Assessing Stem Cell Therapeutics in Murine Models

Giles Carlos, 54951701, gpcarlos@uci.edu
Nathan Gin, 54951701, nbgin@uci.edu
Alexander Nathaneal, 54951701, anathana@uci.edu
Vinh Nguyen, 54951701, vinhhn2@uci.edu
Owen Sitiabudi, 54951701, ositiabu@uci.edu

Github Repository: https://github.com/gilescarlos/Stats-170-Cap-Stone

1 Introduction and Problem Statement

Spinal cord injury (SCI) is a debilitating condition that impacts up to 300,000 individuals in the U.S. each year. As such, a significant focus of stem cell research is dedicated to developing therapeutics that could help bring affected individuals' livelihood back. Likewise, the tests and methods used to assess different therapeutics are incredibly important. The efficiency and rigor of these tests allow for discovery of novel therapies and help advance the research field dedicated to solving spinal cord injury. The ladder beam test is a behavioral method for assessing recovery following SCI in murine models. During the test, mice must walk across a ladder with fifty rungs. Injured mice are expected to have more missteps while recovering mice should have more plantar or sufficient steps. However, to properly utilize this test our sponsors must spend several hours analyzing hundreds of videos of mice completing the task in order to individually score each mouse's performance. Consequently, this tedious process tends to slow down the lab's workflow and some automation would provide a significant increase in efficiency. Streamlining the ladder beam task and its data analysis would allow for significant efficiency in retrieving data necessary for the advancement of SCI research and therapeutics. Our primary goal is to use appropriate machine learning algorithms and build off existing research to aid in the lab's data collection process for the ladder beam task. Secondly, we will assess the effectiveness of different treatments through appropriate statistical models and hypothesis tests.

2 Related Work

Several other labs have encountered this bottleneck in efficiency and have aimed to address this problem as well. One such solution is DeepLabCut[1], which is an open source software developed in Python that utilizes a deep neural network to track various body parts in multiple species across a broad collection of behaviors or physical assessments. Another study was able to utilize the software to conduct a comprehensive 3D gait analysis of mice after focal cerebral ischemia[2]. The authors concluded that using a previously trained data set for tracking mice movement, their own recordings of mice completing the ladder beam task, and the DeepLabCut neural network provides accurate and sensitive data to describe the complex recovery of rodents following a stroke. Other researchers have also been successful in building upon DeepLabCut and creating their own toolbox utilizing a convolutional neural network appropriate for their recording equipment[3].

[1] Mathis, A., Mamidanna, P., Cury, K.M. et al. DeepLabCut: markerless pose estimation of user-defined body parts with deep learning. Nat Neurosci 21, 1281–1289 (2018). https://doi.org/10.1038/s41593-018-0209-y

[2] Weber, R.Z., Mulders, G., Kaiser, J. et al. Deep learning-based behavioral profiling of rodent stroke recovery. BMC Biol 20, 232 (2022). https://doi.org/10.1186/s12915-022-01434-9

[3] Aljovic, A., Zhao, S., Chahin, M. et al. A deep learning-based toolbox for Automated Limb Motion Analysis (ALMA) in murine models of neurological disorders. Commun Biol 5, 131 (2022). https://doi.org/10.1038/s42003-022-03077-6

3 Data Sets

We obtained our data from our sponsors at the UCI Stem Cell Research Center. Specifically, we received about a hundred videos of mice completing the ladder beam task and the corresponding manually labeled excel sheet corresponding to the videos.

