# Computational Design of a Bird-Inspired Perching Landing Gear Mechanism

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## Project Objective

Create a modeling tool that enables designers to predict whether the perching landing gear mechanism will be able to kinematically grasp structures of various cross-sectional shapes, sizes, and orientations and quantify the forces exerted by the grasp.

*Bio-Inspired Perching Landing Gear*

## Background

- Small UAVs often need to operate in settings with insufficient space for take-off and landing
- Bird-inspired landing gear enables perching on objects and surfaces
- Tieu *et al.* created a system using four-bar linkages and opposing, under-actuated flexible feet
- Grasping is actuated by cable tendons
- As the UAV's lands, its weight compresses the linkage, tensioning the tendon which curls the feet around the perch
- A computational model has been created to support the design and optimization of this mechanism

*Perching on a Ledge*

*Landing Sequence*

## Computational Model

A hybrid empirical-numerical model simulates grasping by iteratively updating the geometric state as the four-bar linkage collapses, then evaluates the resulting forces to determine if the grasp is successful

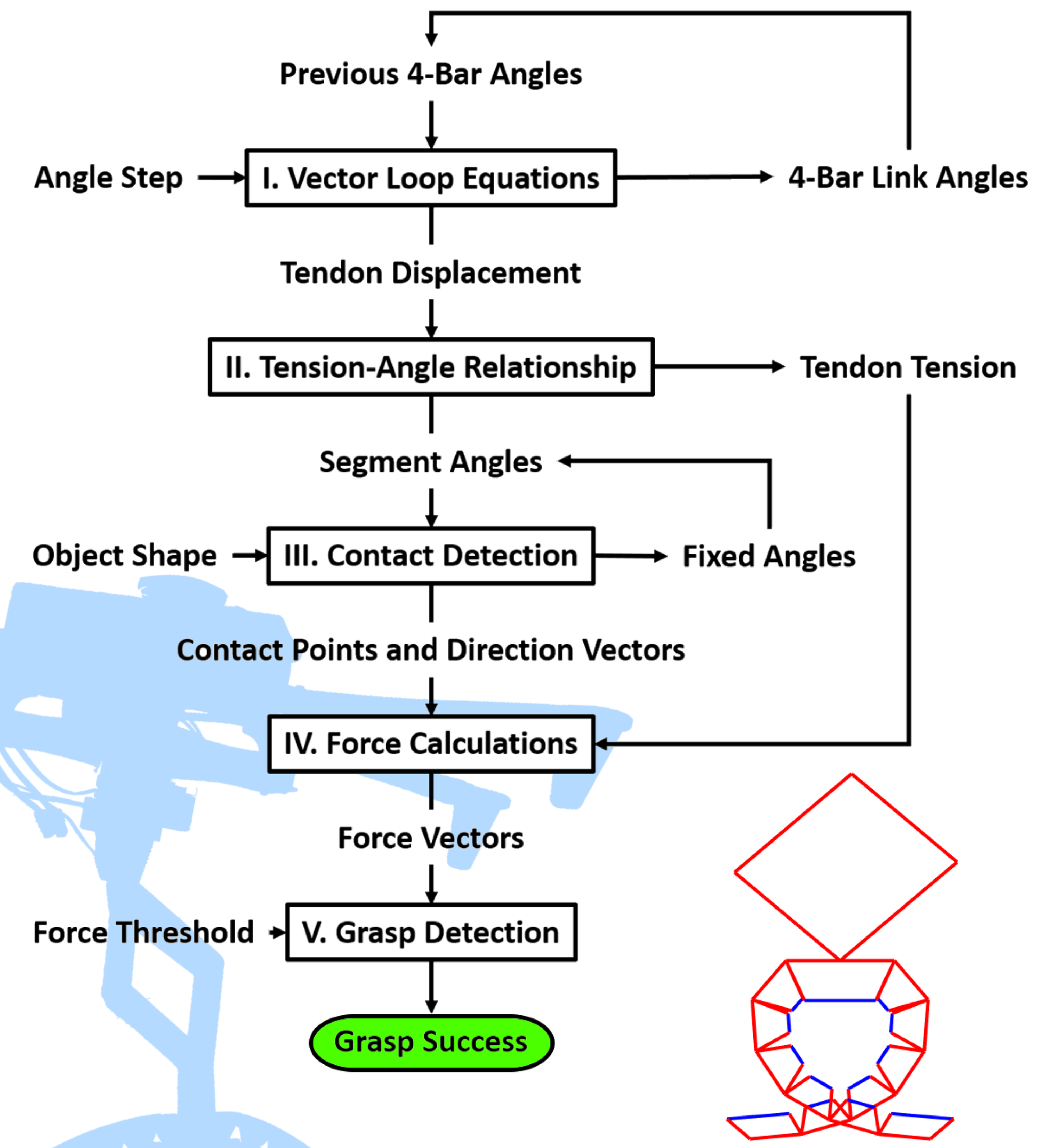
I. Changes in the geometry of the 4-bar linkage (modeled by vector loop equations) cause displacement of the cable tendon

