Nebula: An Interactive Garment Designed for Functional Aesthetics

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Abstract
In this paper we present *Nebula*, a prototype for examining the properties of textiles, fashion accessories, and digital technologies to arrive at a garment design that brings these elements together in a cohesive manner. Bridging the gap between everyday performativity and enactment, we aim at discussing aspects of the making process, interaction and functional aesthetics that emerged.

Nebula is part of the *Sound Clothes* project that aims at exploring the expressive potential of wearable technologies creating sound from motion.

Author Keywords
Wearable technology; design process; fashion; music computation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. H.5.5: Sound and Music Computing.

Introduction
The Sound Clothes project, which has been running since the fall of 2013, is an exploration of design practices and techniques for sound producing garments. By following several stages of prototyping,

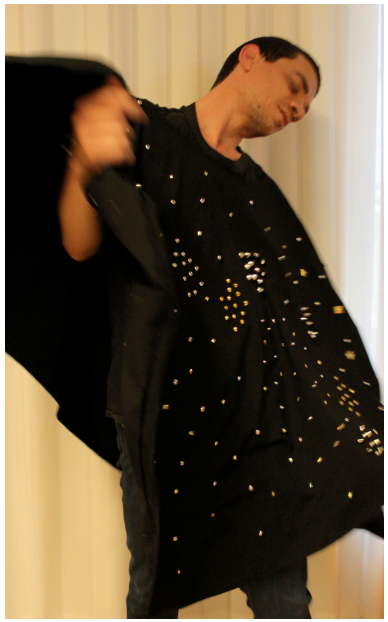

Figure 1: The Nebula Garment: a juxtaposition of delicate fabrics and metal studs.

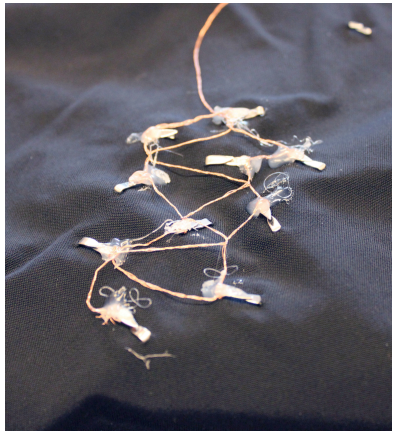

Figure 2: A cluster of studs wired together on the inside of the Nebula garment.

we have been exploring ways to merge fashion with music technology in terms of materials and electronic equipment involved, resulting in a number of produced artifacts and exploratory samples. Here we are presenting the most promising outcome of the project, Nebula, a studded cloak that reacts to the movements of the wearer and responds with an ethereal soundscape. Through the Nebula prototype we are investigating, among other topics, how wearable technologies could enhance the potential of making statements [2] using both the performativity of the body and the identity of garments. Instead of following the trend of developing wearable technologies whose function is mainly targeted towards healthcare or sports, we propose this garment as an alternative means for self-expression through sound and body movement paired with a strong visual identity.

Design

A central concept of the design of Nebula is the juxtaposition of the soft and delicate fabrics with a large number of metal studs. The studs are arranged in a myriad of patterns, forming clusters that envelop the garment, providing a seemingly aggressive addition to the free flowing fabric, as can be seen in Figure 1. The flowing and folding fabric provides the mode of interaction that is explored. Specifically, we chose to position clusters of studs in areas of the garment where there are spontaneous wrinkles and folds in the fabric, for example close to the arms. By positioning clusters of studs to exploit these textile deformations, the design of the data capture was a consequence of qualities of the materials used. And, vice versa, several fabrics were tried but were ultimately discarded due to the fact that their folding and other exploitable behaviors offered very little to work with.

One of the goals of the design process was to challenge a common model of producing garments embedded with technology, which seemingly adds customized technology to a separately designed garment. This can be seen as a result of how designers and interaction designers work, often lacking a common vocabulary and design goals. But since our research group consists of people with an experience both in fashion and interaction design projects, we followed an equal approach to both topics, which was reflected in the design process. The wearable produced was to be equally informed by technology and garment design. Therefore, each design decision was to be evaluated both by how it furthers the artifact from a garment design perspective, and how it enhances the technical functionality supporting the interaction with the garment as a tool for sonic expression. The decision that most embodies this goal is the use of the studs that simultaneously are both the defining aesthetic component and the central technology for interaction.

Although not an exact comparison, as an alternative to industry aligned wearable computing products (e.g. smart watches, heart-rate monitors), our speculative approach, like that of Dunne and Raby, aims "toward more social ends that address the citizen rather than the consumer or perhaps both at the same time." [1]. From a conceptual perspective, the Nebula garment speculates about the future of wearable technologies by proposing new purposes and social functions for clothing.

