UCLA MECHANICAL ENGINEERING

CONCUSSION SIMULATION

MID-QUARTER UPDATE

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OVERVIEW

1. Progress Made
    a. Spine
    b. Skull
    c. Brain as a mass spring damper system
2. Required Future Work
    a. Integrate all parts together
    b. Validate acceleration data from our model that satisfactorily matches existing studies
    c. At realistic values and vary parameters
3. Additional Future Work if Time Allows
    a. Simulating the effects of concussion prevention devices

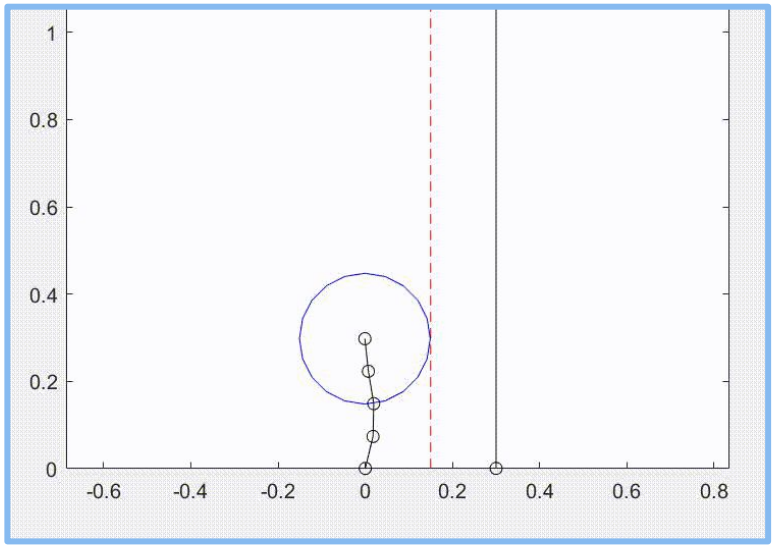
OBJECTIVES

1. Create a simple yet accurate kinematic model of the brain, skull, cerebrospinal fluid, and neck.
2. Determine the force and acceleration of a brain experiencing impacts of varying severity and direction.
3. Validate the model using existing studies. Use the simple model to compare many different variables.
4. See the effects of traumatic brain injury mitigation devices, like simple helmets, MIPS helmets, and Q collars.
5. Look for suggestions or improvements to reduce concussion risk

SPINE

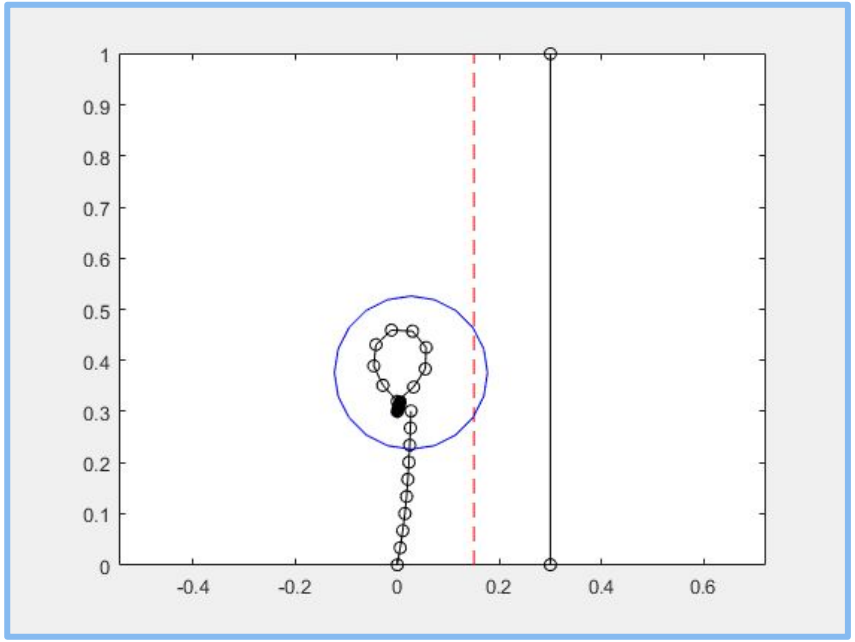
We modeled the spine as a beam and introduced a “wall” to bounce off

