

To Move or Not to Move: Principal Curvatures of Articular Surfaces

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Yale University

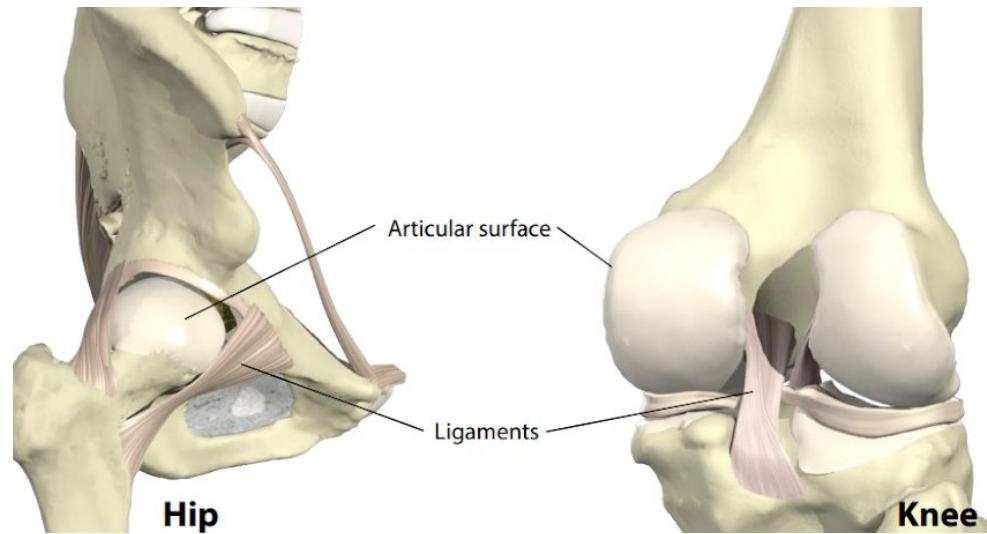
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Background: Ligaments

- The fibrous connective tissue that connects bones to other bones.
- Toy Example:
 - The rubber bands are the ligaments.



Background: Stiffness

- The resistance of a member against deformation



Motivation

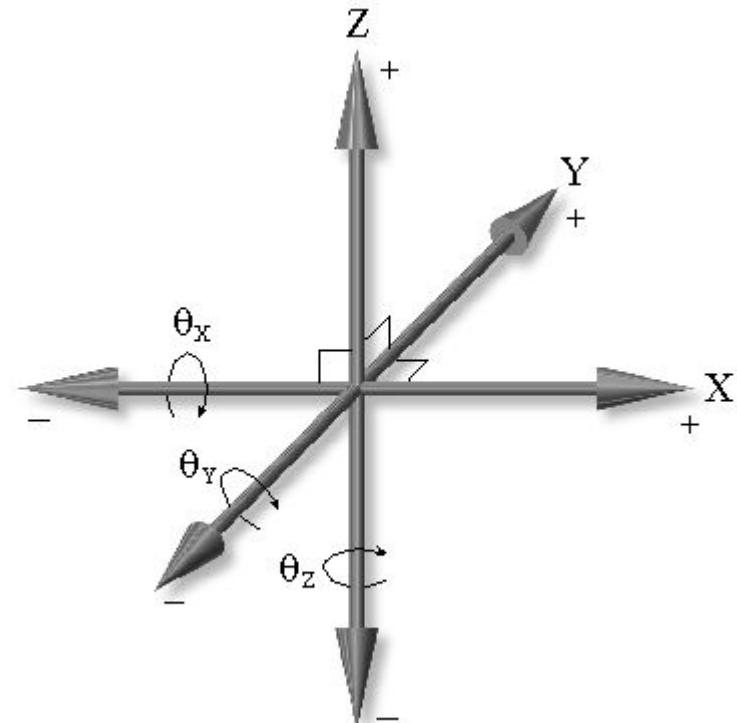
- Goal:
 - Explore what key geometrical features of the articular surface determine joint motion
- How:
 - Design an experimental setup that will allow us to predict movement capabilities at a joint based purely on the principal curvatures of the articular surfaces.
- Application:
 - Creates predictive model for anatomists and paleontologists.
 - Serves in surgical remodeling of joints and building of prosthetics

