EEG Controlled Robotics
(Technical Paper)

Digital Privacy on American Heterosexual Women's Sexual Bodily Autonomy
(STS Paper)

A Thesis Prospectus
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By
Cayla Celis

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Technical Team Members:
Hailey Boyd
Abigail Dodd
Joshua Rivas-Zelaya

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Prof. Coleen Carrigan, Department of Engineering and Society

Prof. Michael Momot, Department of Mechanical and Aerospace Engineering

Prof. Sarah Sun, Department of Mechanical and Aerospace Engineering

Introduction

Bodily autonomy is inherently and implicitly an American concept since the beginnings of the United States, from when Thomas Jefferson wrote the Declaration of Independence, stating that people have the right to life, liberty, and the pursuit of happiness; people should be free to live the way they want, including the freedom to dictate what happens to their own body. But after centuries of technological advancement within and outside of the United States, have we actually allowed people, particularly minorities in the U.S., to exercise this freedom?

In this paper I aim to discuss the concept of bodily autonomy and my efforts to promote and analyze this concept through my technical project and my STS case study respectively. My technical project, in a broad sense, focuses on how we can use personal data to enable bodily autonomy for people who cannot move how they want to due to neurodisabilities. More specifically, my technical project will use reinforcement learning algorithms to enable bodily autonomy. My STS case study, in a broad sense, will use the STS frameworks commodity chain analysis and politics of knowledge to examine the consequences and ethics of gathering personal data/user data even if it is used primarily to create more popular products. My STS research question is the following: How do technological advancements as seen in Bluetooth-connected and/or WiFi-utilizing sex toys affect American heterosexual women's sexual bodily autonomy and privacy? Both of these projects discuss privacy and bodily autonomy as well as how they are connected, especially with minorities in the United States.

Socio-Technical Problem

To examine how digital privacy affects American heterosexual women's sexual bodily autonomy, I will explore one case study that exposes one sex toy company's egregious data collection practices, how they relate to previous American court case precedents, and what this could mean for future technological development.

Case Study

Between August 4 and August 7, 2016 two hackers, follower and goldfisk, hosted a presentation during DefCon 24 discussing how they hacked into a "We-Vibe", or a vibrator used for sexual purposes (Hern, 2016). This vibrator can be connected to smartphones via Bluetooth through a mobile application so that users can control how fast and how often it vibrates (Domonoske, 2017). Follower and goldfisk found that this mobile application, when the We-Vibe is used, communicates what the We-Vibe's temperature is "every minute" to Standard Innovation, the manufacturer responsible for producing We-Vibe, as well as communicating to it "every time the intensity of the vibration changes" (Hern, 2016). The hackers also criticized the company's vague private policy (Hern, 2016). Standard Innovation responded to the presentation through a statement. This statement defended the need to collect this information by stating that this information is used to "understand what settings and levels of intensity are most enjoyed" with "CPU temperature data" being taken only for "hardware diagnostic purposes" rather than location and mentioning that while it has said that they "may collect data", they will go over the policy in order to "provide more transparency" to users (Hern, 2016). Within a month an anonymous American woman who bought a "We-Vibe" in May 2016 initiated a class-action lawsuit for these privacy violations (Domonoske, 2017).

