The Kinematics of Bird Landings and Takeoffs on Natural and Artificial Surfaces

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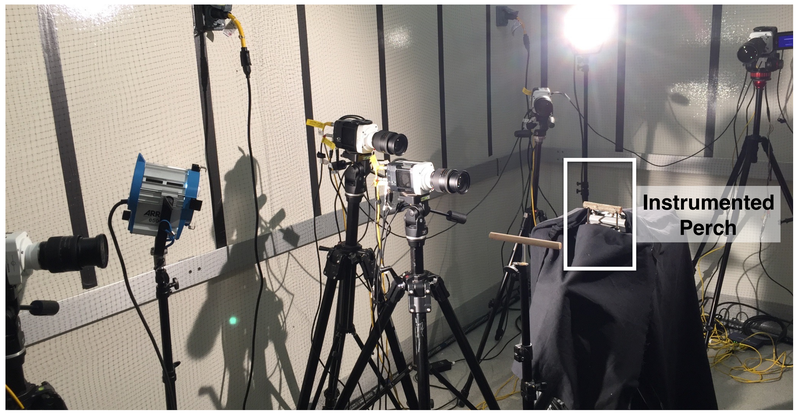
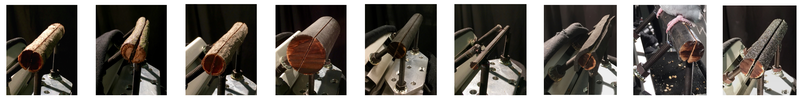
Abstract

Birds are able to perch on a variety of different surfaces in the natural world, from rough tree bark to smooth building exteriors. Landing and taking off reliably is also critical to the mission success of aerial robots. By studying the kinematics of how birds land and take off on different natural and artificial surfaces, we hope to integrate elements of bird perching behavior into aerial robot designs, enabling robots to perch more reliably. For this experiment, five high-speed cameras filmed parrotlets taking off and landing on nine different surfaces. The videos were analyzed with Ty Hendrick's point tracking software DLTdv5, recording the bird's body velocity, orientation, foot angles, and claw angles during each flight. To understand the feedback system that birds use after landing to correct for balance and stability, we also analyzed the number and type of foot lift adjustments they use after landing, as well as the frictional forces acting between different claw angles and surfaces. By integrating these results with previous findings, we will gain insight into the biological solutions of perching and grasping and use that as inspiration for future robotic mechanisms.

Experimental Setup





All recorded takeoffs and landings were made on an instrumented perch, which was made up of the 9 different natural and artificial surfaces shown above. From left to right: coast live oak, sweet olive tree, floss-silk tree, 1.5" diameter wood, .75" diameter wood, .25" diameter wood, foam, teflon, sandpaper

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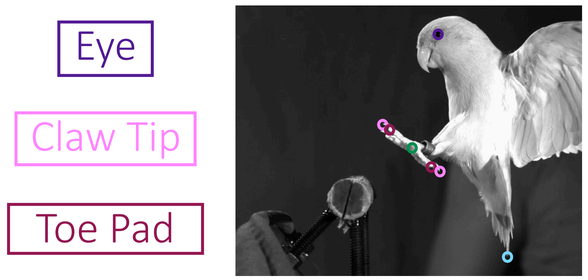
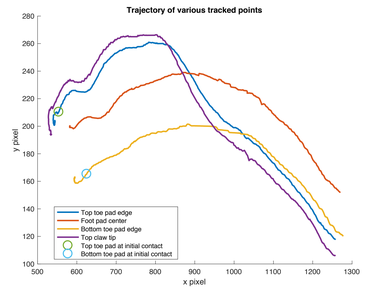
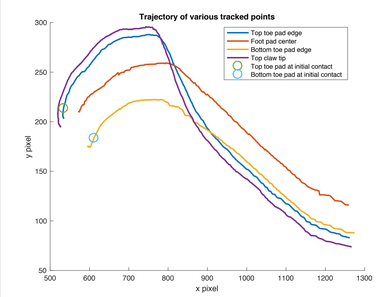
Point Tracking



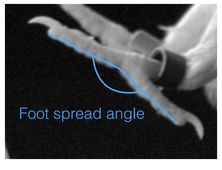
Teflon

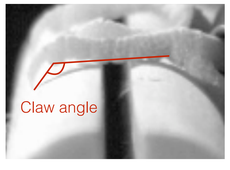


Sandpaper



Different points on the bird were tracked to better understand how the bird moves during flight, takeoff, and landing. The position of the bird eye, tail, left foot claw tips, left foot claw skin, and left foot claw joint were recorded. These points are then used to calculate the bird's body velocity and orientation during flight, as well as the foot spread angle and claw angle during flight, perching, and grasping. Below is the travel trajectory of different points. A foot and claw angle model is also depicted.





