airMorphologies: A Wearable Device for Social Interaction in Air Polluted Environments

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Abstract
A facial mask, as part of the daily outfit for people living in an air polluted environment, has become a barrier for social interaction and self-expression. airMorphologies, a pneumatic wearable device, shapes our body language and the manner of social interaction. Controlled by users' voices, airMorpholgies allows two users to interact and express when they wear the shape-changing devices. By changing their appearance, users gain a novel way to communicate and socialize with their new body language and expressions.

Author Keywords
Embodied Interaction; Wearable Technology; Body Architecture; Soft Robotics.

CCS Concepts
•**Social and professional topics** → *User characteristics;*
•**Human-centered computing** → *Human computer interaction (HCI);* Interaction devices;

Introduction
Air pollution is a global issue. For residents in China, for example, masks have become a means of protecting one's personal health. As part of one's daily outfit, masks block our facial expression and inhibit social interaction. Wearing a mask changes the way we communicate. How can we

improve the quality of communication and expression when wearing masks?

As social beings, we use language to communicate. Currently, spoken language-based communications mainly fall into two categories: voice over air, and voice over internet protocol. The human voice, as a biometric authentication mechanism, is used in applications such as speech recognition and speaker verification. Computer interfaces that use a microphone are often built within hard plastics or metal materials, such as mobile phones or computers. How can we design a voice-activated communication device that is soft and comfortable?

The goal of this project is to alter our body language and our social interactions in the context of environmental pollution through a wearable device called airMorphologies. airMorphologies, a voice-activated pneumatic mask, is designed for improving our communication by using soft materials (such as silicon and fabric) and electronics (such as a microcontroller, microphones, and an air pump). With biomimicry design and a multi-layer method digital fabrication, the mask changes its shapes by inflating and deflating the silicon modules.

airMorphologies

airMorphologies consists of three parts: two morphing masks and a pneumatic control system (figure 1). The morphing masks are shape-changing wearable devices built with inflatable silicon modules (figure 2). They connect to the pneumatic control system by means of vinyl tubing. When a user wears the mask, they can control the shape of the mask through an embedded microphone. The control system receives a voice signal when the user speaks. It then tells the specific valve to let air inflate the mask of the user (figure 3). When two users wear morphing masks

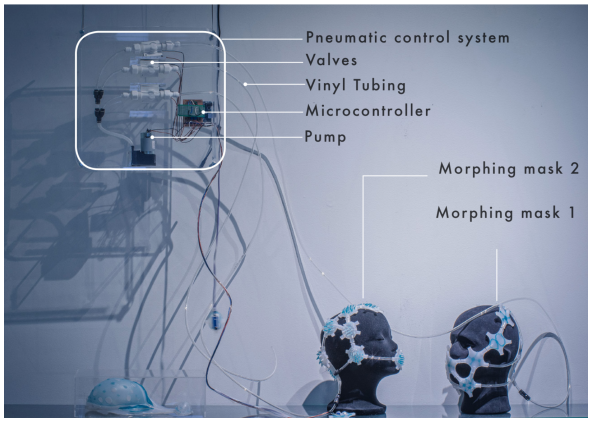

Figure 1: The components of airMorphologies

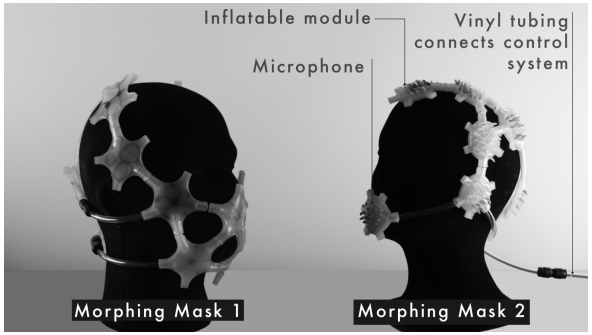

Figure 2: The details of the wearable devices

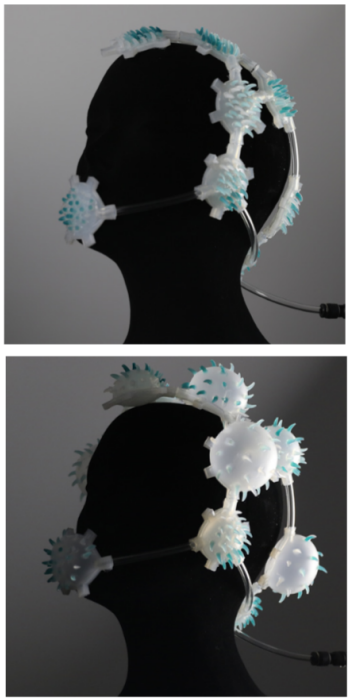

Figure 3: Appearance changing before and after inflating

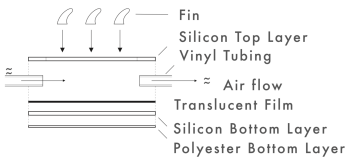

Figure 4: Multiple layers method

and speak, they not only can communicate through their voices but also through dynamic changes in the shape of their heads.