Motivation

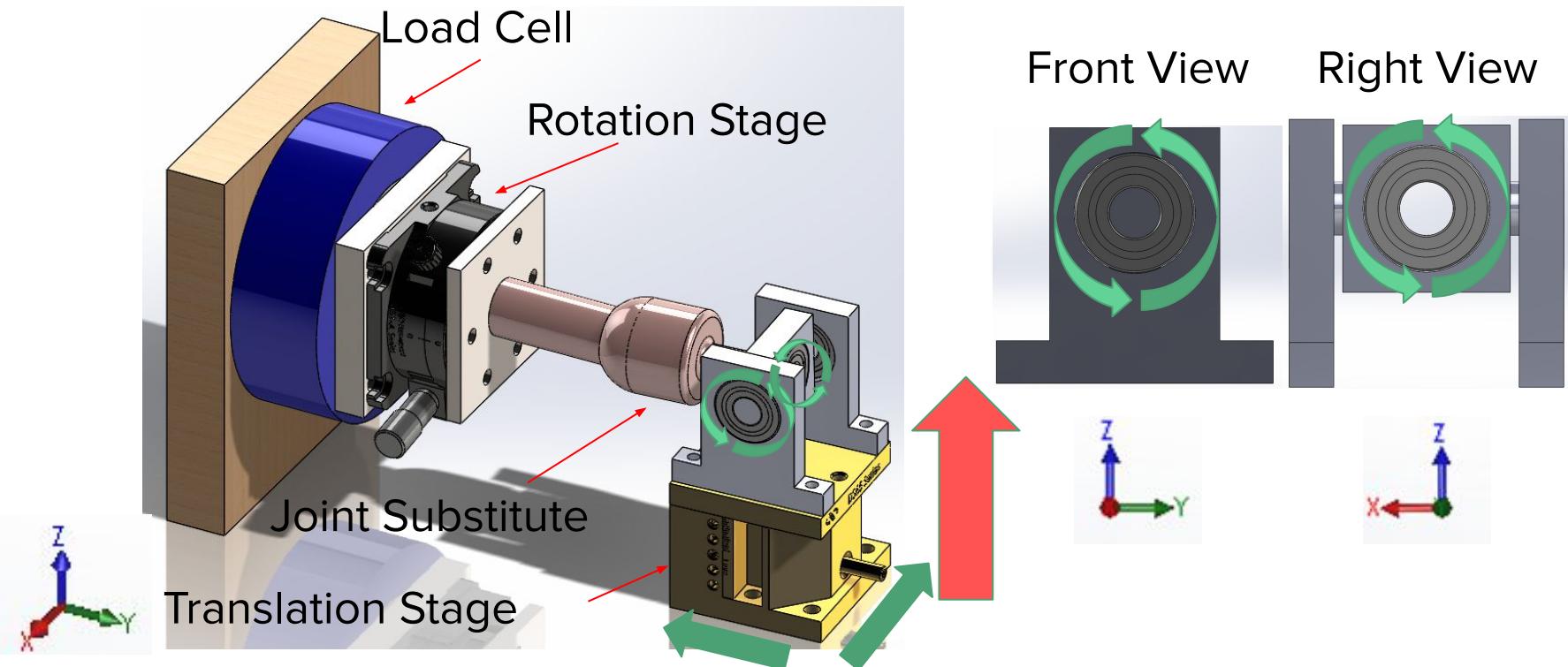
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Initial Key Design Principles and Design Constraints

