WIP: Undergraduate Led Redesign of an Open-Source Parkinson's Glove

Mr. Joseph Andrew Bartlett, Purdue University

Joseph Bartlett is a sophomore Mechanical Engineering Technology student at Purdue Polytechnic New Albany. His research interests include renewable energy systems as well as assistive and medical device development. With an extensive background in the manufacturing and metalworking industry, he is quite interested in integrating practical design and research to advance both energy systems and human-centered engineering solutions.

Dr. Rustin Webster, Purdue University, New Albany

Dr. Rustin Webster is an associate professor in the Purdue Polytechnic Institute at Purdue University and specializes in mechanical engineering and computer graphics technology. Prior to academia, he worked for an aerospace and engineering company as a mechanical engineer, product development lead, and researcher. Dr Webster designed various solutions for multiple branches of the Armed Forces, the Department of Defense, and the National Aeronautics and Space Administration. He holds a B.S. in Engineering Graphics and Design and a M.S. in Management of Technology from Murray State University, and a Ph.D. in Interdisciplinary Engineering from the University of Alabama at Birmingham. Dr. Webster is a certified GD&T-Technologist, SOLIDWORKS Expert, and Six Sigma Green Belt. For his teaching and mentoring of students he has been awarded the American Society for Engineering Education (ASEE) Engineering Technology (ET) National Teaching Award, Purdue University Teaching Academy Fellowship, School of Engineering Technology Outstanding Faculty in Teaching and Learning Award (twice), Purdue Teaching for Tomorrow Fellowship, Purdue Teaching Academy Pandemic Teaching Award, ASEE Engineering Graphics and Design Rising Educator Award, and SME Distinguished Faculty Advisor Award (twice). Dr Webster's research interests include ET design education with focus areas in computer-aided design (CAD) and pedagogy.

Evaluation, Testing, and Improvement of Parkinson's Disease Treatment Gloves

Abstract
This undergraduate-led case study in undergraduate and applied research in Engineering Technology evaluates and improves upon an open-source Parkinson's Disease Treatment Glove system through an iterative cycle of use, reflection, and redesign. The project asks: How do end-user experiences with weeklong at-home trials inform tangible hardware, ergonomic, and usability improvements, and do those changes measurably affect perceived usability?

During the Fall 2025 semester, an undergraduate researcher gathered a published open-source glove design, recreated the device, and deployed the device for a one-week trial with a participant with Parkinson's disease. Data collection consisted of a post-trial System Usability Scale (SUS) assessment and daily audio recorded reflections by the participant. Rapid thematic analysis of these reflections identified deficiencies in enclosure geometry, strap architecture, component placement, and general usability. These findings guided a structured down selection process and informed a Human-Centered Design approach. The student researcher implemented targeted revisions using computer aided design (CAD) tools and additive manufacturing techniques. A second one-week trial with the revised prototype produced a new SUS score and an additional set of reflections. Triangulation of pre- and post-trial SUS scores along with qualitative themes informed changes in perceived usability and documentation of the design decision logic.

Introduction
Parkinson's Disease (PD) is a neurological disorder with no known cure, which causes nerve cells in the brain (neurons) to progressively deteriorate, weaken, and die. This results in symptoms such as difficulties with balancing, shaking of one's hands (referred to as tremors), difficulty eating and swallowing, and speech changes resulting in slurred speech or speaking quietly. These symptoms can affect one's ability to eat and drink, to put on clothes, to speak, and other day-to-day tasks [1].

While there are many PD treatments available that can mitigate symptoms, most are pharmaceutical or quite invasive in nature. According to the Michael J Fox Foundation website, there are at least eight categories of medication for motor symptoms (symptoms that manifest physically) and eleven categories of medication for everything from cognitive health, depression, fatigue, and urinary issues [2], [3], [4]. There are two main procedures available to treat Parkinson's Disease: Deep Brain Stimulation, where wires are placed on the brain to help control motor symptoms, and Focused Ultrasound, in which ultrasonic beams of sound are used to eliminate areas of problematic neurons [5], [6]. There are pharmaceutical treatments that are being developed that either modify the disease or relieve motor and non-motor symptoms, as well as a stem cell therapy that aims to rebuild the areas of the brain primarily affected by this disease [7], [8]. While increased exercise and dietary changes can relieve symptoms and slow the progression of PD, the late onset of Parkinson's Disease can make it more difficult for older patients to adapt to their new lifestyle and an increasing difficulty in taking medication [9].