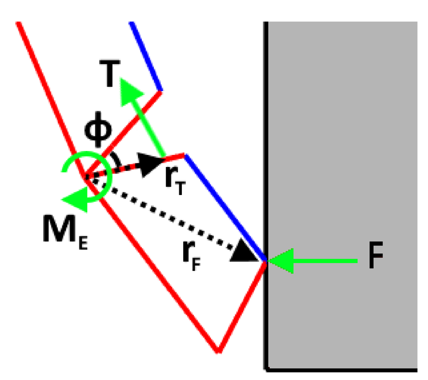
II. The displacement is used to compute the tendon tension and the relative angles of each foot segment using empirically determined relationships

III. Contact between each foot segment and the grasped object is detected

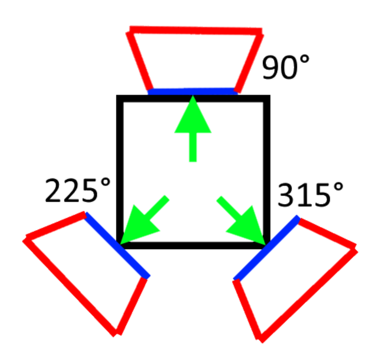
IV. The angle and magnitude of the resulting force is determined by computing torque on the foot segment

V. A successful grasp is recorded if the calculated forces fully constrain the system

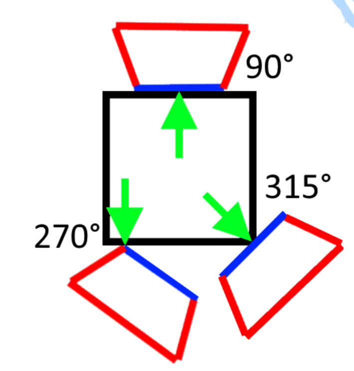



*Free Body Diagram*



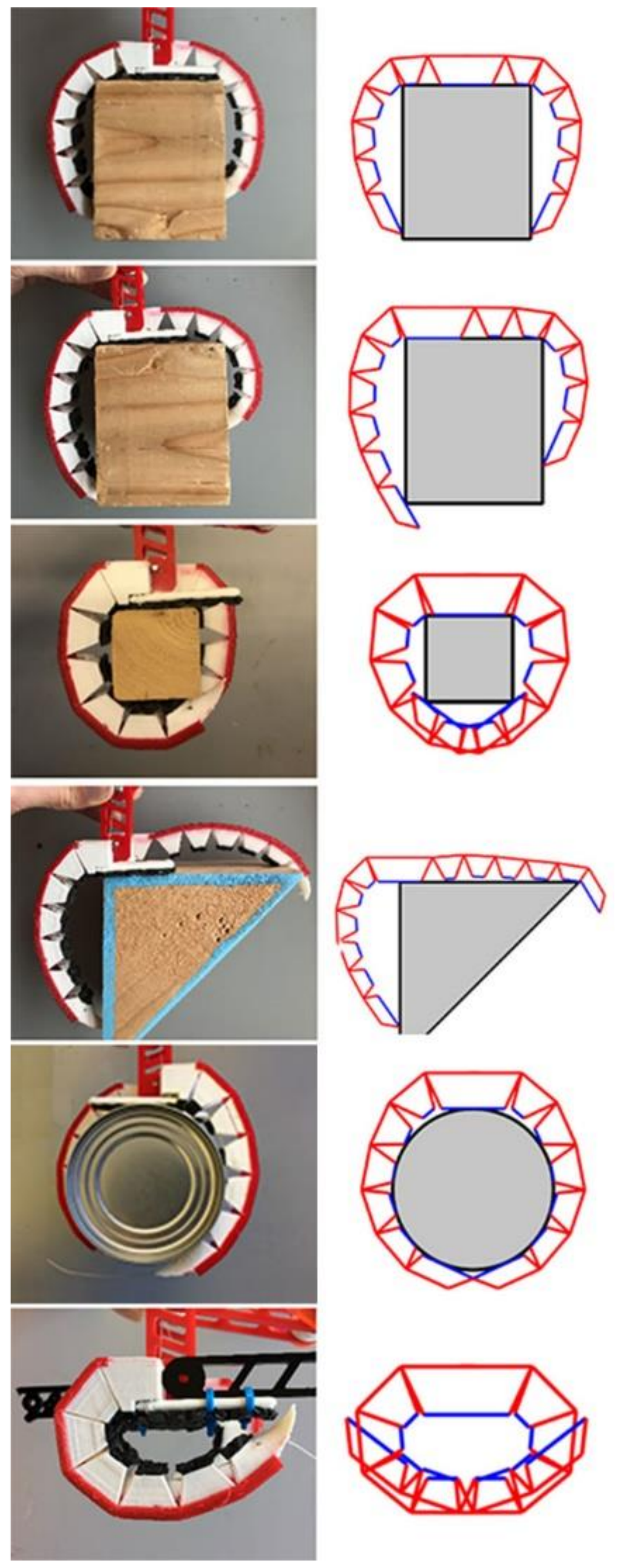

*Grasp Success*




*Grasp Failure*

*Simulated Model Geometry*

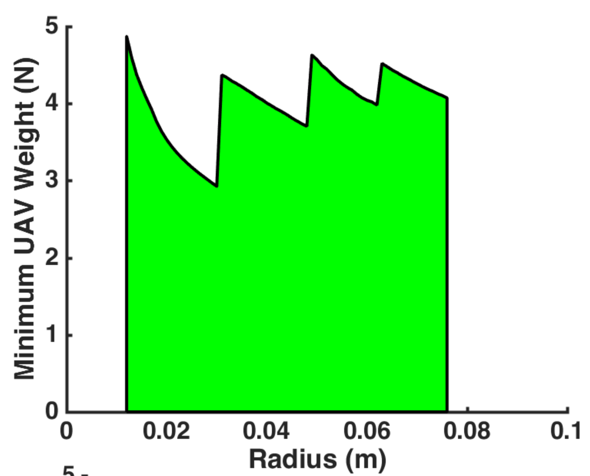
