communication of unspoken emotional context across social circumstances. With the sudden need for everyone to wear masks in the wake of our current global pandemic, facial expression is obstructed, stripping away a vital source of non-verbal interpersonal communication. [2] Indeed, research turned specifically towards this question of the impact of masks on interpersonal communication has found there are distinct and significant challenges that this environment presents. [3]

Drawing upon prior work by artists such as EIGHTHSENSE by THEUNSEEN [4] and the GER mood sweater by SENSOREE [5], we surveyed several existing emotionally-responsive wearable designs, however we observed a distinct pattern among these works of primarily visual output, often focused on the use of colour. Apart from being relatively narrow in their modalities, these applications further felt emotionally prescriptive. Wearers and others nearby were not invited to engage with the complexities and nuances of the wearer's emotions, but rather they were being given explicit instruction regarding some algorithmically determined mood.

Wishing to depart somewhat from the exclusive domain of light and colour-based output, we turned to the work of Ying Gao, particularly her pieces Incertitudes [6], and (No)where (Now)here [7]. These works make considerable use of physical motion in their behavior and so at the outset, our project endeavored to bring together the emotional responsiveness afforded by tech integration in a wearable, with less conventional physical outputs, acting both as a visual stimulus, as well as a haptic one.

Process

At the start of this project, we first began by conducting a survey of some of the biometric sensors available to us that seemed most suitable for an emotionally responsive wearable. Our main criteria for evaluation were physical obtrusiveness, reliability of signal, and relevance to mood. Ultimately, we tested six biometrics and eight sensors/methods (fig. 1) of measuring those biometrics, with multiple approaches taken towards the

Biometric	Technology (sensor, technique)	Exploratory Stage	Experimental Stage	Prototyping Stage
Pulse	Light oximetery			
	Piezoelectric transduction of acoustics			
Respiration	IR proximity detector measuring thoracic circumference			
	Piezoelectric transduction of acoustics			
Skin Conductivity	Galvanic skin response			
Muscle Contraction	Electromyography			
Pupillary Response	Camera			
Brain Activity	EEG			

measurement of both breathing and pulse. In the course of this evaluation process, we ultimately narrowed down our array of biometrics to a combination of pulse and respiratory data, both measured using optical methods, and with heart rate, respiratory rate, and depth of breath as our primary metrics of interest.

In the process of designing our protocol for interpreting the biometric data we were gathering from the wearer, we discussed several options for how best to make the data meaningful. Ultimately, we agreed that we didn't want to be aiming to create a traditional "mood ring" where the behavior of the garment correlates to an absolute mood. Rather, we were interested in capturing some aspect of the wearer's emotional dynamics. That is to say, we were less concerned with whether someone was nominally happy or sad, but rather if they experienced a momentary fluctuation in their emotional state. This led us to exploring ways to interpret the rate of change in the biometric data, rather than the absolute values themselves. Similarly, we also determined we didn't want to

attempt to reduce mood to a singular dimension, opting instead to adopt a two-dimensional paradigm of arousal and valence (fig. 2), as is often used in the field of psychology.

At the same time, our early explorations touched on several different forms of output for our wearable, including embedded LEDs, interwoven fiber optics, and thermochromic ink, though ultimately we decided these visual forms of output robbed the wearer themself of any meaningful explicit interaction with their own wardrobe. Consequently, we began drawing on work in physically dynamic textiles, allowing us to create a visual effect that also offered a level of haptic feedback to the wearer. Further exploring these physical modalities, we struck upon the idea of using a garment structure similar to a hoop skirt, but with hollow inflatable tubes rather than rigid boning, allowing us to dynamically control the shape with air pumps and solenoid valves.

Over several iterations, we tested the inflatable bone model and found that a fully inflatable frame would require a far greater quantity of air than we felt we could reliably move in the form factor of a wearable. Consequently, we shifted our design intentions towards inflatable spines (fig. 3) beneath a lighter organza layer, facilitating a garment surface that can be made to "breath" with varying patterns of inflation between the spines.