Peter A. Tass at Stanford University was aware of these difficulties for Parkinson's patients and developed a noninvasive treatment, designed to stimulate a patient's neural pathways by way of vibrotactile fingertip stimulation [10], [11]. This is the use of vibrations transmitted through touch to help rewire a patient's brain to relieve symptoms [12]. According to Kanwarjit Bhutani, his Parkinson's symptoms had become so severe that he took up to 25 medications daily to manage sensory loss, muscle rigidity, speech difficulties, mood swings, and compulsive behaviors. After three weeks of using the treatment gloves, his taste and smell returned, his muscle stiffness decreased, and he was able to garden again, and was able to reduce his dosage to ten medications per day, with benefits that continued even as he used the gloves less frequently [13].

To practically address these issues with Parkinson's Disease, a Mechanical Engineering Technology (MET) undergraduate student, [REDACTED], produced a version of the treatment gloves/system. The design for these gloves was an adaptation of a design which was developed by pdbuzzboard, iterating on Peter A Tass's original design [14].

Methods

The student met with a MET professor (project mentor) in August 2025, to discuss the scope of the design and Bill of Materials (BOM) for the first iteration. The student used the "Updated Motor Shield Glove controller (RJ-45) parts list" [15], from pdbuzzboard [14], as the basis of his design and BOM. Much of the equipment and parts required to build the first iteration of the system were readily available at the university. In the first iteration of the design, it required vibratory motors to be installed into the fingertips of the archery gloves, an Arduino Uno R3 and corresponding motor controller to act as the basis of a controller box, a large plastic junction box for the enclosure of the controller box, and a pair of RJ45 (Ethernet) cables to send signals from the controller box to the gloves. The program for the controller box was then installed, and the vibratory motors were tested by plugging each glove in and checking the vibrations in the fingertips. This marked the completion of the first iteration of the gloves and controller box and its readiness for testing (Figures 1 & 2).

Figure 1 – 1st Iteration of Gloves

Figure 2 – 1st Iteration of System

To justify the second iteration of the gloves, audio reflections taken from the end user expressed the following issues after using the first iteration of the gloves and its accompanying controller box:

- **Wiring issues:** Wires came loose and were hard to reinsert, especially with hand tremors.
- **Usability:** Gloves were not clearly labeled for left/right or orientation, causing confusion.
- **Fit & comfort:** Limited finger coverage and long wear reduced comfort.
- **Portability & Daily Use:** Gloves and control box were unwieldly and interfered with basic tasks.
- **Instructions:** Guidance on setup and treatment timing was unclear.

"I ran into another issue with the wires, a couple of the other wires popped out of, I think, the other glove. But fortunately, since I had Mother take pictures of me holding the gloves up, I was able to look and see where those wires should have been. So I got them where they belonged and ran my session, so that worked out nicely." – End User

Further discussions determined that the best course of action would be to focus on the portability and daily use of the System in order to improve overall system usability.

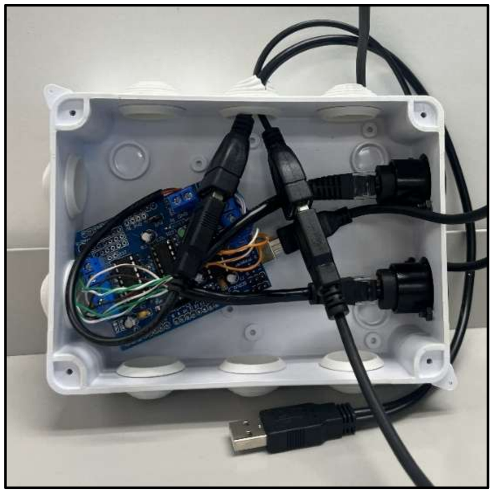

Figure 3 – Controller Box (Internal)