Table 1: Example of First 10 Rows of Manually Input Data Set Obtained from Ladder Beam Task

animal	**total_good**	**total_bad**	**ave_good**	**ave_bad**	**lb_score**	**type**
1	276	24	46.00000	4.000000	92.00000	w
2	280	20	46.66667	3.333333	93.33333	k
3	255	45	42.50000	7.500000	85.00000	w
4	228	71	38.00000	11.833333	76.25418	k
5	267	33	44.50000	5.500000	89.00000	v
6	279	21	46.50000	3.500000	93.00000	v
7	276	24	46.00000	4.000000	92.00000	k
8	226	74	37.66667	12.333333	75.33333	w
9	227	73	37.83333	12.166667	75.66667	k
10(11)	222	78	37.00000	13.000000	74.00000	v

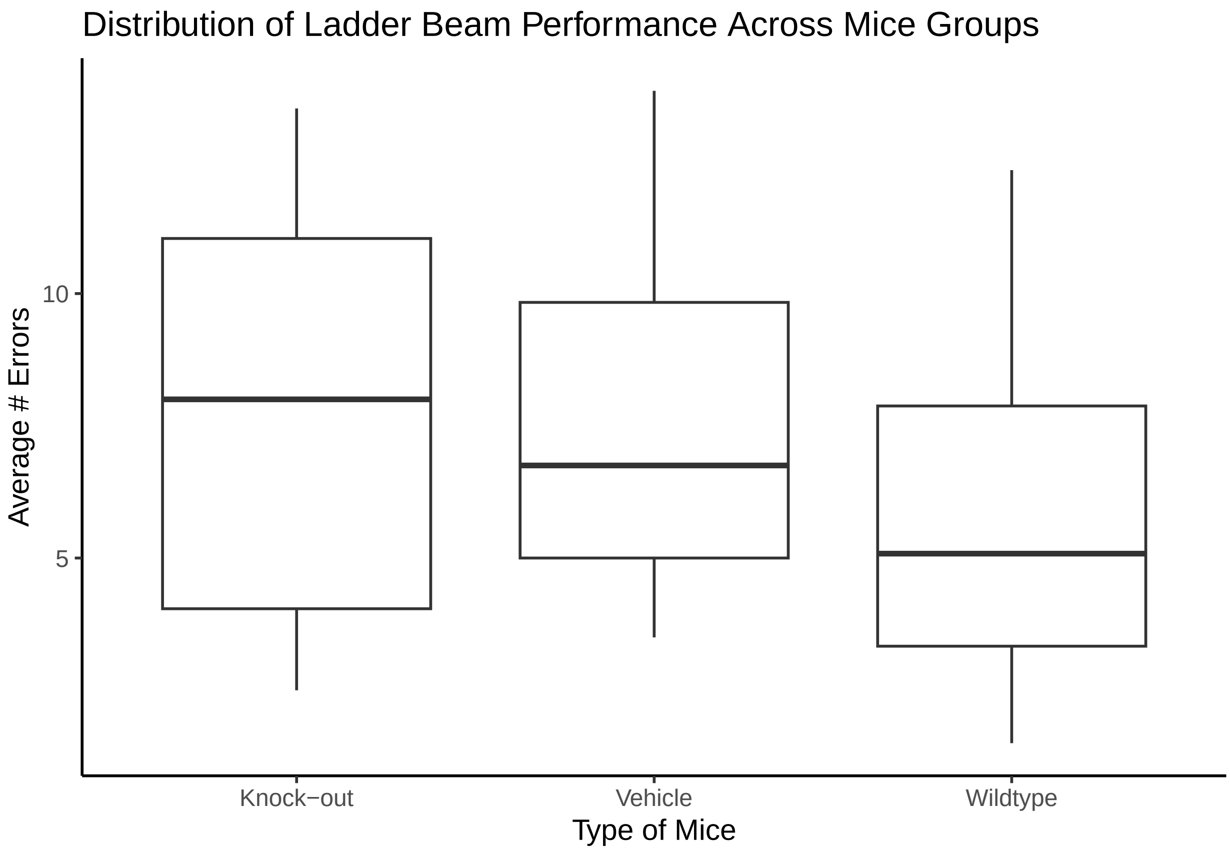
Table 2: Example of First 10 Rows of Training Data from a Single Video

