Thesis Project Portfolio

Development of a Robotic Lewis Rat Ankle & Foot for Advanced Testing and Evaluation of Regenerative Treatment Solutions

(Technical Report)

An Exploration of How the Development of Increasingly Advanced Medical Technology Has Contributed to the Segregation of Healthcare and Health Technology Solutions

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2025

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Executive Summary

While cutting-edge medical innovations hold the potential to combat the world's most threatening diseases and conditions, their development has a significant negative impact on global health. The capstone portion of this research project is focused on the development of the ankle and foot components of a robotic Lewis Rat hindlimb to create a testing platform for the evaluation of functional recovery from volumetric muscle loss (VML). With all current regenerative treatment options for VML failing to achieve full functional recovery, this research is a key step towards filling the gap in recovery for these patients. The sociotechnical component of this project covers how the development of increasingly advanced medical technology has contributed to the segregation of healthcare and health technology solutions. Without a focus on access to these medical innovations, those who would benefit the most from such solutions are progressively removed from the evolving medical landscape. This capstone project and sociotechnical research are aligned in that the development of a novel regenerative therapy solution for VML is a prime example of a medical advancement that actively builds on the disparities within the health industry through its creation.

Currently, the Motor Analysis and Motor Performance Laboratory at the University of Virginia, directed by Dr. Shawn Russell, is investigating the impact of VML on Lewis Rats via computational studies. Dr. Russell and his lab have the long-term goal of designing a new regenerative treatment that is capable of complete functional recovery as well as returning patients to their original gait patterns. The design of a robotic Lewis Rat hindlimb for this capstone project will serve as an intermediate testing platform for Dr. Russell's lab to transition from computational studies to animal testing. The physical model will help address current discrepancies between the computational models and existing data as well as provide a method

for evaluating the impact of VML in a more realistic space outside of just simulations. This project was segmented into four key phases: development of an actuated ankle model, development of a passive foot model, writing of code to recreate Lewis Rat ankle and foot motion, and validation of the combined ankle and foot actuated model via motion analysis.

Following the design of the ankle and foot model, as well as the development of code to program the integrated servos to control the model through the normal walking motion of a Lewis Rat, we ran a motion analysis test to evaluate how accurately our model mimicked the data of the live Lewis Rat (provided to us by Dr. Russell). By tracking several points in space along our model as it was programmed through the normal walking motion code we developed, we were able to derive the angle between the foot and theoretical tibia at each point in time. This was then overlayed with the actual Lewis Rat angle data where we were able to validate the accuracy of our model as it tracked accordingly throughout the walking motion period. This confirmed our robotic ankle and foot model to be an accurate and effective tool for the Motor Analysis and Motor Performance Laboratory to use as they continue to study the impact of VML on Lewis Rats and progress towards a novel regenerative solution.

The sociotechnical research for this project investigates how the development of increasingly advanced medical technology has contributed to the segregation of healthcare and health technology solutions. This research question is significant because it questions the innovative field of medicine and highlights how the same technologies that are meant to improve global health are furthering the disparities that exist within the field. This research incorporates a justice evaluative technique to assess fairness and equity across the industry. This analysis is structured into four key dimensions: distributive, procedural, structural, and policy factors. These dimensions cover the medical systems, decision-making processes, technological barriers, and policies that come together to create disparities in the health industry.

Through the justice evaluative technique, this research highlights how medical technology disproportionately benefits wealthier, well-resourced institutions and individuals while excluding lower-income and marginalized communities. Several sources of evidence are incorporated highlighting how high development costs, restrictive insurance policies, profit-driven focuses, inadequate infrastructure, and a lack of targeted policies on medical device and pharmaceutical organizations all help reinforce the inequality in access to health solutions. These results indicate that without policy reform and a shift in institutional practices and focus, these disparities will only deepen. Systemic changes such as equitable pricing, government incentives, redesigned insurance coverage plans, and consideration for distributive access throughout the design process are necessary steps to allow for all individuals to benefit from the advancements in health technology solutions.