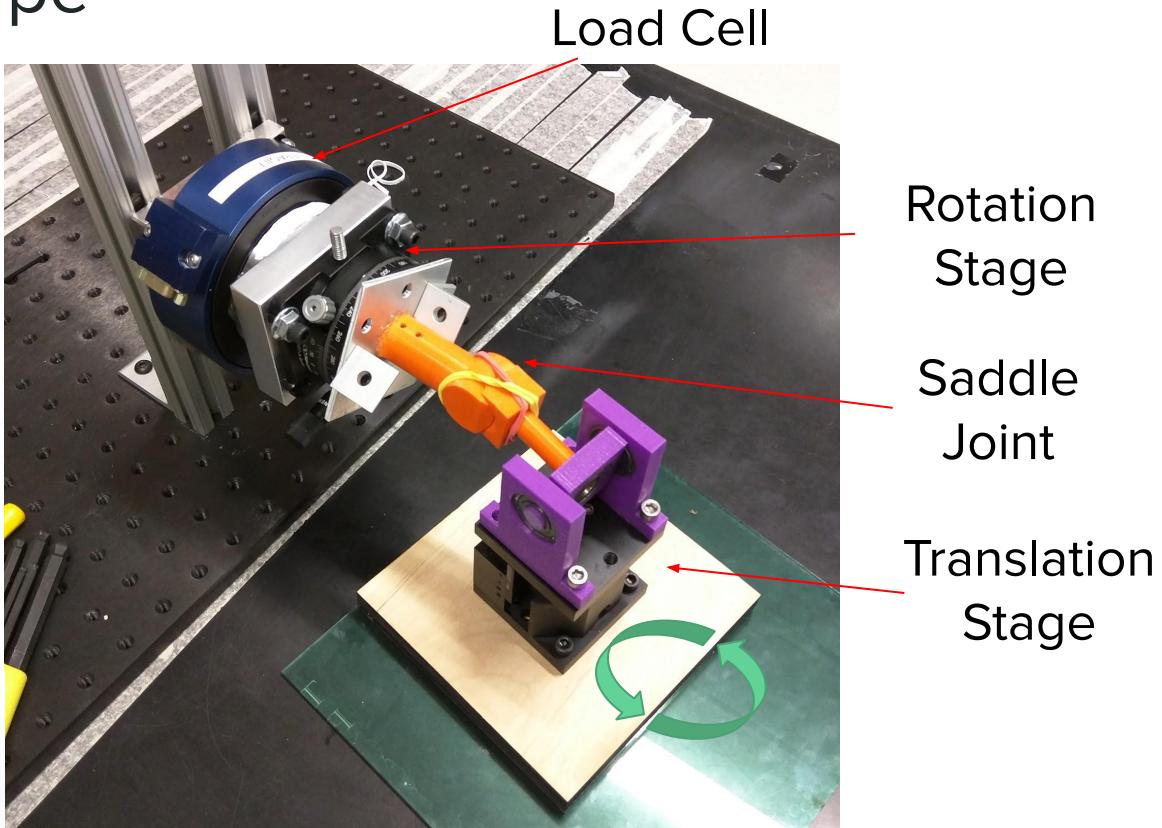
- 3 Key Principles:
 - Apply Displacement
 - Measure a load
 - Rotate
- Hooke's Law
 - $F = kx$
- 5 free degrees of freedom
- 1 imposed motion