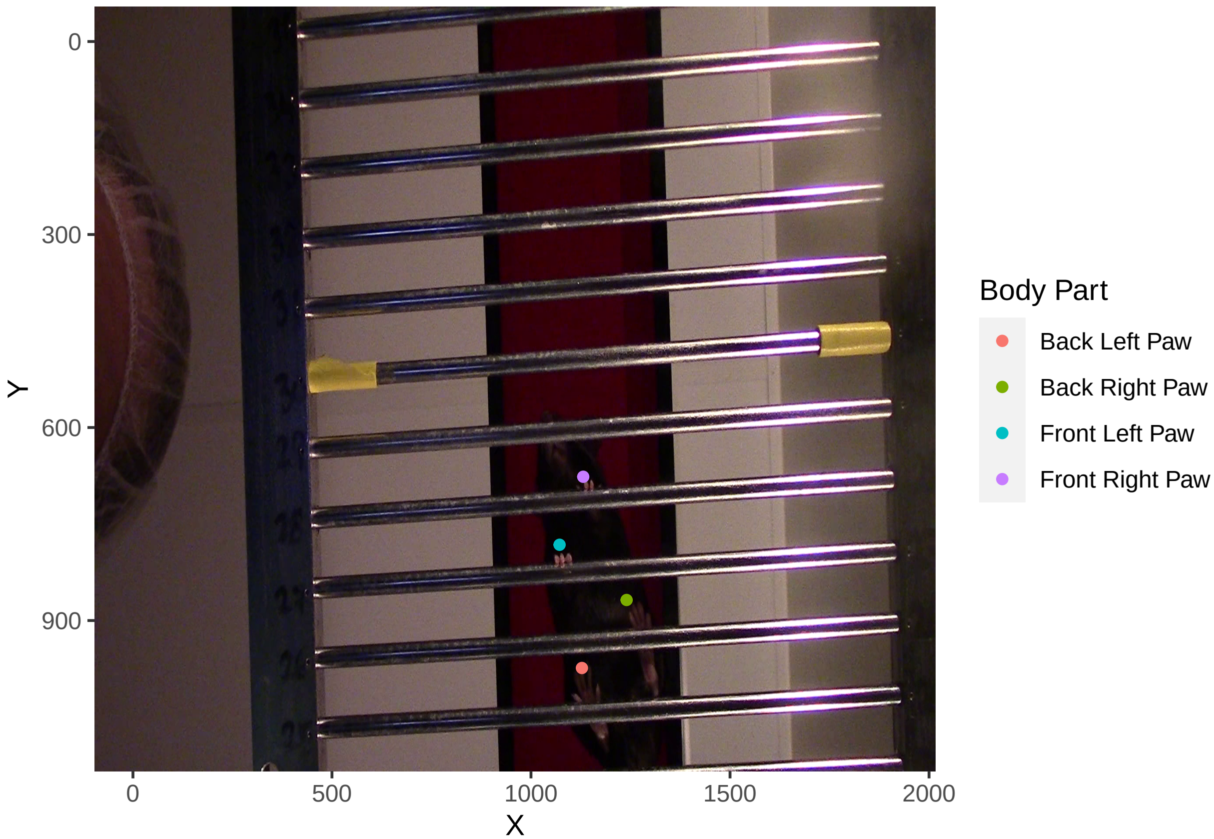
video	**frame**	**bodypart**	**x**	**y**
MVI_8324	img0234.png	front_left_paw	1058.571	673.2461
MVI_8324	img0234.png	front_right_paw	1137.828	613.8034
MVI_8324	img0234.png	back_left_paw	1124.619	1023.2978
MVI_8324	img0234.png	back_right_paw	1223.690	917.6218
MVI_8324	img0272.png	front_left_paw	1160.945	564.2678
MVI_8324	img0272.png	front_right_paw	1250.109	491.6156
MVI_8324	img0272.png	back_left_paw	1141.131	874.6909
MVI_8324	img0272.png	back_right_paw	1243.504	973.7622
MVI_8324	img0392.png	front_left_paw	1124.619	399.1491
MVI_8324	img0392.png	front_right_paw	1243.504	488.3132

