Social Prosthesis: Social Interaction Through 3D Dynamic Makeup

Morgan Chen
Hybrid Body Lab, Cornell University
Ithaca, USA
mjc881@nyu.edu

Jingwen Zhu
Hybrid Body Lab, Cornell University
Ithaca, USA
jz497@cornell.edu

Hsin-Liu (Cindy) Kao
Hybrid Body Lab, Cornell University
Ithaca, USA
cindykao@cornell.edu

Figure 1: A model wearing the Social Prosthesis headpiece, nosepiece, and touch-sensing temporary tattoo. When the temporary tattoo is triggered through touch contact, the nose-piece starts curling in reaction.

ABSTRACT

Prosthetic makeup is the use of prosthetic materials for cosmetic or makeup effects to extend the skin and features. Commonly used to simulate wounds or exaggerate physical characteristics, prosthetic makeup is usually created for film or theatrical purposes, rather than for everyday fashion or social wearability. Social Prosthesis is a design project which aims to introduce interactivity, movement, and aesthetic within silicone prosthetics by providing design considerations and fabrication techniques unique to on-face wearables. Through opening up opportunities for cosmetic expression and storytelling through dynamic makeup, Social Prosthesis invokes the sociality of beauty—the change and movement that happens when we alter our appearances in contact with others.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

Media arts; wearables; prosthetic makeup; moving prosthetics; special effects makeup

UbiComp/ISWC '23 Adjunct , October 8–12, 2023, Cancun, Quintana Roo, Mexico

ACM ISBN 979-8-4007-0200-6/23/10.
https://doi.org/10.1145/3594739.3610783

ACM Reference Format:
Morgan Chen, Jingwen Zhu, and Hsin-Liu (Cindy) Kao. 2023. Social Prosthesis: Social Interaction Through 3D Dynamic Makeup. In *Adjunct Proceedings of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing (UbiComp/ISWC '23 Adjunct), October 8–12, 2023, Cancun, Quintana Roo, Mexico.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3594739.3610783

1 INTRODUCTION

Prosthetic makeup (also known as *special effects makeup*) is the use of prosthetic materials for cosmetic or makeup effects to extend the skin and features. Due to the small surface area and variance between an individual's features, facial prosthetic makeups are created by either being sculpted directly onto the skin or pre-modeled on a face cast to ensure fit before application and wear.

While most existing prosthetic makeups serve to add a 3D structural element to the face or body, they commonly are applied for film or theatrical purposes rather than for everyday fashion or social wearability. These types of prosthetics usually stay static on the skin once applied. Some special effects studios branch into puppetry and animatronics [12] in order to create moving characters, but these projects usually require funding for larger-scale electronic devices, studio space, and research and development time. Conversely, while current wearable technologies have been miniaturized for everyday fashion [6, 7], there is still a lack of facial wearables due to the aforementioned constraints of facial applications.

Social Prosthesis (Figure 1) was created as an artist residency project in the Hybrid Body Lab, where researchers merge makeup techniques and on-body miniaturized technology [7, 8]. In Social Prosthesis, 3D resin-printed structures suspend a molded and dyed cosmetic prosthetic "skin" on the face. When a capacitive touch sensor is triggered, an embedded shape memory alloy in the silicone contracts, causing the "skin" to curl and move. The shape of the prosthetic will be visibly altered, creating a new appearance or style through the movement (bunching) of the silicone.

The term "social prosthesis" is inspired by "Queer Cyborgs and New Mutants: Race, Sexuality and Prosthetic Sociality in Digital Space," a text which suggests that technologies enhancing the human body have social contexts that extend past the merging of biological and artificial [13]. Social Prosthesis invokes the sociality of beauty—the change and movement that happens when we alter our appearances in contact with others.

2 BACKGROUND AND RELATED WORK

Makeup has long been regarded as a powerful, transformative tool, and cosmetic use dates back to ancient civilizations [2]. Beyond everyday fashion and social expression purposes, makeup has been used for performance and theatrical purposes throughout the ages and is an essential tool for character building and communicating context through visual language [3].

Prosthetic makeup (also known as *special effects makeup*) is the use of prosthetic materials for cosmetic or makeup effects. While standard makeup practices such as paints, creams, or powders intentionally remain flat and appear "two-dimensional" on the skin, prosthetic makeups build new three-dimensional surfaces when adhered to the existing face and/or body. Common materials used in prosthetic makeup include latex, foam latex, silicone, and gelatin, and these materials are often colored and painted to look in conjunction with a model or character's existing skin and features. In this work, we utilized silicone, a common material in prosthetic makeup effects to achieve a three-dimensional, colorful on-face expression that is also compatible with interactive technologies.