First Prototype



First Prototype

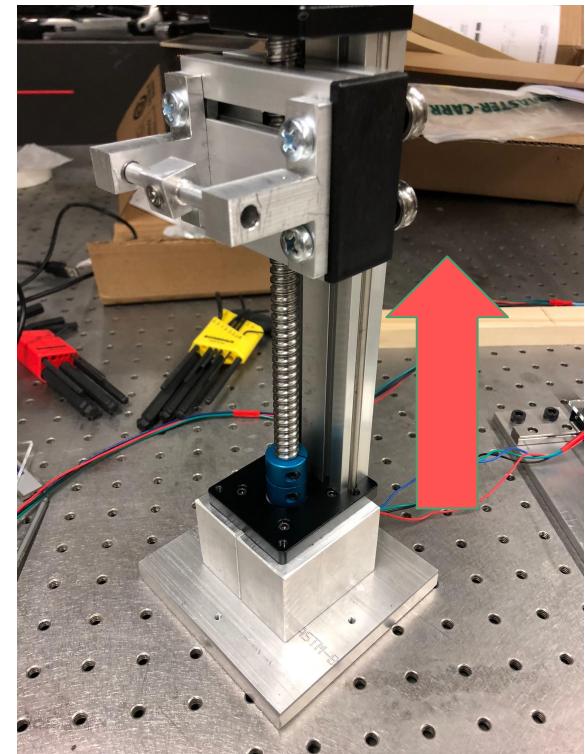


Takeaways

- Need a larger translation stage.
- Need to automate the translation stage.
- Want a lower friction 2D Rotation Stage.
- Want a more mechanically sound XY planar stage.

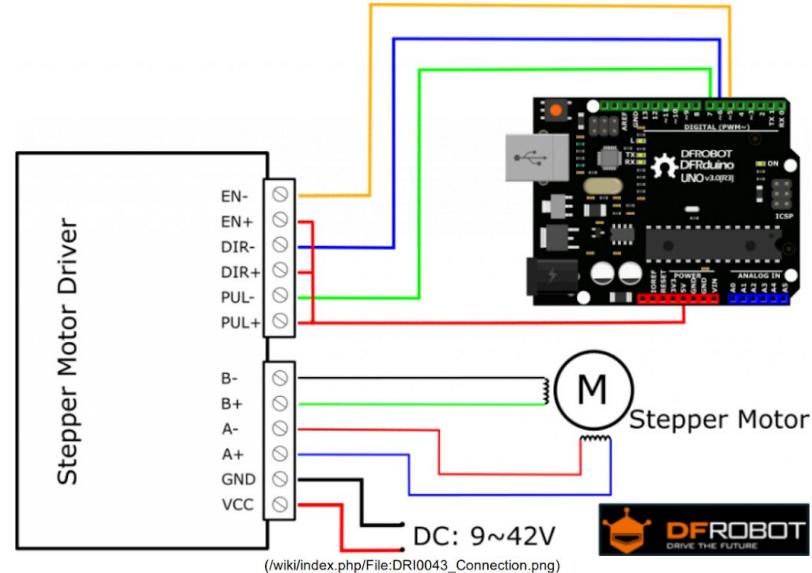
Final Design: Automated Translation Stage

- Nema 17 Stepper Motor
- 200mm Translation Stage



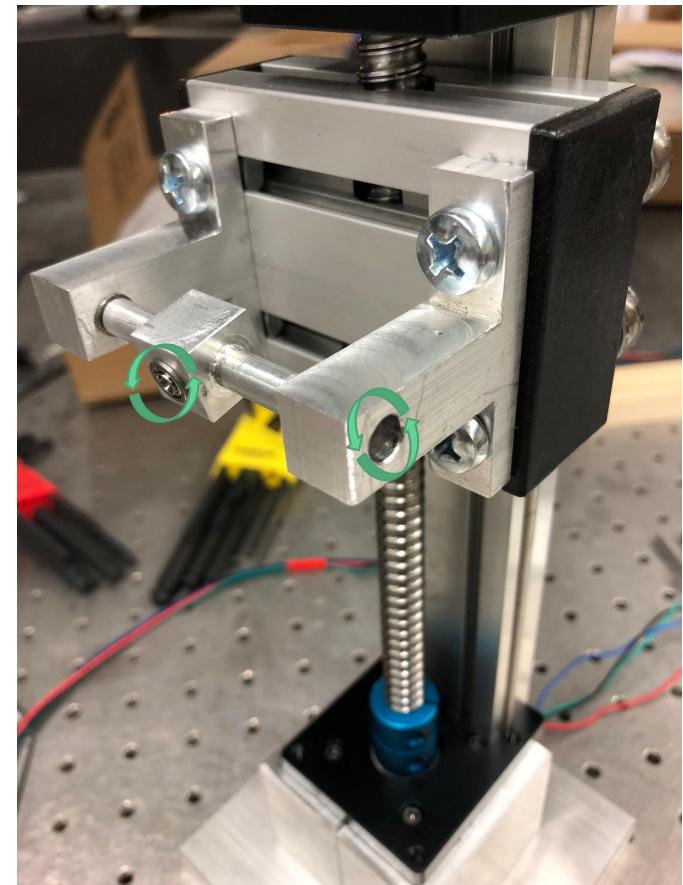
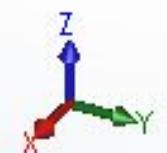
Final Design: Automated Translation Stage