4 Overall Technical Approach

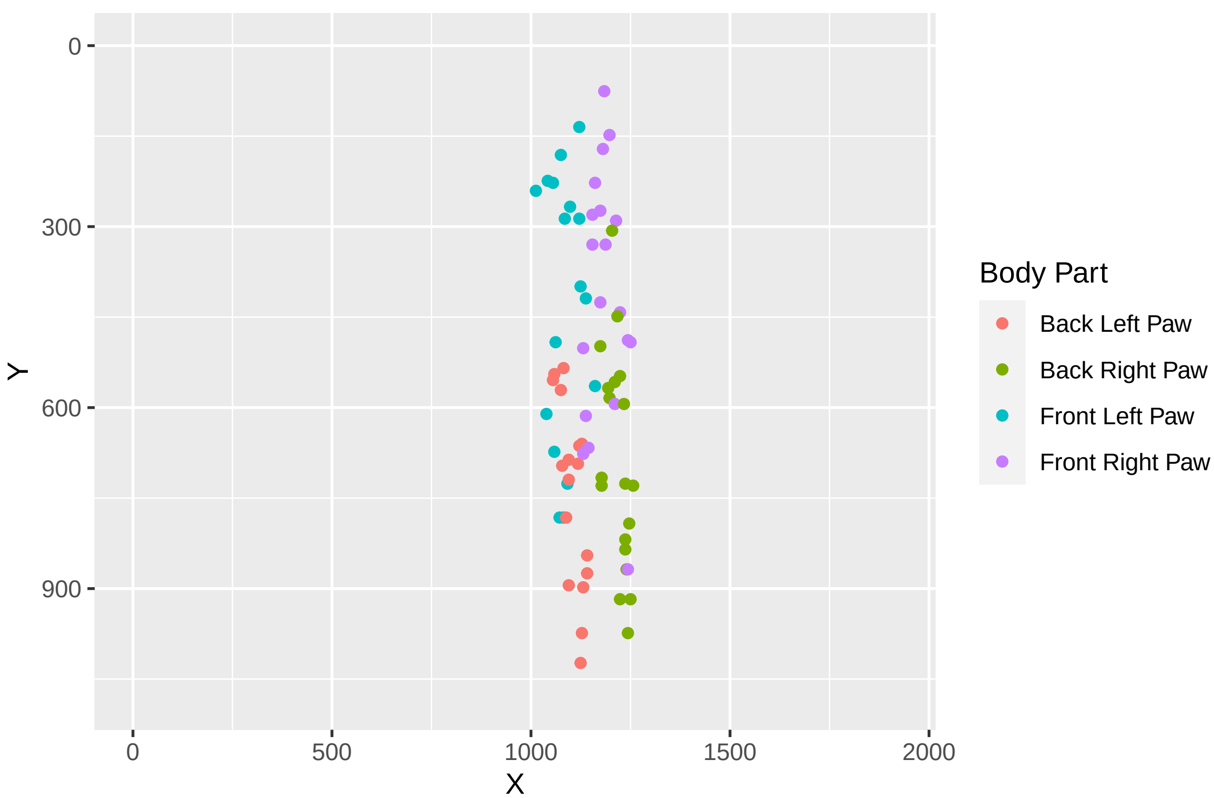
4.1 Data Wrangling

4.2 Exploratory Data Analysis





Tracking Individual Paws Throughout a Single Video



5 Software

6 Experiments and Evaluation

7 Notebook Description

8 Members Participation

Table 3: Percentage of workload across group members

Task	Giles	Nathan	Alex	Vinh	Owen
task 1	100%	100%	100%	100%	100%

9 Discussion and Conclusion

What did you learn about the methods and algorithms you worked with? What did you learn about their strengths? And their limitations?

test text

What ended up being harder than you expected in your project? What was surprising about your project?

test

What other lessons did you learn, expected or unexpected (e.g., perhaps about the tools you used, if you used anything out of the ordinary?

test text

If you were in charge of a research lab, what ideas and directions might you invest in over the next year or two to try to make major progress on this problem? Feel free to be speculative in discussing possible future directions.

test text