The System's Controller Box was originally designed to have little physical support for the power and communication wires, and for the Arduino Uno R3. The ethernet cables were leading to interference with daily activities (Figure 2). To remedy these issues, a simpler design was proposed, which retained most of the same parts, and emphasized system usability in a few areas:

1. Smaller Controller Box
   - A new enclosure was chosen, less than half the size of the original plastic junction box.
   - Battery pack was moved to the inside of the new enclosure.
2. SLA 3D Printing and CAD for quick and iterative manufacturing
   - Glove finger inserts for reliable placement of fingers on vibratory motor.
   - Custom front controller box panel: Battery slot and a power switch on the front.
3. Wire and Cable Management
   - Wires inside the controller box and on the gloves were carefully routed and had heat shrink tubing installed.
   - Retractable RJ45 cables replaced the standard ones for easier maneuverability.

After new parts were shipped (smaller enclosure, some specialty USB cables, new set of archery gloves, retractable cables, and new panel mount RJ45 connectors), the glove inserts and front panel were designed and printed (Figures 5 & 6).

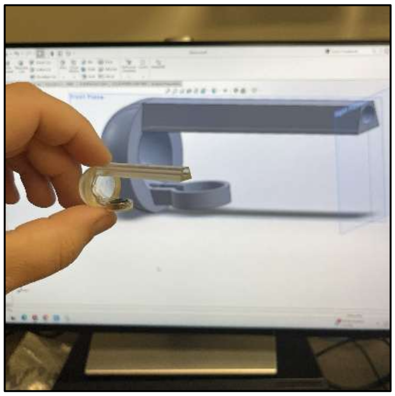
Figure 5 – Printed & CAD

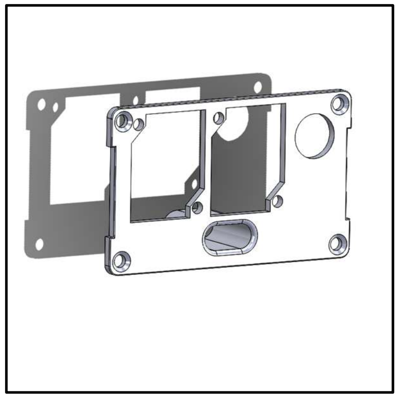
Figure 6 –Panel CAD Model

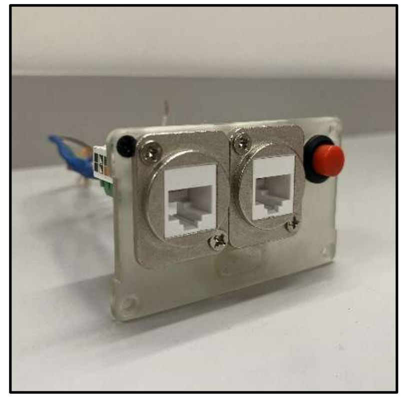
Figure 7 – Front Panel

The new glove inserts were glued in after confirming the new glove inserts would fit the vibratory motors and the archery gloves. The new front panel for the controller box (Figure 7) had multiple iterations before its components were installed, being integrated with the battery, Arduino, and motor controller. With an added set of belt hooks (Figure 10) and a laser engraved Purdue Logo on the back panel, this completed the assembly of the controller box and the second iteration of this device (Figures 8 through 12).


Figure 8 – 2nd Iteration of System


Figure 9 – 2nd Iteration of System


Figure 10 – Belt Hooks


Figure 11 – Front of Box


Figure 12 – Engraved Logo

Results and Discussion

The testing criteria of the Treatment Gloves and Controller Box was evaluated using a SUS in an online form, in combination with daily audio recordings collected from the end user during a seven-day trial. Following this initial testing period, a revised glove design was made based upon identified usability issues. This second iteration of gloves underwent an additional seven-day testing period using the same SUS form and round of daily audio recordings to assess changes in overall usability.