- 24V Power Supply
- Microstep Motor Driver



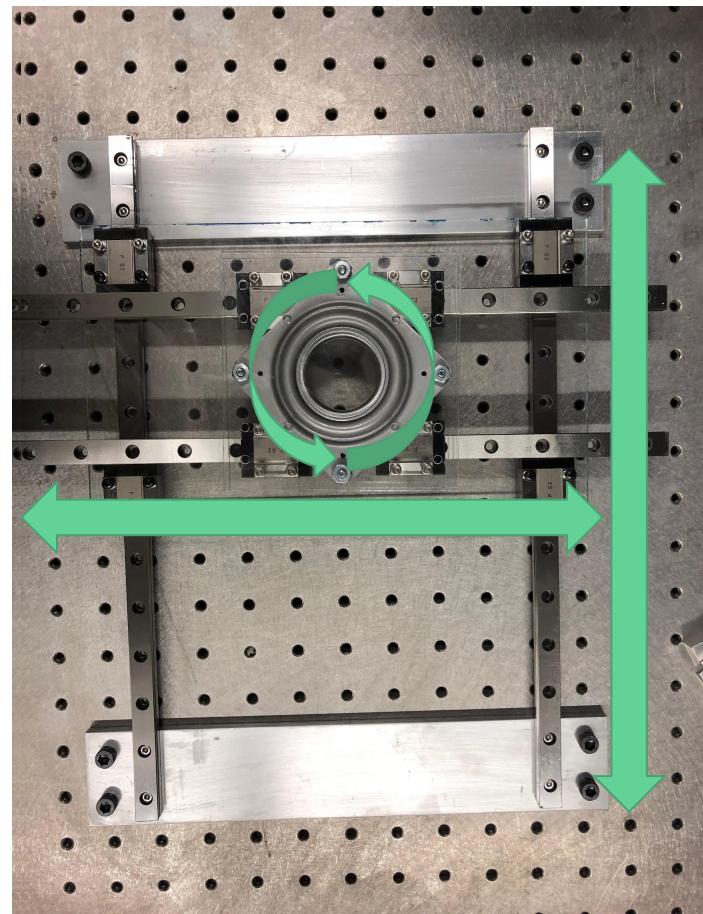
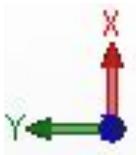
Final Design: 2D Rotation Stage

- Shielded Stainless Steel Ball Bearing
 - $\frac{1}{4}$ in Inner Diameter
 - $\frac{1}{2}$ in Outer Diameter
- Free rotation about the:
 - X-axis
 - Y-axis



Final Design: 2D Planar Stage

- Low Friction Stainless Steel Ball Bearing Carriage
- Free translation along the:
 - X-axis
 - Y-axis
- Free rotation about the:
 - Z-axis



