Super SCAMP: Relevant Scaling Considerations for Perching and Climbing with a Multimodal Robot

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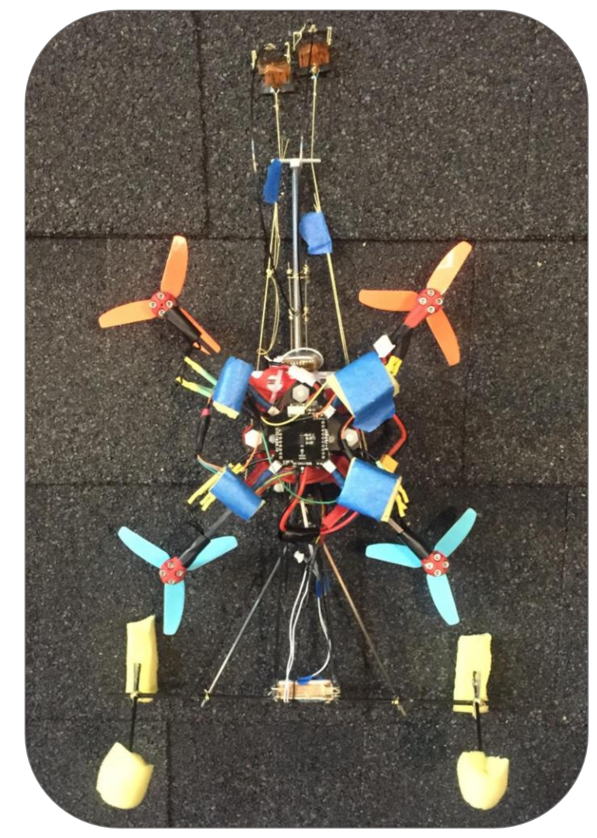
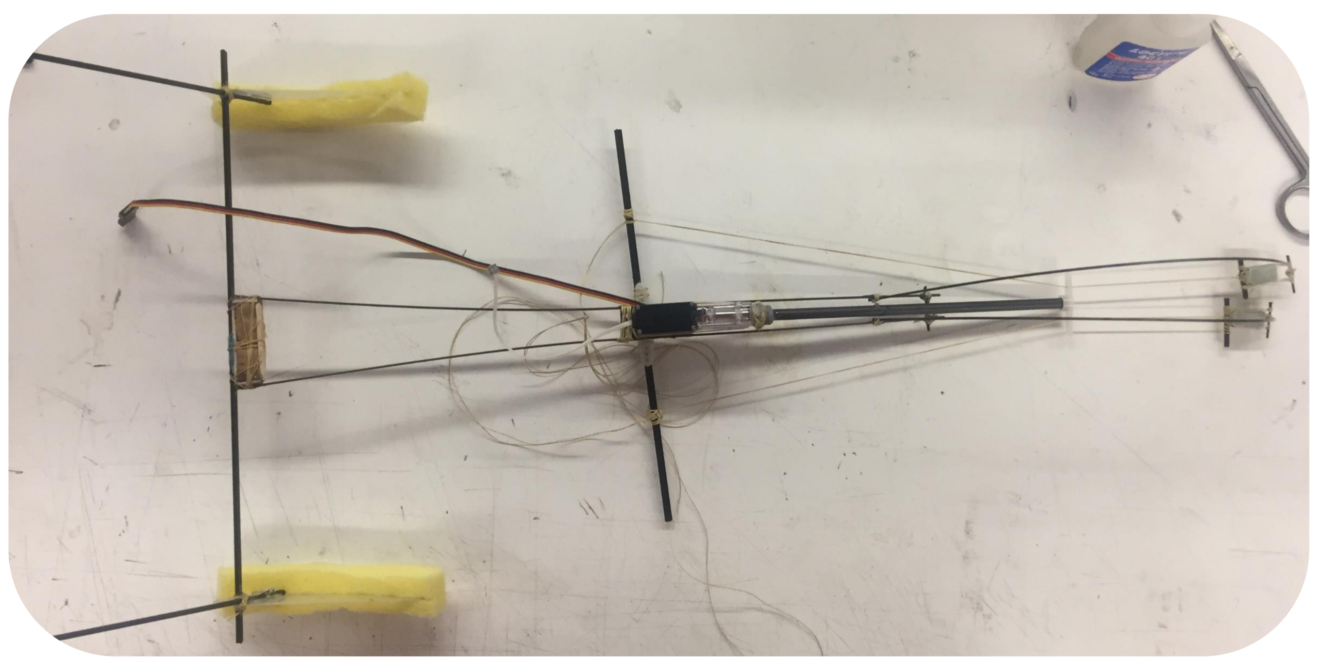
INTRODUCTION & MOTIVATION