With this shift to the use of inflation as our primary output, the next challenge became to determine how we'd relate our input (inferred emotional arousal and valence) to our output. Unlike other possible solutions like light-based output, our air-based output lacked a variety of axes for expressing the multiple dimensions of our input. Consequently, we had to devise a way of patterning the inflation of the spines so as to convey this more complex information. This resulted in us constructing three separate air pump circuits (fig. 4), each of which controls a separate set of spines. These independent circuits may then be influenced to become more inflated or less inflated, as well as inflate synchronously or asynchronously with their fellow circuits. As such, we've chosen to express emotional arousal (via respiratory and heart rate) as the degree of inflatedness of the circuits, and emotional valence (via respiratory depth) as the degree of synchronicity between the circuits.

Figure 3: From left to right : chronological iterations of several airtight structures. The inflatable spines are independently inflated, as opposed to the hoop skirt system.

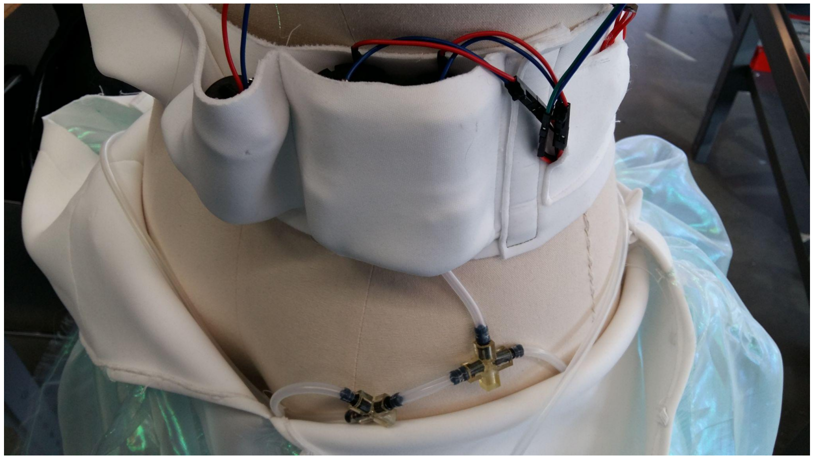

Figure 4: the waistband comprises three motors that independently control three spines each, giving a wider array of possible combinations in terms of visual output.

The Artefact

Our final artifact takes the form of a white neoprene A-line dress, wound round with a layer of iridescent organza (fig. 5). Between the neoprene body and organza layer are nine air-tight "spines" connected into three separate air pump circuits, and which can be thereby inflated on command from a microcontroller. These air pumps are mounted on a belt designed to fit comfortably about the wearer's natural waist. A second band carries an Arduino Uno microcontroller to serve as the computational brain of our artifact, as well as an infrared proximity sensor mounted across a short elastic stretch to measure change in thoracic circumference while breathing, and finally a tether point for our heart rate sensor, which extends and clips to the earlobe of the wearer (fig. 6).

The Algorithm

Since we wanted the behaviour of our garment to be primarily responsive to changes in emotional state, rather than some interpretation of absolute emotional state, although our sensors track respiratory and pulse features, that data then undergoes a more complex algorithmic process to determine the behaviour of our output.

At each frame of the loop cycle running on our Arduino, the peak respiratory depth, respiratory rate, and heart rate are calculated, from which the change between the prior and current frame's biometrics are then computed.

These changes in biometric value are added to running tallies, which are themselves multiplied by a decay constant *D* at each frame of the looping function, such that for any given frame *n* of the main loop, the tally *T(input)* is of the general form:

$$T_n(input_n) = \Delta input_n + (T_{n-1}(input_{n-1}) * D)$$

Though there are individual differences regarding resting values for both pulse and respiration, we did also want our algorithm to account for the change in biometrics relative to their actual value, such that vascilations in mood are registered as more significant if they result in a more strongly positive or negative state. This was achieved with a sigmoid activation curve of the form:

$$f(x) = \frac{1}{1 + e^{-\delta x}}$$

Where x is the current metric's tally value and δ is the deviation of the metric's actual values from an arbitrary global average (breathing rate = 14 breath/min; heart rate = 90 beats/min; breath depth = 0.75 in.) mapped to an experimentally determined range of suitable values.