Implementation

The garment is cut in the style of a cloak or poncho and made using a fine black fabric. On the inside of the garment, the legs of the studs that penetrate the outer

Figure 3: When an active stud touches another in a receptive cluster, an electrical connection is made, alerting the electronics that the garment is moving.

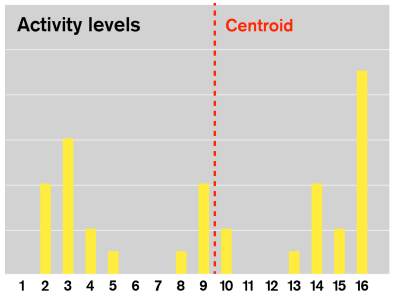

Figure 4: The measured activity in each stud cluster are ordered according to their position on the garment, and a centroid measure is calculated and used as additional control data.

fabric are bent to hold the studs in place. On the bent legs of the studs, conductive thread is tied and fastened with glue. The studs that are to form a cluster are connected with the conductive thread in a mesh-like fashion to ensure connection even in the case of one of the threads breaking. Figure 2 shows a cluster of studs wired together on the inside of the Nebula garment. To protect the wires and threads when it is worn, a removable lining is used that still permits access to the web of connections, if needed.

While there are studs of several shapes and colors placed on the garment's surface, they all fall into two categories of function: *active* and *receptive*. The wires from the receptive stud connect to the inputs of an *x-OSC* wireless I/O board (hereafter denoted x-OSC) [4]. The wires from the active studs are connected to the positive voltage potential output of the x-OSC. When an active stud touches a stud in a receptive cluster, an electrical connection is made, connecting the +5V output of the x-OSC to one of its analog inputs, resulting in detectable change in the input signal from low to high (Figure 3). Thus, data produced by interaction with the garment can be gathered and transmitted by the x-OSC. When the receptive studs are unconnected, an internal pull down resistor on the x-OSC ensures a zero reading at the analog input. The x-OSC itself and its battery are placed inside a fitted pocket on the inside of the garment.

The software of the Nebula garment is developed in the SuperCollider[1] programming language. It runs on a laptop, separate from the garment, receiving the digitized analog readings from the x-OSC in Open Sound Control format over WLAN at a sample rate of 40 Hz. The incoming data streams, each corresponding to a stud cluster connected to a physical input on the x-OSC, are sent to identical processing algorithms. The algorithm computes a measure of how much activity, i.e. positive incoming samples, is present in the stream. The response of the algorithm is such that the activity measure increases rapidly as soon as activity is present in the incoming signal, but decreases more slowly, even if all activity suddenly stops.

The resulting activity measures are then interpreted similarly to a spectrum or a two-dimensional-graph using cluster number on the x-axis and activity on the y-axis, on which a center-of-mass-calculation, or *centroid*-calculation is performed. This centroid value is called the *position*. The diagram in Figure 4 shows the relationship between activity measurements and the position calculation. This means that the amount of activity in each cluster of studs, as well as a measure of where on the garment the activity is taking place both influence the sound that the garment creates. Therefore, the Nebula transfers some of the qualities of the movements of the wearer, into the quality of the corresponding generated sounds.

Each cluster is represented by a separate sound generator in the software, controlled by the activity measure of the corresponding cluster. The outputs of the sound generators are mixed and sent to a multi effect processing stage that is controlled by the position value. Finally, the resulting signal is run through some commonly used finalizing audio effects, i.e., equalization, reverberation, and dynamics processing.

[1] http://supercollider.sourceforge.net

Figure 5: The design of the garment evokes images of star fields and nebulas.

Interaction

The garment has been used in many different ways, but the version that is currently being explored is a relatively low key form of interaction, that is intended to use the folding and flowing that is naturally occurring in the fabric while it is worn. The generated sounds make the wearer conscious and mindful of the subtleties in the motions of everyday activities. Once aware, the user can further play with the interaction, attempting more expressive or performance-like results. The garment is unisex, one-size, and can easily be worn over other clothes, so it is designed with an exhibition context in mind. Figure 5 shows the garment photographed in front of a black background, illustrating the aesthetic connections to star fields and nebulas.

Final Reflections

With the Nebula garment, the boundaries between everyday performativity and enactment [3] on the one hand, and artistic performances on the other, are questioned and explored. The way we chose to design both the aesthetics and interaction of Nebula after a series of design iterations was based on the simple enjoyment of wearing it and interacting with it. The garment lent itself equally for everyday settings as more theatrical approaches, and on-stage use is a promising next step of our investigations.

Designing the Nebula garment and probing it through a number of preliminary tests, led us to the following statement: Interactive fashion should be designed by considering the properties of interactive technologies and textiles in tandem. In the case of the Nebula garment, the specific fabric chosen, in relation to the type and amount of metal studs used, are crucial elements for both aesthetic and interactive qualities. Neither the fundamental aspects nor the finer details of the garment exist purely for the interactive function or as decoration: they are elements of *functional aesthetics*.

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