Understanding the Case Study

For this study I aim to understand it through two STS frameworks, commodity chain analysis and politics of knowledge, and how they interact. Both of these frameworks will be based primarily on my understanding of Birch's concept of automated neoliberalism, where personal user data is essentially currency in the modern world and companies are given the power to view and exchange personal user data with each other (Birch, 2020). Overall Birch's knowledge and familiarity with neoliberalism and its interactions with technology will be immensely helpful in understanding the technoscientific capitalism that allows automated neoliberalism to take place and therefore allows sex toy companies to under-prioritize user digital privacy (Birch, 2020). Birch's understanding of automated neoliberalism can be further supported by Wilson-Barnao & Collie's understanding of how human bodies are reduced into things that can be observed and probed for personal data by sex toy companies in order to satisfy a wide range of consumers with their products and thereby profit off consumer private behavior (Wilson-Barnao & Collie, 2018). While some of Wilson-Barnao & Collie's (2018) article discusses topics interesting but irrelevant to this project such as the Australian adult entertainment industry, they nevertheless highlight the application of automated neoliberalism on sex toy company operations. Additional articles such as one by Sundén discussing sex toy privacy breaches and privacy in general will be taken into account (Sundén, 2023). This article is valuable in that Sundén discusses how digital sex toys disrupt the notion that sex is solely a property in the private sphere in society and sex and therefore can give insights on the social consequences of sex toy companies having such personal user data. Ospiva et. al (2024) further discuss this by focusing on one sex toy company, KIIROO, and their products' lack of privacy.

Finally, Huq & Wexler (2023) emphasize the importance of protecting digital privacy after the overturning of Roe v. Wade and is an important application of this case study's topic.

Incorporating Lessons Learned in Future Related Engineering Projects

For future engineering projects to succeed in enabling both bodily autonomy and privacy, engineers should not conflate the act of refusing personal data being collected with the user being guilty of something unfavorable to them. To minimize harm, engineers should prioritize user agency regardless of whether users refuse data collection or not. My further work will better detail how we can prioritize user agency by using the articles written by Benjamin (2016), which discuss minorities' interactions with informed refusal in four case studies, and Zong & Matias (2023), which discuss how engineers can incorporate informed refusal in designs, to create solutions with the STS frameworks discussed previously.

Technical Project

Technical Problem

Neuromuscular disorders, or conditions that affect the performance of the musculoskeletal system and/or the nervous system, can be debilitating due to the lack of medicinal options those affected have in completely curing them (Zare & Sun, 2024). Because of this, people afflicted with neuromuscular disorders are often treated using rehabilitation technologies (Zare & Sun, 2024). There has been promise with technologies that use brain-computer interface (BCI) to allow users to move and control their motions more independently, specifically using electroencephalography (EEG) as a non-invasive method to probe into a patient's motor intentions and machine learning supplementing these EEGs to more quickly classify said users' intentions (Zare & Sun, 2024). Keeping this context in mind, my technical project will explore how EEG BCI technology can become more efficient and more accurate with identifying intentions so that users can move with one degree of freedom on one arm.

Existing Designs

There have been previous projects exploring this side of rehabilitation. For instance Shamsie (2023) worked on creating a light upper body exoskeleton consisting of stepper motors, a battery, and Raspberry Pi that used EEG through a headset of electrodes to read brain electrical signals; this EEG used filters and Convolutional Neural Network (CNN) layers to process data. While Shamsie (2023) was able to achieve much accuracy while training the necessary algorithms, Shamsie had varying rates of success when testing the programs — some accuracy rates were as low as 40%. While my team and I will use essentially the same physical set-up as Shamsie since we all have or have had Dr. Sun as a technical project advisor, my team and I

would like to explore altering Shamsie's algorithms in hopes of stabilizing and increasing testing accuracy rates. Zare & Sun (2024) seemed to experience more success than Shamsie (2023) in their experiment as they saw an average accuracy rate of 75.3% using an CNN model to extract features from images and supplemented this process with a transformer encoder in order to remove noise from the EEG signals; however, they saw variations in accuracy like Shamsie. In addition to CNNs, we also looked into implementing reinforcement learning algorithms, which is where the machine teaches itself sequentially how to accomplish a task "based on the penalties and rewards it receives in order to decide on its next step action" (Sanei & Chambers, 2021). We were also interested in Zhang et al.'s (2024) work on how they incorporated reinforcement learning algorithms with EEGs. Based on this research, my team and I have decided to use a two-step filtering process to filter unwanted noise in electrical signals captured by the EEG headset as discussed below.