System Usability Statement	**First Iteration SUS Score**	**Second Iteration SUS Score**	**System Usability Improvement**
I think that I would like to use this system frequently.	2/5	5/5	85.71 %
I found the system unnecessarily complex.	4/5	1/5	120.00%
I thought the system was easy to use.	3/5	4/5	28.57%
I think that I would need the support of a technical person to be able to use this system.	4/5	1/5	120.00%
I found the various functions in this system were well integrated.	3/5	4/5	28.57%
I thought there was too much inconsistency in this system.	2/5	1/5	66.67%
I would imagine that most people would learn to use this system very quickly.	3/5	5/5	50.00%
I found the system very cumbersome to use.	5/5	1/5	133.33%
I felt very confident using the system.	3/5	4/5	28.57%
I needed to learn a lot of things before I could get going with this system.	2/5	1/5	66.67%

In the first iteration of the system, the end user expressed enthusiasm for having tried out the gloves but encountered frequent usability challenges. The wiring on the gloves repeatedly came loose, which caused frustration and reliance on assistance, the limited portability interfered with daily activities, and overnight use was uncomfortable and inconsistent. These issues then informed the design of the second iteration.

> *"There was a little trouble with a couple of the wires. that came loose out of one of the glove setups, but I sent him a note, and he gave a great description of what I needed to do to fix them up, and I did, and they worked great for the rest of the day."* – End User

With an overall improvement in the system usability score of 72.81%, the end user noted a marked improvement in durability, portability, and overall build quality in the gloves and controller box with this updated version. The retractable cables, compact enclosure, and belt clips helped reduce handling and wiring issues. The gloves were also noted as feeling sturdier and safer for extended and overnight use.

Conclusion and Potential Next Steps

The responses from the end-user yielded a number of positive mechanical and ergonomic improvements, which the student researcher used to make measurable improvements in perceived usability through design iteration, and set up a repeatable, input-based prototyping process. As such, this project has the potential to be a model for engineering educators to integrate direct user feedback into design coursework, helping students take end-user input to quickly design, manufacture, and iterate new products and components. The student researcher has considered what steps they would take to further develop this project into a viable commercial product.

References

[1] "Parkinson's disease," National Institute of Neurological Disorders and Stroke, https://www.ninds.nih.gov/health-information/disorders/parkinsons-disease

[2] "Medications & treatments," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/medications-treatments

[3] "Medications for motor symptoms," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/news/medications-motor-symptoms

[4] "Medications for non motor symptoms," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/news/medications-non-motor-symptoms

[5] "Deep Brain stimulation," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/deep-brain-stimulation

[6] "Focused ultrasound," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/news/focused-ultrasound

[7] "Medications in trials," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/medications-trials

[8] "Stem cell research and Parkinson's disease," The Michael J. Fox Foundation for Parkinson's Research | Parkinson's Disease, https://www.michaeljfox.org/stem-cell-research-and-parkinsons-disease

[9] I. Straka et al., "Adherence to pharmacotherapy in patients with Parkinson's disease taking three and more daily doses of medication," Frontiers in Neurology, vol. 10, Jul. 2019. doi:10.3389/fneur.2019.00799

[10] K. J. Pfeifer et al., "Coordinated reset vibrotactile stimulation induces sustained cumulative benefits in Parkinson's disease," Frontiers in Physiology, vol. 12, Apr. 2021. doi:10.3389/fphys.2021.624317

[11] P. A. Tass, "Vibrotactile coordinated reset stimulation for the treatment of Parkinson's disease," Neural Regeneration Research, vol. 17, no. 7, 2022. doi:10.4103/1673-5374.329001

[12] L. Kim, "Game-changing Parkinson's glove | 90 Seconds w/ Lisa Kim," YouTube, https://www.youtube.com/watch?v=GySCSlEBC6M

[13] H. A. MacCormick, "Can a vibrating glove treatment relieve Parkinson's symptoms?," Stanford Medicine Magazine, https://stanmed.stanford.edu/vibrating-glove-reorganize-neurons-parkinsons/%C2%A0

[14] "Pdbuzzboard - overview," GitHub, https://github.com/pdbuzzboard [15] "Motorshield Gloves Update," YouTube, https://www.youtube.com/watch?v=W2gthMw9JYo