## Data and Results

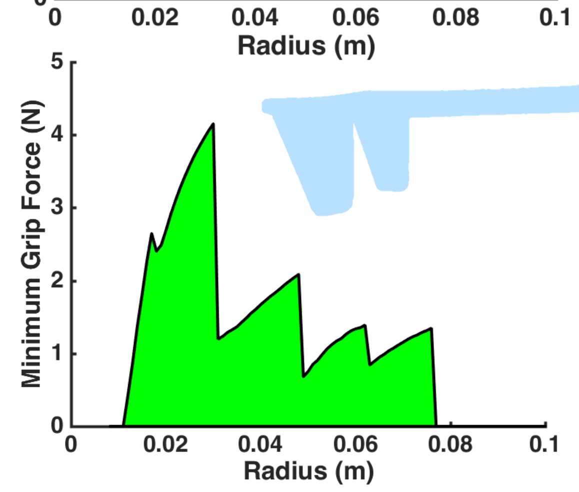


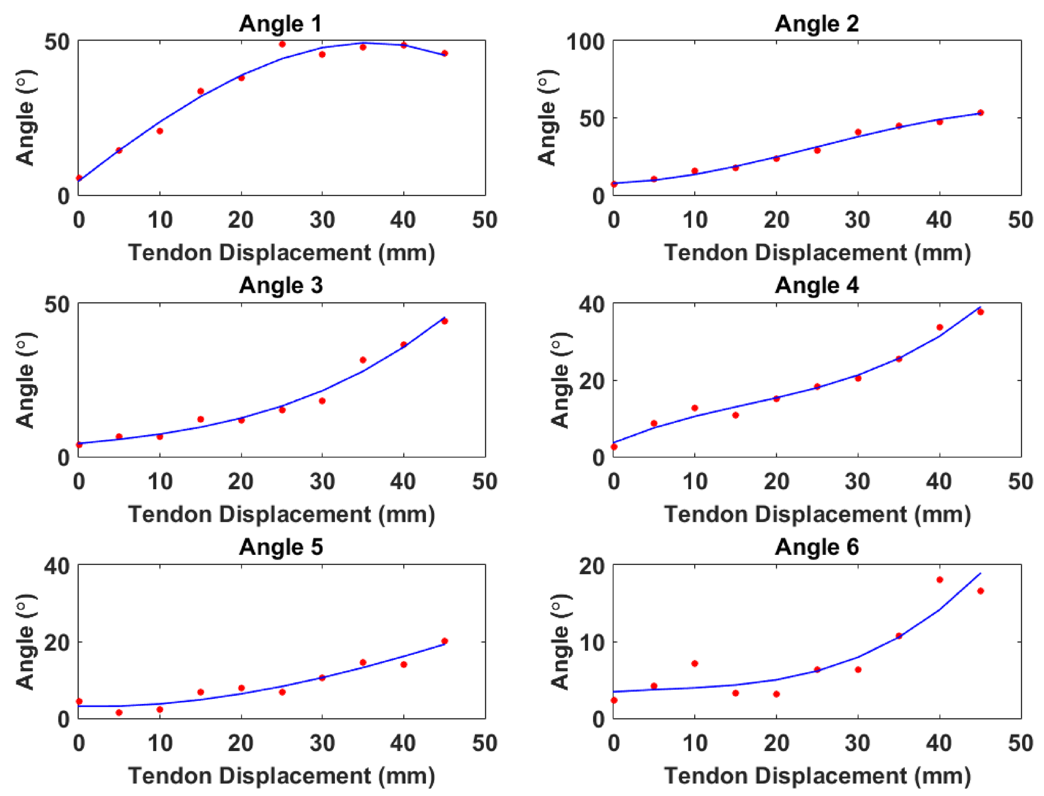
*BELOW:* Cubic polynomials are fit to the experimental tendon displacement vs tension and angle data

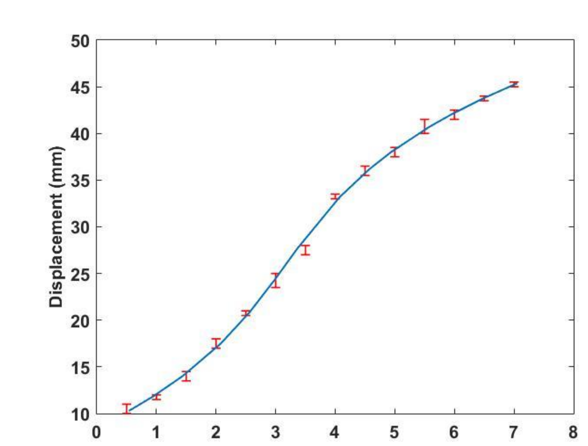
*LEFT:* Side-by-side comparison of simulation results with photos of the prototype grasping a variety of cross-sections