This is necessary to eventually have the modeled brain impact the skull interior

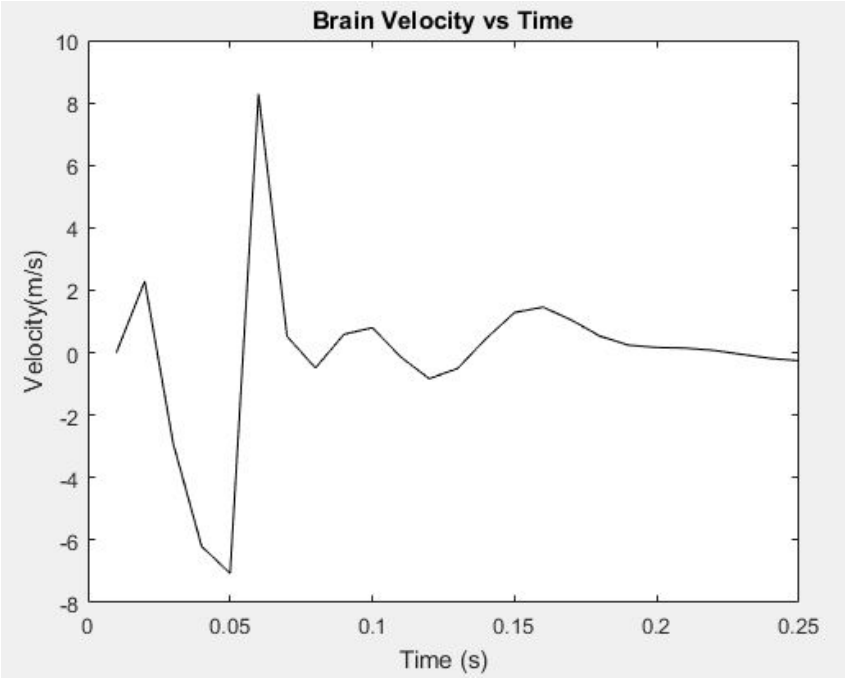


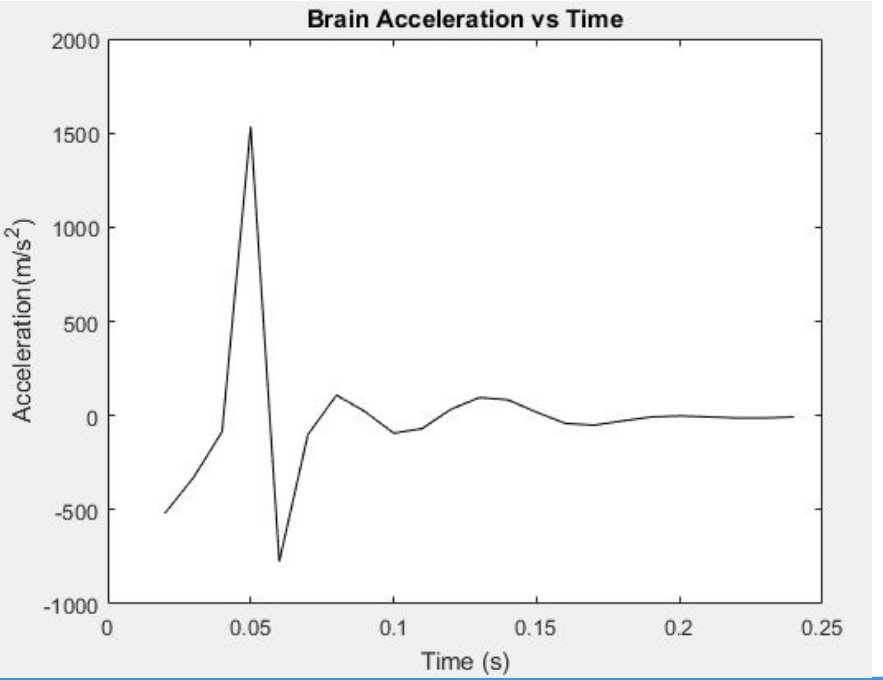
BRAINSTEM AND BRAIN

Brainstem and
brain placeholder added.



