Undergraduate Thesis Prospectus

3D Printed Rehabilitation Robotic Exoskeleton

(technical research project in Mechanical Engineering)

The Struggle for Control of User Data

(sociotechnical research project)

by

Samantha Nicholson

October 27, 2022

technical project collaborators:
Joel Valentin
Abigail Kong
Alex Parson
Caleb Jung
Carly Thurman
Madison DePierro

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.
Samantha Nicholson

Technical Advisor: Dr. Sarah Sun, Department of Mechanical Engineering
STS advisor: Peter Norton, Department of Engineering and Society

General Research Problem

How can technology better serve human wellbeing?

Technology can empower its users, for example by restoring capacities to persons with disabilities. Yet it can also compromise personal autonomy, for example by fostering behavioral addictions in the form of compulsive social media engagement. Excessive engagement with digital media can impair wellbeing (Anderson & Rainie, 2018). Website design can influence user behavior, either to promote or to prevent compulsive use (Binns, 2014).

3D Printed Rehabilitation Robotic Exoskeleton

What robotic exoskeleton design best aids users with limited mobility in their rehabilitation?

My capstone advisor is Sarah Sun in the Mechanical Engineering department. This capstone project is for MAE 4610. My team consists of Joel Valentin, Abigail Kong, Alex Parson, Caleb Jung, Carly Thurman, and Madison DePierro.

Our team seeks to build an inexpensive wearable robotic exoskeleton for stroke rehabilitation patients. According to the American Heart Association, about every 40 seconds a person in the US has a stroke (American Heart Association, 2022). Oujamaa et al. (2009) concluded that post stroke, early motor function takes at least 25 hours to improve. Lean tissue mass (including muscle) loss is significant in paretic limbs after stroke (English et al., 2010). Despite the cause and effect relationship between strokes and muscle loss, the fact is that researchers have concluded that there is a low patient adherence to follow-up guidelines following stroke (Pedersen et al., 2018). Knowing this our exoskeleton design will aim to factor in the end user by being open source and operable at home.

Our project will use a combination of soft pneumatic actuators and motors to operate a preprogramed upper-body exoskeleton through selective therapeutic stretches. The exoskeleton must be heavy enough to support a patients arm under however light enough that it does not induce pain on the wearer. The exoskeleton must also produce repeatable results across exercises in order to provide a relative standard of care.

Most modern upper-body exoskeletons are large and clunky with more than 4 degrees of freedom. While they may have 7 degrees of freedom, they can struggle to achieve joint specific therapy (Shen et al., 2018). They also may require patients to travel to the device. Knowing there is a low patient adherence to follow up visits after strokes, having a portable exoskeleton that maintains the ability to travel to or with the patient may increase its usage. By narrowing degrees of freedom to 2-4, this increases the capability of joint specific therapy.

The Denvait-Hartenberg Convention (DH) will allow us to examine the kinematics of a multiple degree of freedom system (Denavit & Hartenberg, 1955). Using DH equations, we can understand the exoskeletons position and orientation of the arm. Possible signal inputs from will come from inertial measurement unit (IMU) or electromyography (EMG) sensors, allowing our group the option to program specific feedback control. IMU sensors will allow for measurement of the orientation of the exoskeleton. EMG sensors will allow us to measure small electrical signals from the muscles and appropriately operate the exoskeleton based off the user input. By focusing on approximately 4 degrees of freedom specifically concerning the shoulder and the elbow, we may be able to better target specific joint therapy motions. Using 3D printing for our design allows for an open source and lightweight design while undergoing rapid prototyping. This will produce multiple prototypes to be tested and modified for the various constraints

mentioned earlier. The end product should be an open source design that is lightweight, cost effective, and produces a repeatable therapeutic motion for patient rehabilitation.

The Struggle for Control of User Data

In the U.S., how are privacy advocates and data collectors competing to influence digital data privacy standards?

Digital data is collected to track and influence Americans daily. The 1986 Electronic Communications Privacy Act (ECPA) offers some online privacy protections, but civil libertarians contend it is outdated (Calabrese, 2010). Large tech corporations have had unlimited access to personal data for decades. Privacy advocates have been seeking stricter regulatory standards.