*RIGHT:* The model is swept over a range of circular cross-sections to determine grip force and UAV weight for a successful grasp (in green)



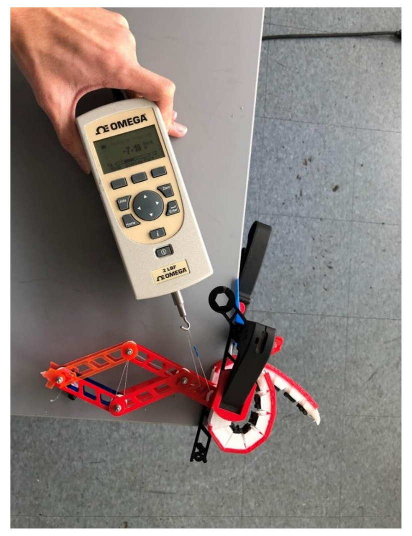



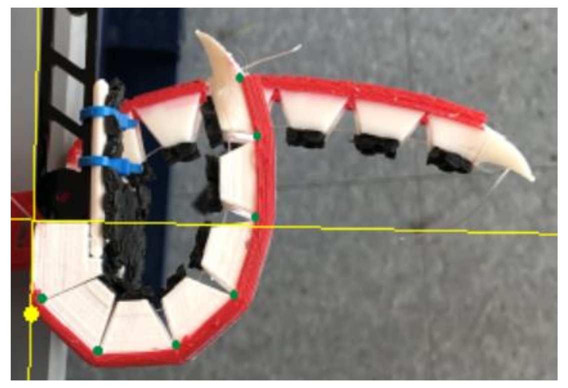




## Experimental Setup

- The model requires relationships relating tendon displacement to the tension and resulting individual segment angles
- Force gage measures tension at specified displacements
- Segment angles were extracted from photos at each displacement



*Force Measurement*



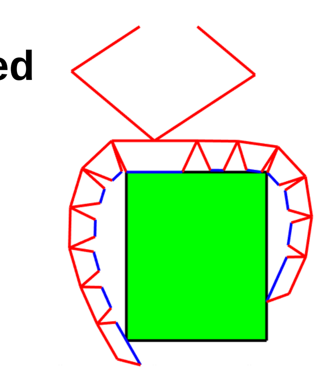
*Angle Measurement*

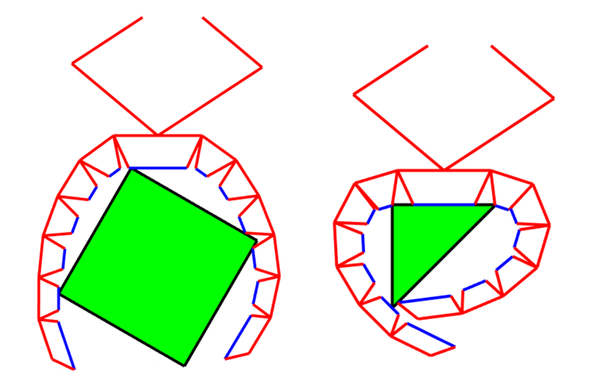
## Conclusions

- Successfully validated the kinematic motion of the landing gear grasping various objects
- Computed forces and moments were used to verify the success of the grasp
- The model has been swept over a range of parameters to extract useful data for designers

## Future Studies

- Experiments to validate forces computed by the model
- Relate talon geometry to link elasticity allowing simulation of new designs without the need for empirical measurements
- Further exploration of the design space and parameter optimization for a wider range of perching targets





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