Overall Proposed Project Design

My team and I propose that to solve this technical problem, we will need to implement a Deep Q-Learning algorithm, which is a type of reinforcement learning algorithm that uses both Q-Learning algorithms and Neural Networks (Johnny Code, 2023). These algorithms will work together in order for the EEG headset to better identify the user's intentions without being overwhelmed by possible frequency noise.

How the algorithm will work can be seen in the two figures below. Figure 1. details how we will initially filter the raw EEG signals from a user, while Figure 2. details how we will implement Deep Q-Learning.

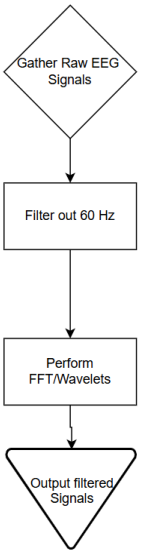

Figure 1. Filtering Flow Chart

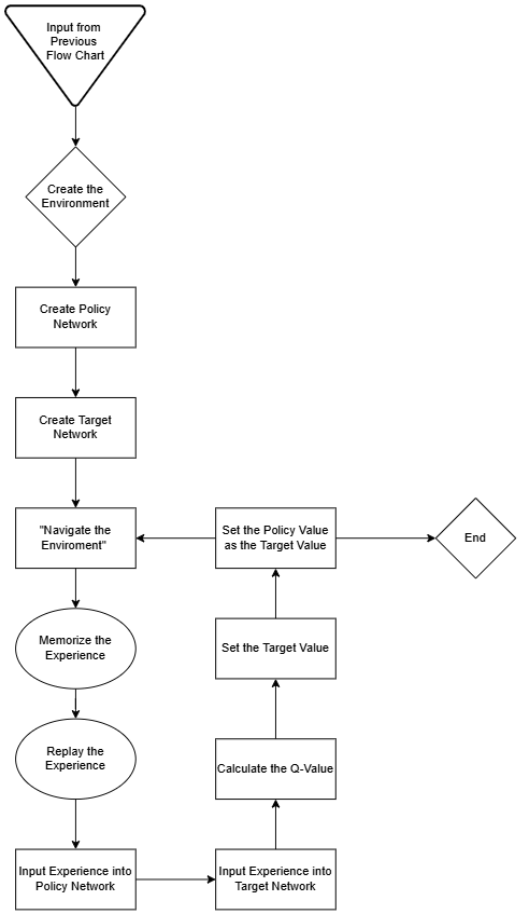

Figure 2. Deep Q-Learning Flow Chart, which depicts the functionality of our program.

Project Development & Testing Methods

My team and I plan to start coding development by the end of December 2024 and finish initial coding by February 2025. Assembly of the EEG headset will be completed by the end of January 2025. We will then test the code by using the technology on at least ten different participants at least three different times and finish by the end of March 2025 to then make adjustments by the end of April 2025. Testing may be delayed due to needing certification by the Institutional Review Board (IRB) to test on human subjects, although our advisor advised us to wait until our code is fully functional before testing and pursuing IRB certification.

Conclusion

The United States was founded on the concept of bodily autonomy, as Thomas Jefferson made sure to include in the Declaration of Independence. Over the course of three centuries, the United States has had multiple challenges to its preservation of bodily autonomy such as the overturning of Roe v. Wade and the technological development that has happened in between. This socio-technical challenge of enabling bodily autonomy in the digital age will be explored with my technical and STS research projects. My technical project will allow bodily autonomy by ensuring arm movement through EEG technologies and various machine learning algorithms with an accuracy rate greater than 80%. This accuracy rate will be ensured by meticulous testing and development strategies. My STS research project will explore how bodily autonomy, specifically sexual bodily autonomy, is enabled or not enabled based on the authorities monitoring sex toy usage. With this focus in mind, I aim to explore how bodily autonomy can be established through competent technologies while also allowing users to have digital privacy. Both of these technical and STS research projects will allow future engineering projects to

perform efficiently, ethically, and with consideration of the social factors that impact our technology today.

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