The American Innovation and Choice Online Act (AICOA), a bill now before the U.S. Senate, would prohibit online platforms from promoting their own products by excluding competitors or by applying their terms of service selectively. The bill would restrict some uses of nonpublic data generated on the platform and grant competitors' access to the data (S.2992, 2022). Senator Dick Durbin, a cosponsor of the bill, said in October 2021, "Choice is fundamental to competition. American consumers have been systematically denied access to critical information about their market choices. This new bill will fight strong arm tactics used by Big Tech to disadvantage their consumers and exclude competitors from the marketplace" (Klobuchar, 2021).

Several privacy advocates are involved. Fight for the Future, an advocacy, led the 2012 Internet Blackout to protest the Stop Online Piracy Act (SOPA) and the Protect IP Act (PIPA) (Sheehan, 2017). These bills were backed by Hollywood with the goal of censoring websites

under accusations of copyright infringement. Fight for the Future claims s.2992 (AICOA) could impose proper changes that would begin to release us from "Big Tech domination" (Fight for the Future, 2022). Electronic Frontier Foundation (EFF) is a nonprofit advocating for online civil liberties. EFF uses litigation to protect data privacy. Through its "Cover Your Tracks" website, users can access their 'digital fingerprint' and learn how to secure their data (EFF, n.d.). American Civil Liberties Union (ACLU), an advocacy, publicizes data collection practices and means of limiting them. It warns that the U.S. has no national privacy policy, and that corporations with use legal jargon to ensure company access to use your data (Stanley, 2019).

Trade associations protect corporations' access to user data. The members of the Chamber of Progress include Amazon, Apple, Google, Meta (formerly Facebook) and Twitter. It characterizes itself as "a new center-left tech industry policy coalition promoting technology's progressive future," asserting that "voters do not prioritize tech regulation as a public policy issue (Chamber of Progress, 2022b). Chamber of Progress Claims AICOA would prevent social media platforms from removing hate speech (Chamber of Progress, 2022a). The American Economic Liberties Project opposes monopolistic corporations. It's executive director, Sarah Miller, contends that the Chamber of Progress is an astroturfed group "intended to head off policymakers' effort to break up these companies" (Friedman, 2021).

Researchers have stressed the importance of data protection. Drummond et al. (2015) concluded that because most email services collect data for targeted advertising, they put HIPPA patient data at moderate to high risk. Using a software plugin called policyxray, Libert (2018) studied the privacy policies for their third-party data tracking standards. He found that to read a privacy policy through, users need an average of 84.7 minutes, excluding time for locating the policy and for rereading segments of it, and concluded that the typical notice and choice policy

fails to reasonably notify consumers of what they are agreeing to (Libert, 2018). In a study of data in politics, Howard (2005) found that politicians use them to target ads and lobbyists use them as polling data. Contending that internet access is a human right derived from rights of expression and to information, Mathiesen (2014) proposes a "Declaration of Digital Rights" to protect users.

References

AHA (2022). American Heart Association, Council on Epidemiology, Prevention Statistics Committee, Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics: 2022 Update. *Circulation*, *145*(8), e153–e639. doi.org/10.1161/CIR.0000000000001052

Anderson, J., & Rainie, L. (2018, April 17). The Future of Well-Being in a Tech-Saturated World. Pew Research Center: Internet, Science & Tech. www.pewresearch.org/internet/2018/04/17/the-future-of-well-being-in-a-tech-saturated-world

Binns, A. (2014). Twitter City and Facebook Village: Teenage girls' personas and experiences influenced by choice architecture in social networking sites. *Journal of Media Practice, 15*(2), 71–91. doi.org/10.1080/14682753.2014.960763

Calabrese, C. (2010, March 30). Electronic Privacy Law is Older Than the World Wide Web—It's Time for An Upgrade | News & Commentary. American Civil Liberties Union. www.aclu.org/news/national-security/electronic-privacy-law-older-world-wide-web-its-time-upgrade

Chamber of Progress. (2022a, Aug. 26). Why Are Some Democrats Standing with Senator Ted Cruz in Support of the American Innovation and Choice Online Act and Open App Markets Act?. progresschamber.org/why-are-some-democrats-standing-with-ted-cruz-in-support-of-aicoa-and-oama%ef%bf%bc