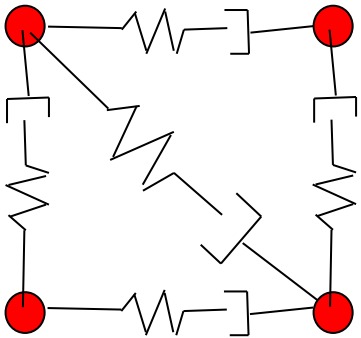
DATA CAPTURE

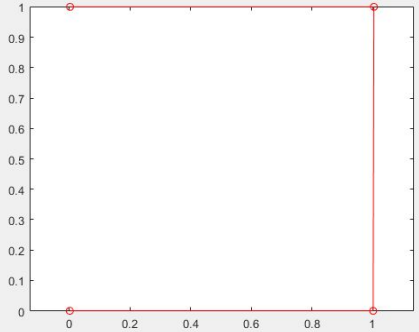




THE BRAIN AS A MASS SPRING DAMPER SYSTEM

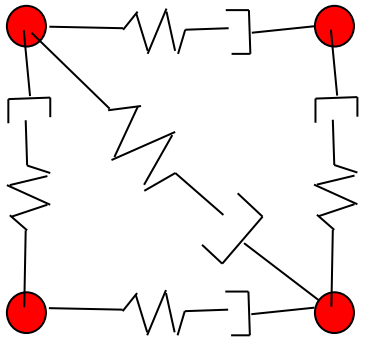
Currently, our brain script models the brain as a system of four nodes in a square, with springs and dampers between each node as shown in the figure. The script has the brain moving through viscous fluid with an initial force applied to the top right node.





THE BRAIN AS A MASS SPRING DAMPER SYSTEM

This model will be expanded to at least a 9 node model, and ideally 16 nodes. Once this is complete, it will be integrated with the skull and spine models.



FUTURE WORK

1. Required Future Work
    a. Integrate all parts together
    b. Validate acceleration data from our model that satisfactorily matches existing studies
    c. At realistic values to the simulation
2. Additional Future Work if Time Allows
    a. Simulating the effects of concussion prevention devices

EXPANDING, COMBINING, AND TUNING COMPONENTS

1. Initial Adjustments
    - Expand “wall” to 2 dimensions to simulate the skull interior
    - Add more nodes to brain, brainstem, and neck
    - Add easily adjustable parameters and clean up code
    - Ensure all code and simulated motion is behaving as desired
2. Combining
    - Put together the full brain, brainstem, skull, and neck components
    - Ensure connection points are relaying proper forces
3. Tuning
    - Adjust geometries to more closely resemble biology
    - Adjust elastic parameters to match behavior to studies

REFERENCES

[1] W. Decker, A. Baker, Y. Xin, et al., "Development and Multi-Scale Validation of a Finite Element Football Helmet Model," *Annals of Biomedical Engineering,* no. 48, pp. 258-270, 2020.

[2] E. D. Anderson, T. Wu, M. B. Panzer, et al., "Predicting Concussion Outcome by Integrating Finite Element Modeling and Network Analysis," *Frontiers in Bioengineering and Biotechnology,* vol. 8, p. 309, 2020.

[3] M. Falstedt, P. Halldin and S. Kleiven, "Importance of the Bicycle Helmet Design and Material for the Outcome in Bicycle Accidents," in *International Cycling Safety Conference*, Göteborg, 2014.

[4] L. J. Ng, V. Volman, M. M. Gibbons, et al., "A Mechanistic End-to-End Concussion Model That Translates Head Kinematics to Neurologic Injury," *Frontiers in Neurology,* 2017.

[5] S. Rowsen, S. M. Duma and J. G. Beckwith, "Rotational Head Kinematics in Football Impacts: An Injury Risk Function for Concussion," *Annals of Biomedical Engineering,* vol. 40, pp. 1-13, 2012.

[6] S. P. Broglio, A. Lapointe, K. L. O'Connor, et al., "Head Impact Density: A Model To Explain The Elusive Concussion Threshold," *Journal of Neurotrauma,* vol. 34, no. 19, 2017.

[7] Bicycle Helmet Safety Institute, "Researcher's Resource Page," 2022. [Online]. Available: https://helmets.org/research.htm.

THANK YOU! QUESTIONS/FEEDBACK?

LINK TO THE VIDEO:

https://github.com/lilyrclay/ucla-259b/blob/main/midterm/midtermpresentation.mp4