The results of these activation curves, calculated respectively for both emotional arousal and valence, were then converted to values for air pump duty cycle and synchronicity of air pump phase. Values for duty cycle ranged from 0% to 100% of a 3 second period and phase ranged from perfectly synchronous, to a ⅓ period offset between each of the three pumps.

The Experience

The combination of our tangible artefact and algorithm produces an effect that, while subtle, nonetheless colours the wearer's relationship, both with other people and their own emotions. Though the motion of the inflatable spines is relatively small, their movement is amplified by the iridescent layer with which we've covered them. As the spines extend from the body and then relax, their small movements send distributed patterns of shimmer across the surface of the garment, creating a greater visual effect.

More importantly, as we developed the garment to inflate, rather than any other given output modality, we rapidly discovered the garment's potential as an introspective artifact. As the spines inflate and deflate, there are a variety of sources of haptic feedback experienced by the wearer. Most directly, the air pumps mounted against the small of the back provide vibratory feedback to the wearer, allowing them to detect both the duty cycle and synchronicity of the pumps. When we became aware of this phenomenon, we made the decision to design the air pump belt to sit at the waist rather than hips, in the hopes that this would expose a more sensitive region of the body to the pumps, thereby creating a greater awareness of them. As well as the pumps themselves, the inflatable spines create their own sensation. As they inflate, both the air pressure and the force of gravity on the increasingly extended tip creates subtle localized pulls across the surface of the garment, adding an additional level of haptic sensation for the wearer to contemplate.

Though it might seem impractical to expect wearers to be constantly engaged with the specific patterns of their garment, we in fact feel it is not necessary for the wearer to constantly interrogate their feelings. Rather, we find it more useful in cases when the wearer might be experiencing a sudden shift in their mood– one that they might not necessarily be consciously assessing. In these circumstances, the added stimulus of a rapid alteration in the behaviour of their garment becomes not an explicit read-out of their mood, but rather simply a conspicuous cue for them to engage in introspection. Through this process, the wearer is not prescribed an emotion but rather encouraged to engage actively in deciphering their own feelings and the causes for it. Effectively, the specific relationship between the garment and the wearer's emotion is less important than the general fact that the wearer's emotional state has altered significantly.

We feel that this contemplatory aspect of our artefact has considerable potential as an introspective and meditative tool. Indeed, through prolonged or repeated use of our artefact, we feel it might even be possible for the experience to improve the wearer's general awareness of their own somatic emotional responses. Over time, this might allow them to engage in similar introspection as a response directly to cognizance of their heart rate and breathing rather than the secondary garment, training their emotional self-awareness to act in absence of the secondary artefact. Consequently, we see our artefact not only as a communicative device, but also as a mediative one, helping strengthen interpersonal communication as well as one's relationship to their own internal state.

Conclusion

In light of these developments and observations, we would advocate strongly in favor of further design research being conducted on the potential for emotionally responsive wearables to aid in introspective activities. More specifically, from our experience with this project, we see both a way in which this model could be improved, and one in which it could push further into untested territory.

On the improvement side, with greater time and resources, it would undoubtedly be advantageous to include additional sensors for monitoring biometrics for which we ultimately did not account. The integration of additional metrics would provide a richer picture of bodily behaviour and therefore be less susceptible to ambient noise. Similarly, we feel there is considerable room to build upon the artefact here presented by extending its range of outputs, particularly those making use of touch-based modalities. Temperature, pressure, and perhaps even more unusual outputs such as texture might be explored as suitable methods for a garment to signal its wearer, all while maintaining a low profile and relatively small form factor.

Regardless of the specific direction of further developments, we feel strongly that this project demonstrates the core value of such an artefact as a contemplative device. We hope, in future, to see this concept advanced in the field of tech-integrated wearables.

References

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