Chamber of Progress. (2022b, June 16). How voters think about antitrust policy. progresschamber.org/what-voters-think-antitrust-policy/#/m/NY

Denavit, J., & Hartenberg, R. S. (1955). A Kinematic Notation for Lower-Pair Mechanisms Based on Matrices. *Journal of Applied Mechanics*, *22*(2), 215–221. doi.org/10.1115/1.4011045

Drummond, A., Cromarty, P., & Battersby, M. (2015). Privacy in the digital age: Implications for clinical practice. *Clinical Psychology: Science and Practice*, *22*(3), 227–237. doi.org/10.1111/cpsp.12105, EBSCOhost

EFF (n.d.). Electronic Frontier Foundation. How do Trackers Work? Cover Your Tracks. coveryourtracks.eff.org/learn

English, McLennan, Thoirs, Coates, & Bernhardt, (2010). Loss of Skeletal Muscle Mass after Stroke: A Systematic Review. *International Journal of Stroke*, *5*(5), 395–402. doi.org/10.1111/j.1747-4949.2010.00467.x

Fight for the Future. (2022, June 7). Why we're dropping everything to go all in on antitrust. www.fightforthefuture.org/news/2022-06-07-all-in-on-antitrust

Friedman, D. (2021, April 9). An ex-Google lobbyist who backed Jim Jordan is leading Big Tech's bid to court the left. *Mother Jones*. www.motherjones.com/politics/2021/04/chamber-of-progress-google-facebook-amazon-twitter/

Howard, P. (2005). Deep Democracy, Thin Citizenship: The Impact of Digital Media in Political Campaign Strategy. *The Annals of the American Academy of Political and Social Science, 597*, 153–170., JSTOR

Klobuchar, A. (2021, Oct. 14). Klobuchar, Grassley, Colleagues to Introduce Bipartisan Legislation to Rein in Big Tech. U.S. Senator Amy Klobuchar (press release). www.klobuchar.senate.gov/public/index.cfm/2021/10/klobuchar-grassley-colleagues-to-introduce-bipartisan-legislation-to-rein-in-big-tech

Libert, T. (2018). An Automated Approach to Auditing Disclosure of Third-Party Data Collection in Website Privacy Policies. *Proceedings of the 2018 World Wide Web Conference*, 207–216. doi.org/10.1145/3178876.3186087

Mathiesen, K. (2014, Jan.). Human Rights for the Digital Age. *Journal of Mass Media Ethics, 29*(1), 2–18. doi.org/10.1080/08900523.2014.863124, Taylor & Francis Online

Oujamaa, Relave, Froger, Mottet, & Pelissier. (2009). Rehabilitation of arm function after stroke. Literature review. *Annals of Physical and Rehabilitation Medicine, 52*(3), 269–293. doi.org/10.1016/j.rehab.2008.10.003

Pedersen, R. A., Petursson, H., & Hetlevik, I. (2018). Stroke follow-up in primary care: A prospective cohort study on guideline adherence. *BMC Family Practice, 19*(1), 179. doi.org/10.1186/s12875-018-0872-9

S.2992— 117th Congress (2021-2022): American Innovation and Choice Online Act. (2022, March 2). www.congress.gov/bill/117th-congress/senate-bill/2992

Sheehan, K. M. (2017, Jan. 18). Five Years Ago, Internet Users Showed Their Political Might. And They Will Do It Again. *Slate*. slate.com/technology/2017/01/the-fifth-anniversary-of-the-sopa-pipa-protest-internet-blackout.html

Shen, Ferguson, Ma, & Rosen. (2018). Upper Limb Wearable Exoskeleton Systems for Rehabilitation. In *Wearable Technology in Medicine and Health Care* (pp. 71–90). Elsevier. doi.org/10.1016/B978-0-12-811810-8.00004-X

Stanley, J. (2019, Nov. 14). Three Common Privacy Misconceptions That Companies Love. *American Civil Liberties Union*. www.aclu.org/news/privacy-technology/three-common-privacy-misconceptions-that-companies-love