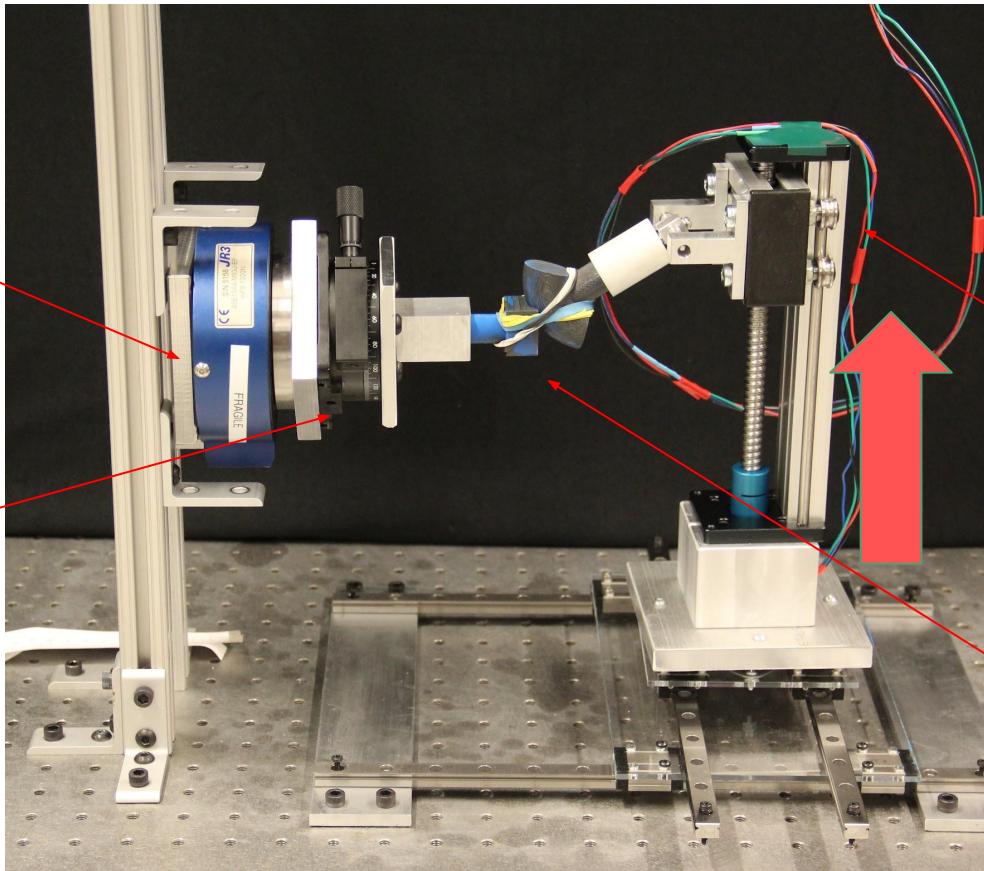
Final Design

Load Cell

Rotation Stage

Translation Stage

Joint Substitute



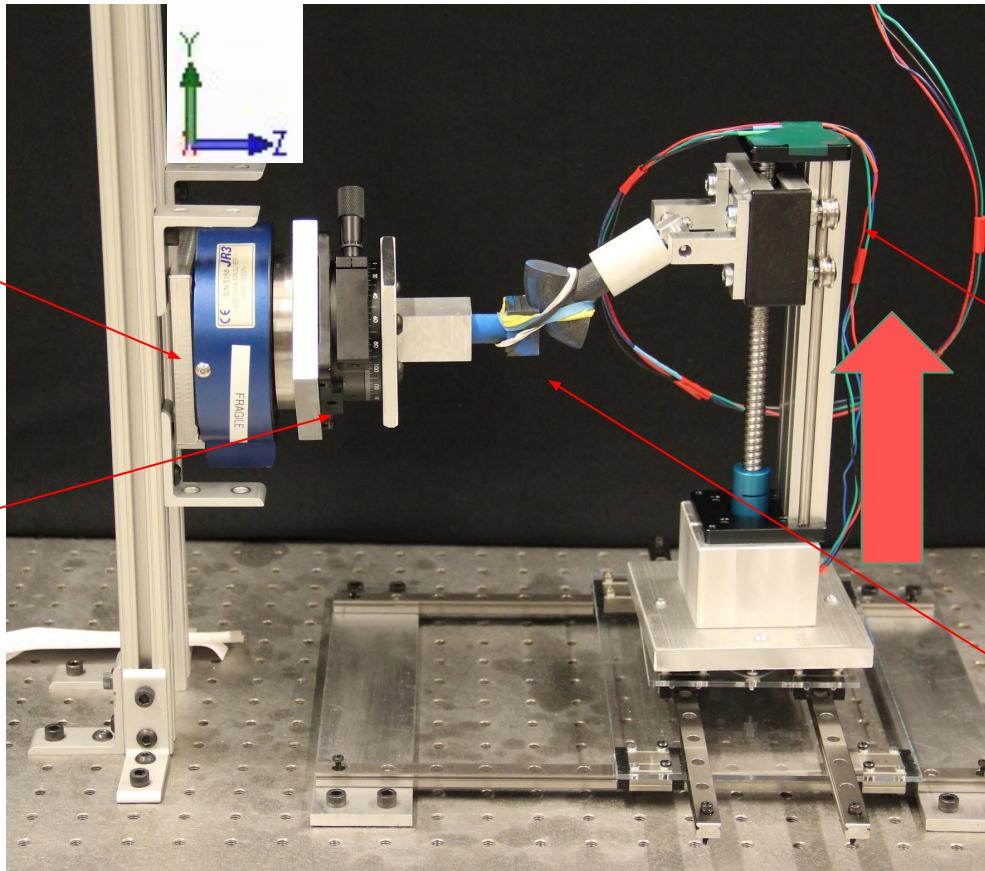
Final Design

Load Cell

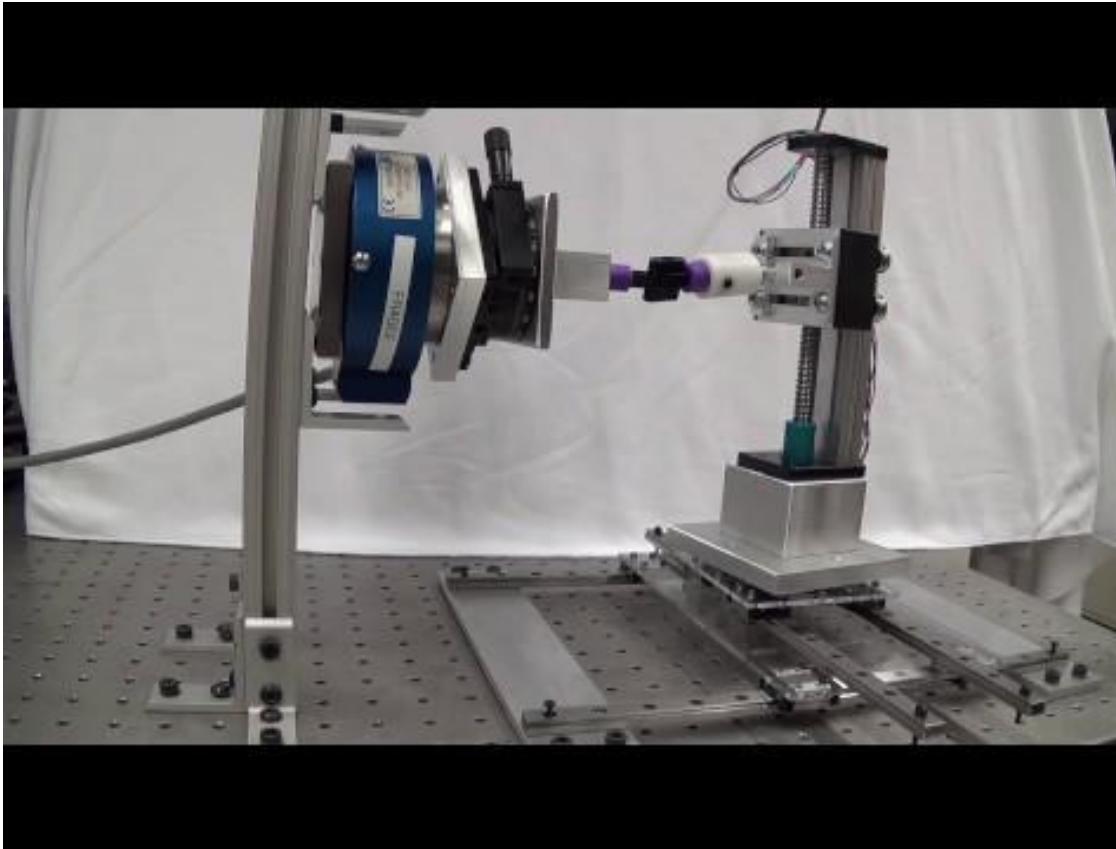