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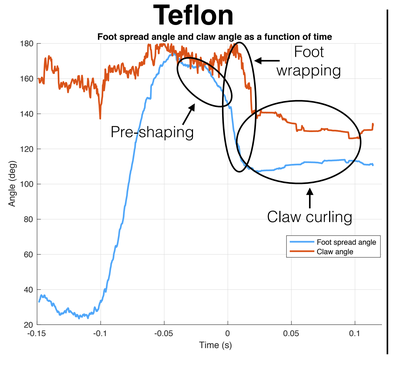

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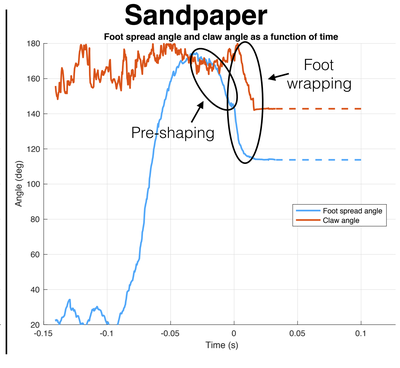


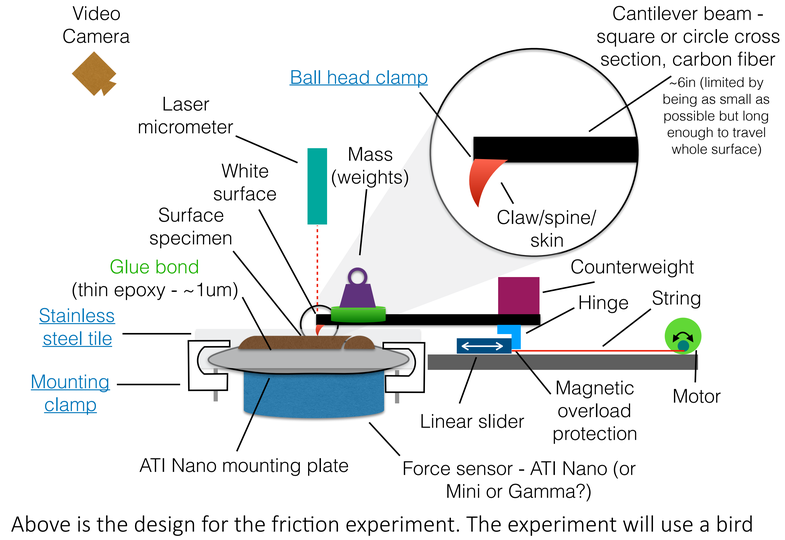
Landing Adjustments

The tables below show the average number of times the birds picked up their feet on different surfaces, which foot they lifted first, and which direction they moved the foot first.

Average #	Bird1	Bird2	Bird3	Avg
Natural Branch 1	1.67	3.00	2.67	2.44
Natural Branch 2	1.67	2.00	1.67	1.78
Natural Branch 3	2.33	2.00	1.67	2.00
Diameter Branch 1	1.67	1.67	2.00	1.78
Diameter Branch 2	2.67	1.67	1.67	2.00
Diameter Branch 3	2.33	1.00	0.67	1.33
Surface Branch 1	2.00		1.67	1.83
Surface Branch 2	3.67	1.67	3.00	2.78
Surface Branch 3	2.33	1.67	2.33	2.11
Avg	2.26	1.83	1.93	2.01

Total %	Bird1 (Right Footed)	Bird2 (Left Footed)	Bird3 (Left Footed)
Right Foot First	81%	17%	64%
Forward First	92%	83%	72%
Backward First	4%	9%	8%
Side First	4%	8%	20%

Friction Experiment



Above is the design for the friction experiment. The experiment will use a bird claw at different angles, a spine, and a regular indenter on the nine different surfaces to measure friction coefficients.