Previous research in on-skin interfaces explores how interactive technologies can enable on-skin expressions in the format of makeup [4, 7, 15]. The concept of beauty technology [14] has been widely explored to computerize body surfaces. Beyond academic research, commercialized interactive makeup products have also been developed and well-perceived by the public. For example, fashion technology brand, Neon Cowboys, offers flashing LED shapes that can be adhered with eyelash glue on the face and activated with a clip-on battery pack[1]. These on-face interactions have further expanded the capability of makeup, but the format of actuation remains in more two-dimensional or optical changes, such as color-changing or light-emitting technologies.

Avant-garde fashion designers have been exploring novel materials for creating robotic garments or kinetic textiles to achieve dynamic movements on the human body. Work from fashion designer Ying Gao[2] explores how robotic garments can simulate organic body movements, and Iris Van Herpen[3] utilizes silicone in organic structure designs that create the illusion of movement as the wearer moves and walks. In Human-Computer Interaction (HCI) research, various actuators have been explored to achieve robotic wearables, including shape memory alloy (SMA) [9], mobile robots [5], and pneumatics [1, 16]. In this project, we explored how soft actuation can create dynamic, skin-like effects in an aesthetically intriguing 3D makeup design.

[1]https://neoncowboys.com/products/alien-led-face-jewelry
[2]http://yinggao.ca/
[3]https://www.irisvanherpen.com/

3 DESIGN

In this section, we report the three main steps of the design process: synthesizing on-face design considerations, exploring the design and aesthetics of dynamic makeups, as well as their fabrication and implementation.

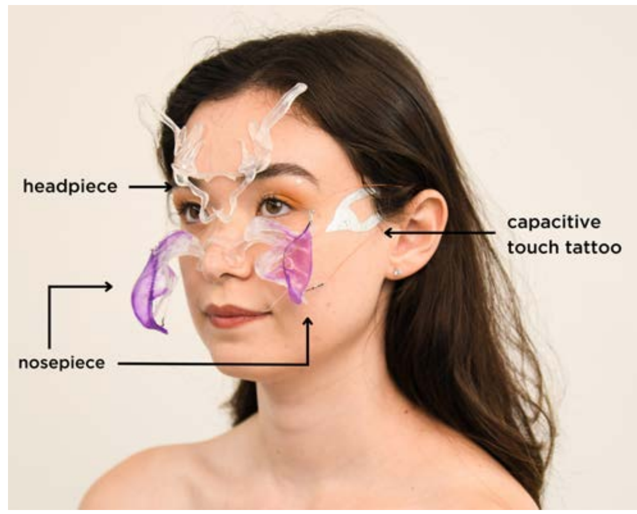

Figure 2: A model wearing the Social Prosthesis headpiece, nosepiece, and touch-sensing temporary tattoo. When the temporary tattoo is triggered through touch contact, the nosepiece starts curling in reaction.

3.1 On-Face Design Considerations

Compared to other wearable design form factors that are worn on common body locations such as wrist and shoulder, on-face designs for dynamic makeups have their unique design criteria to achieve wearability [11]. We synthesized the following on-face design considerations based on the primary author's prior practice as a makeup artist, and wear trials of several different on-face designs:

- Keeping the design light enough to not slip downwards or pull on the skin. Since the face is an upright surface, it is important to design prosthetics to be lightweight, so as not to drag on the skin or risk detachment from the face.
- Preventing the heat of the circuit from being placed directly on the sensitive skin of the face. In this case, we used the rigid resin nosepiece to suspend the casted shape memory alloy spring away from the face.
- Balancing around the human face's uneven plane and bone structures. In Social Prosthesis, the flatter surface area of the forehead and the bridge of the nose were chosen to be balance points to design around.
- Not obstructing regular facial movement, breathing, or vision.

- Hiding any parts of the circuit that could take attention away from the overall intended aesthetic.

3.2 Design and Aesthetics

While most prosthetic makeups are created to blend in and mimic existing human facial structures, the design intention behind Social Prosthesis was to create a dynamic makeup expression that suggests social interaction and inspires visual interest. Thus, while the design has "skin" and "bones" and is recognizably an organic form (drawing from the patterns in microbial cultures, insect antennae, and floral hues), it does not follow the existing features on the human face—it suggests new 3D forms and structures and compels you to look at it.