Expressive Design

The morphing mask, as part of the user's new body, offers a novel way to communicate, express, and interact with people. Inspired by nature, the design of the inflatable module is a biomimicry of pufferfish's skins. A high density of fins attached on the top of each inflatable module. When it is inflating, the silicon layer stretches and the density of the fins is reduced (figure 4, 6). The fins are blue and the silicon top layer is white. During the inflating process, the module transformed visually from a darker blue to a lighter blue. When the system is operating, the appearance of the morphing masks changes both physically and visually (figure 3). Figure 6 shows a single inflatable modular's appearance changing over time. This design of the morphing masks has an effective expression. With airMorpholgies, users will have engaging social interactions and expressive body languages through morphing masks. airMorphologies adds a new dimension of communication for people living in polluted environments.

System Desgin

The voice-activated pneumatic control system has two microphones for users' voices inputs and two solenoid valves for pneumatic outputs to inflate the masks (figure 1). The two outputs connect to two morphing masks using vinyl tubing. The two microphones wired from the masks to the microcontroller. An acrylic box contents all the electronics, including a microcomputer, solenoid valves, and an air pump.

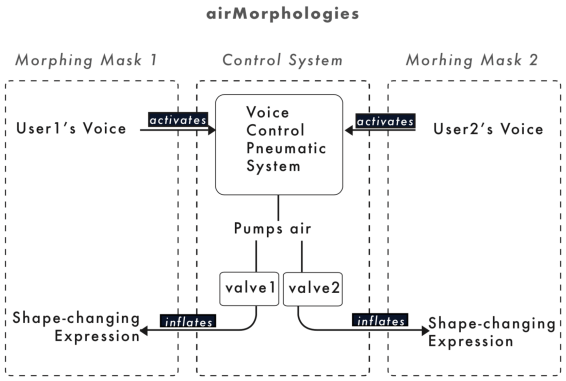

Figure 5: Human-computer Interaction Diagram

Fabrication Design

To create this expressive inflatable structure with soft material, I designed and fabricated a mechanism using a multilayer fabrication method (figure 4). A laser-cutted transparent film sits between two silicon layers. This provides a cavity for the air to come in and inflate the module. A polyester layer at the bottom of the module gives extra strengths, and helps to control the inflating direction. The polyester fabric, like our clothes, also provides comfortable wearing experience for the users. After many prototypes, I decided to use a modular design approach because of its flexibility and faster fabrication process. I designed a 3-dimension mold for the silicon layers with a 3D modeling software–Rhinoceros, then fabricated multiple modular molds with a 3D printer. To make sure the air can smoothly flow between every inflatable module, each module could have two to six connecting directions. Each connecting direction is the point where vinyl tubing is attached. This modular approach design fabrication provides great flexibility and wearability for the morphing masks.

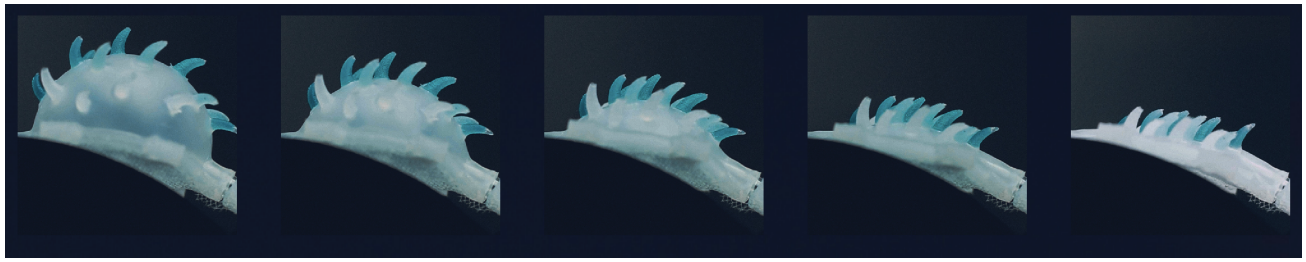

Figure 6: The evolution of shape changes

Conclusion

airMorphologies, a soft wearable device, provides a new dimension of social interaction and communication for people who are living in an air polluted environment and who need to wear masks. I described the operation of the devices in action. I demonstrated how the system works with two users and explained wearable designs and fabrication techniques. For future work, I would like to explore additional morphological designs and add environmental sensors.

Acknowledgments

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