Flytrap Hand: Towards Understanding Dark Patterns of Physical Augmentation via Electrical Muscle Stimulation

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ABSTRACT

Physical augmentation offers opportunities to enhance human abilities, yet these systems can also embed dark patterns that deceive users in ways that are against their best interests. To explore these dark patterns, we developed Flytrap Hand, a system that employs electrical muscle stimulation to automate grasping and releasing actions. While the system enhances grasping speed and reduces physical effort, it also exposes dark patterns in physical augmentation, such as manipulating users through involuntary hand movements and imposing forced control, which diminishes user agency. Ultimately, we hope that our work can deepen the understanding of dark patterns and support practitioners in mitigating these issues within physical augmentation technologies.

CCS CONCEPTS

• **Human-centered computing → Interaction paradigms**.

KEYWORDS

electrical muscle stimulation, wearables, human augmentation, dark patterns

ACM Reference Format:
Siyi Liu, Barrett Ens, Nathan Semertzidis, Gun A. Lee, Florian 'Floyd' Mueller, and Don Samitha Elvitigala. 2025. Flytrap Hand: Towards Understanding Dark Patterns of Physical Augmentation via Electrical Muscle Stimulation. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25), April 26-May 1, 2025, Yokohama, Japan.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3706599.3721344

1 INTRODUCTION

Physical augmentation, a sub-category of human augmentation, aims to enhance human physical capabilities beyond natural limits [2, 14]. From robotic limbs to wearable devices, physical augmentation technologies incorporate sensory feedback, such as vibration, visual, and force feedback, to enhance user-environment interaction [10, 14, 18]. These technologies can change everyday activities and professional practices by reducing physical strain and overcoming biological limitations.

However, integrating technologies into human function comes at a cost [4, 11]. While users may benefit from augmented capabilities such as speed or strength, they also face a trade-off: sacrificing a sense of control over their actions. When functionality or automation is prioritized over user agency, these systems can create experiences that feel manipulative, coercive, or disconnected from the user's intentions, introducing "dark patterns" - designs intentionally crafted to manipulate user behavior against their best interests [6, 7, 12]. While dark patterns have been studied in digital interfaces [3, 7, 19], their presence in physical augmentation technologies has received limited attention. Physical augmentation systems, which directly interface with the body, can amplify the impact of dark patterns, making users feel out of control, intentionality subverted and disconnected from their actions. To further our understanding of dark patterns of physical augmentation, We created "Flytrap Hand" that automates grasping and releasing actions through electrical muscle stimulation (EMS), as prior work has demonstrated that EMS can be used to increase speed [8, 9] and automate movements [5, 13, 20]. While the system enhances physical performance, it can also lead to unpredictable side effects, such as involuntary hand movements, thus impeding hand function and affecting daily activities.

2 FLYTRAP HAND

Flytrap Hand is a glove embedded with a time of flight distance sensor [1] and a flex sensor [15], connected to the SparkFun RedBoard [16] and controlling a dual-channel EMS device (Comfy EMS [17]) via relay switches to produce a safe, adjustable waveform for controlled electrical stimulation delivery to the user. The distance sensor detects the distance between objects and the hand, and the flex sensor measures the bending angle of the little finger. Two rectangle EMS electrode pads (4cm x 2cm) are attached to lumbrical muscles (palmar side) and dorsal interosseous muscle (dorsal side)

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CHI EA '25, April 26-May 1, 2025, Yokohama, Japan
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ACM ISBN 979-8-4007-1395-8/2025/04
https://doi.org/10.1145/3706599.3721344

between the second digit and third digit to flex fingers to generate a close-hand gesture. Another two square EMS electrode pads (4cm x 4cm) are placed around the extensor carpi ulnaris muscle and extensor digitorum muscle to stretch the wrist and fingers to produce an open-hand gesture. When the user's hand approaches an object but not yet holding any object, the system detects it and triggers the EMS to stimulate the hand muscles so that the hand would automatically grasp the object.

To explore how varying levels of user control affect user experience and agency perception, two distinct release mechanisms were implemented: 1) randomized time control, where the grasp is released after a random amount of time (3 to 10s) duration, and 2) body control, where users intentionally release objects by lifting their little fingers. In randomized time control, users have no direct control over their automatic and involuntary movements, which may reduce their sense of agency and lead to a sense of bodily detachment. In body control, users gain control to release an object but through an unfamiliar gesture, potentially causing discomfort and interaction challenges. The system interfered with the user's activities by limiting personal control over basic actions, prompting the user to experience discomfort and interactive challenges. This design method helps designers understand the implications of losing control, thus providing valuable insights into design choices for future augmentation technology development.

3 CONCLUSION

In this paper, we present Flytrap Hand, a system that uses EMS to automate grasping and releasing actions, aiming to explore physical augmentation design through the lens of dark patterns, considering both positive and negative effects. While Flytrap Hand improved physical accuracy and reduced physical exertion, it also increased cognition load, decreased user trust and reduced the sense of agency, which highlights the ethical and experiential challenges of designing physical augmentation systems. Ultimately, we hope that our work can deepen the understanding of dark patterns and support practitioners in mitigating these issues within physical augmentation technologies.

ACKNOWLEDGMENTS

Florian 'Floyd' Mueller acknowledges the support from the Australian Research Council, especially DP190102068, DP200102612 and LP210200656. We thank those participants who agreed to be featured in the photographic material included in this publication. We also thank the Exertion Games Lab for the feedback and support they contributed toward the project.

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