The design of Social Prosthesis is comprised of two rigid structures as the "bones": a headpiece and a nosepiece (Figure 2). The headpiece adheres to the center of the forehead, and the nosepiece adheres to the bridge of the nose. The nosepiece provides a structure for the soft actuator "skin", which will move once triggered by touch, providing "sociality" to the piece.

Aesthetically, we 3D sculpted and modeled the organic shapes and curves specifically designed for the face. The two facial pieces were designed separately so as not to obscure the eyes of the wearer, leaving it still a recognizably human face and form wearing the prosthetic. We identified resin printing as the fabrication approach to afford fine details in the design and casted silicone as the material for the soft actuators. Each of the fabrication techniques is paired with their corresponding coloring and finishing techniques synthesized from our iterative sampling process.

3.3 Fabrication and Implementation

3D Printing Resin Nosepiece: The prototype for Social Prosthesis was initially modeled in NomadSculpt and then cleaned up in Shapr3D. The headpiece and nosepiece were exported separately and scaled into PreForm to be printed with a Formlabs 3 resin printer in clear resin. Since these prosthetics and structures are designed for facial wear, Formlabs 3 was able to capture the intricacies and the delicate nature of the Social Prosthesis design on a small scale.

Silicone Casting with SMA: In order to create the silicone circuit on the nosepiece, we designed a 3D-printed reusable mold for the silicone casting by tracing the outline of the nosepiece to create a suitable fit. The result was a shallow, wing-like mold that could be flipped to work for either side of the nosepiece. Using the molds, we mixed and poured 8g of Part A and 8g of Part B of Ecoflex Near Clear 00-45. The shape memory alloy spring circuit was pre-stretched and cast into each mold before the silicone mixture was cured. We ensured that the spring was fully submerged in the silicone mixture to prevent tearing from the thin silicone. To mechanically attach the silicone-casted actuator to the resin-printed structure, we used sewing thread through small holes in the design of the resin nosepiece, as shown in Figure 3, to tie the silicone actuators to the resin structure without adhesive. This creates a firm attachment without hindering the silicone from moving freely.

Coloring Resin and Silicone: Since Social Prosthesis's design aims to explore expression past the typical usage of prosthetic makeup, we decided to utilize clear and transparent materials in order to augment the aesthetic appeal of the design. To create a variety of colorway options for the facial pieces, as shown in Figure 4, we used alcohol ink mixed with 99% isopropyl alcohol after printing. This post-production method allows for extra flexibility in color choices instead of producing pieces in the identical color of the resin cartridge. We coated the resin prints with Art Resin, a two-part epoxy that creates a high-shine gloss coat. To create a gradient in the silicone, we mixed a pinprick of purple silicone pigment into uncured EcoFlex Near Clear and then gradually added this colorful mixture to one side of the mold. The blended gradient in the silicone showcases the rigid structure underneath.

Figure 3: A 3D render and image of the nosepiece 3D design, with arrows pointing to the holes in the structure for securing the silicone.

Figure 4: A model wearing a red Social Prosthesis headpiece with a clear nosepiece to demonstrate the possibility of different colorways.

Attaching Control Circuit: Social Prosthesis was designed as an embedded shape memory alloy circuit that can be triggered with a touch-sensing temporary tattoo we created following the fabrication approach from literature [6]. As shown in Figure 5, the control circuit utilizes an SMA micro-spring (internal diameter:

0.5mm, Kellogg Research Labs, 45°C) to create an organic "bunching" effect in the silicone. We used an off-the-shelf ATSAMD21E18 microcontroller with a 2N2629 NPN transistor to read the capacitive touch-sensing input and drive the SMA micro-spring accordingly. A 3.7V, 350mAh LiPo battery powers the control circuit. When the touch sensor is activated, the SMA springs contract, creating a gentle ruffling movement in the silicone. To reset, the springs need to be manually stretched out to their original position.

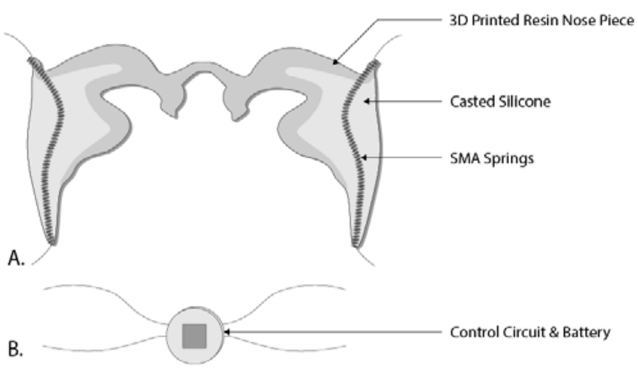

Figure 5: Circuit diagram of the Social Prosthesis headpiece front side (A) and back side (B).