Rotation Stage

Translation Stage

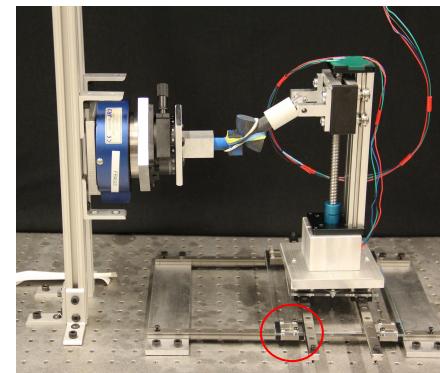
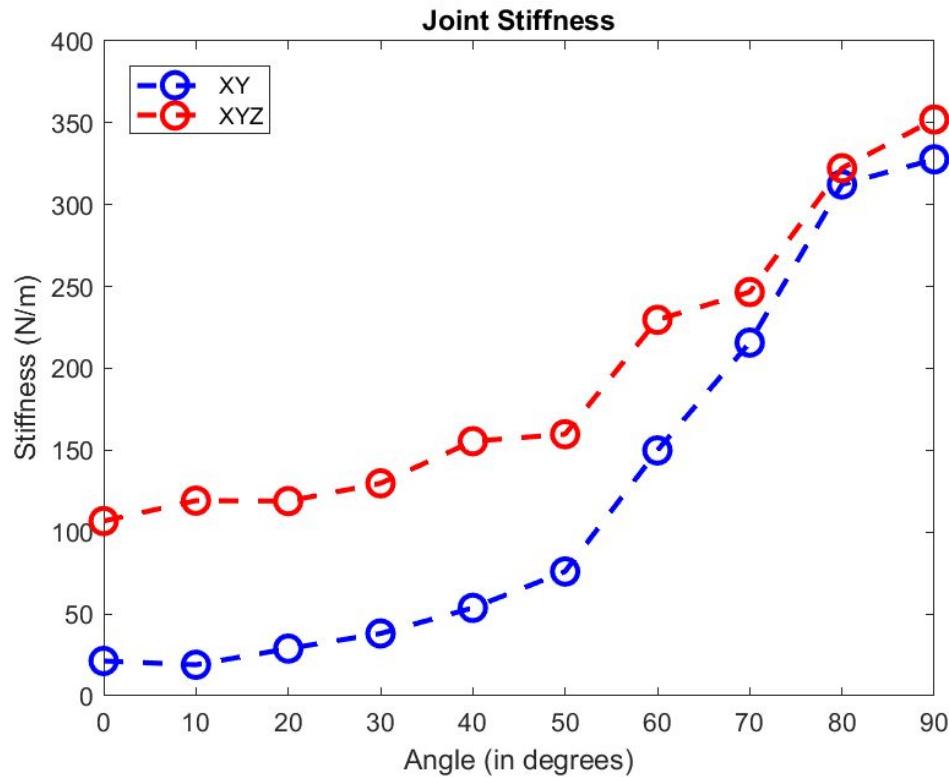
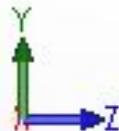
Joint Substitute



Preliminary Experiments



Preliminary Experiments - Results



Takeaways and Next Steps

- Friction in the 2D Planar stage.
 - May need to replace ball bearing carriages.
- Set up the ex vivo chicken knee experiment.

Acknowledgements

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