On-Face Application: To apply Social Prostheis to the face, we used 3rd Degree Silicone (Alcone Company), a fast-curing two-part silicone modeling compound, to adhere the resin prosthetic to the face. 3rd Degree parts A and B were mixed and applied as a thick layer to the back of the prosthetic on the areas that contact the forehead. Then, the prosthetic was positioned on the face for five minutes as the 3rd Degree cured. For extra security, the nosepiece uses an elastic string to loop around the head. The circuit can be tucked over the ears and hidden behind the head or hair, as shown in Figure 1. Social Prosthesis was designed to balance and sit on the contours of the face and uses theatrical quality silicone adhesive meant for gluing prosthetics so that once adhered, the pieces will remain secure for at least two hours with normal movement and wear, and no extreme changes to body temperature or surroundings.

Figure 6: Application of the nosepiece and circuit.

4 DISCUSSION

This project emerged as a collaboration between an artist and a team of researchers within the unique setting of an artist residency in a research lab. Here, we reflect on the process of co-creating the artwork to shed light on fostering multidisciplinary collaborations.

The initial concept of this project originated from the artist's prior work in dynamic makeup, which sought to explore new possibilities for introducing interactive experiences into everyday makeup. During the residency, several skillshare activities were initiated between the artist and the lab, including researchers learning prosthetic makeup practice [10] and the artist learning miniaturized technologies in HCI wearable research. Together, we iteratively explored fabrication techniques and interactive elements, and finally, came to this 3D dynamic makeup mediating social interactions. We learned from the co-creation process that mutual skill and idea exchange fostered novel yet tangible artistic expressions. Unexpectedly, the creative collaboration was not divided by artistic creations or technical explorations. For instance, the researchers actively participated in discussions revolving around artistic exploration, while the artist lead in technical sampling and experimentation, showcasing the seamless integration of our expertise.

We believe that this form of collaboration offers a unique opportunity for HCI researchers to evaluate research outcomes from unique perspectives, thereby reimaging the relationship between human and computational technologies in artistic and expressive ways. Furthermore, we hope that this collaboration can provide artists with emerging tools that enable new creative possibilities.

5 CONCLUSION AND FUTURE WORK

Future iterations of the making process could include the use of more advanced 3D scanning techniques for a measured, custom-fit. This could also help speed up the design prototyping process, reducing the need for minute detail changes to be printed to test the fit and wearability of the headpieces on wearers. Additionally, while Social Prosthesis uses resin facial pieces as a structure to hold the silicone, there is more research area to be done on designing moving silicone circuits that adhere directly on the face.

Social Prosthesis is a starting point for further research on moving prosthetics and interactive makeup wearables. It anticipates the research potential of moving makeup and prosthetics and provides design considerations and fabrication strategies for those seeking to make facial wearables. Social Prosthesis's design and fabrication techniques also create unlimited design potential for on-face wearables, proposing the idea of social interaction and fashionable expression through dynamic makeup. Much like we wear fashion and technology as our social expressions and markers, Social Prosthesis aims to invoke the sociality of physical beauty—the change and movement that happens when we alter our appearances in contact with others.

ACKNOWLEDGMENTS

We would like to thank Andrea Cheon, Viola He, Darcy Rose and Anna Paaske for photography support, and Heather Kim and Pin-Sung Ku for their insights. This project was supported by the National Science Foundation under Grant IIS-2047249 and Cornell University College of Human Ecology Engaged Research Grant.

REFERENCES

[1] Lea Albaugh, Scott Hudson, and Lining Yao. 2019. Digital Fabrication of Soft Actuated Objects by Machine Knitting. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. ACM, New York, NY, USA, 1–13. https://doi.org/10.1145/3290605.3300414

[2] Maggie Angeloglou. 1970. *A history of make-up.* Macmillan, New York, USA.

[3] Richard Corson. 1990. *Stage Makeup.* Allyn & Bacon, Incorporated, Boston, Massachusetts, USA.

[4] Christine Dierk, Sarah Sterman, Molly Jane Pearce Nicholas, and Eric Paulos. 2018. HäirIÖ: Human Hair as Interactive Material. In *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '18)*. Association for Computing Machinery, New York, NY, USA, 148–157. https://doi.org/10.1145/3173225.3173232

[5] Hsin-Liu (Cindy) Kao, Deborah Ajilo, Oksana Anilionyte, Artem Dementyev, Inrak Choi, Sean Follmer, and Chris Schmandt. 2017. Exploring Interactions and Perceptions of Kinetic Wearables. In *Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17)*. Association for Computing Machinery, New York, NY, USA, 391–396. https://doi.org/10.1145/3064663.3064686

[6] Hsin-Liu (Cindy) Kao, Christian Holz, Asta Roseway, Andres Calvo, and Chris Schmandt. 2016. DuoSkin: Rapidly Prototyping on-Skin User Interfaces Using Skin-Friendly Materials. In *Proceedings of the 2016 ACM International Symposium on Wearable Computers (ISWC '16)*. ACM, Heidelberg, Germany, 16–23. https://doi.org/10.1145/2971763.2971777

[7] Hsin-Liu (Cindy) Kao, Manisha Mohan, Chris Schmandt, Joseph A. Paradiso, and Katia Vega. 2016. ChromoSkin: Towards Interactive Cosmetics Using Thermochromic Pigments. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, San Jose California USA, 3703–3706. https://doi.org/10.1145/2851581.2890270

[8] Hsin-Liu (Cindy) Kao, Bichlien Nguyen, Asta Roseway, and Michael Dickey. 2017. EarthTones: Chemical Sensing Powders to Detect and Display Environmental Hazards through Color Variation. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17)*. ACM, Denver, CO, USA, 872–883. https://doi.org/10.1145/3027063.3052754

[9] Jin Hee (Heather) Kim, Kunpeng Huang, Simone White, Melissa Conroy, and Cindy Hsin-Liu Kao. 2021. KnitDermis: Fabricating Tactile On-Body Interfaces Through Machine Knitting. In *Designing Interactive Systems Conference 2021 (DIS '21)*. ACM, New York, NY, USA, 1183–1200. https://doi.org/10.1145/3461778.3462007

[10] Pin-Sung Ku, Kunpeng Huang, Nancy Wang, Boaz Ng, Alicia Chu, and Hsin-Liu Cindy Kao. 2023. SkinLink: On-body Construction and Prototyping of Reconfigurable Epidermal Interfaces. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 7, 2 (June 2023), 62:1–62:27. https://doi.org/10.1145/3596241

[11] Xin Liu, Katia Vega, Pattie Maes, and Joe A. Paradiso. 2016. Wearability Factors for Skin Interfaces. In *Proceedings of the 7th Augmented Human International Conference 2016 (AH '16)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/2875194.2875248

[12] Stefan Marti and Chris Schmandt. 2005. Physical Embodiments for Mobile Communication Agents. In *Proceedings of the 18th Annual ACM Symposium on User Interface Software and Technology* (Seattle, WA, USA) *(UIST '05)*. Association for Computing Machinery, New York, NY, USA, 231–240. https://doi.org/10.1145/1095034.1095073

[13] Mimi Nguyen. 2003. *Queer Cyborgs and New Mutants: Race, Sexuality and Prosthetic Sociality in Digital Space.* Routledge Taylor & Francis Group, New York, USA. 281–305 pages. https://doi.org/10.4324/9780203957349

[14] Katia Vega and Hugo Fuks. 2014. Beauty Technology: Body Surface Computing. *Computer* 47, 4 (April 2014), 71–75. https://doi.org/10.1109/MC.2014.81

[15] Sijia Wang, Cathy Mengying Fang, Yiyao Yang, Kexin Lu, Maria Vlachostergiou, and Lining Yao. 2022. Morphace: An Integrated Approach for Designing Customizable and Transformative Facial Prosthetic Makeup. In *Proceedings of the Augmented Humans International Conference 2022* (Kashiwa, Chiba, Japan) *(AHs '22)*. Association for Computing Machinery, New York, NY, USA, 58–67. https://doi.org/10.1145/3519391.3519406

[16] Lining Yao, Ryuma Niiyama, Jifei Ou, Sean Follmer, Clark Della Silva, and Hiroshi Ishii. 2013. PneUI: Pneumatically Actuated Soft Composite Materials for Shape Changing Interfaces. In *Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology (UIST '13)*. Association for Computing Machinery, New York, NY, USA, 13–22. https://doi.org/10.1145/2501988.2502037