The Stanford Climbing and Aerial Maneuvering Platform (SCAMP) is the first robot capable of flying, perching with passive technology on outdoor surfaces, climbing, and taking off again [1]. SCAMP was manufactured with funding as a part of the U.S. Army Research Lab's (ARL) Micro Autonomous Systems and Technology (MAST) consortium. This summer (Summer 2017), ARL is hosting technical demonstrations for all consortium members to demonstrate their work. The original SCAMP platform was not be suitable for the demonstration. Due to its light weight, we were unable to stabilize the flight of SCAMP's quadrotor. We, thus, decided to scale the platform to provide robustness for the demonstration by increasing the thrust capacity of the quadrotor, allowing us to stabilize and control its flight. We called our new platform Super SCAMP. An increase in the size of the quadrotor also meant that we needed to consider the ways the increased weight, length, and other factors would affect the perching and climbing of the robot.



MECHANISM DESIGN



VERSION 1
~42 g

Proportionally scaled with respect to the original SCAMP platform.

Problem Area:
The long, thin carbon fiber body frame led to activation of resonant vibration modes during flight.

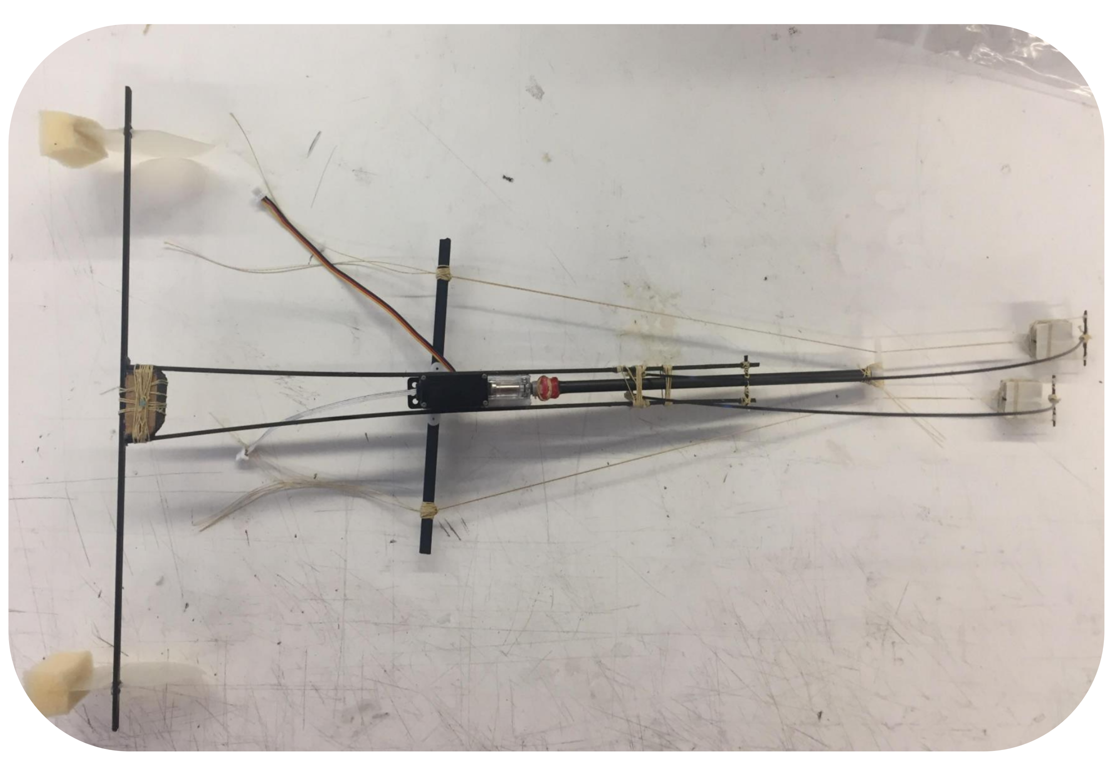
Prototype Solution:
A shortened frame with carbon fiber reinforcements enabled perching.

VERSION 2
~31 g

Adapted from prototype solution of Version 1 design.

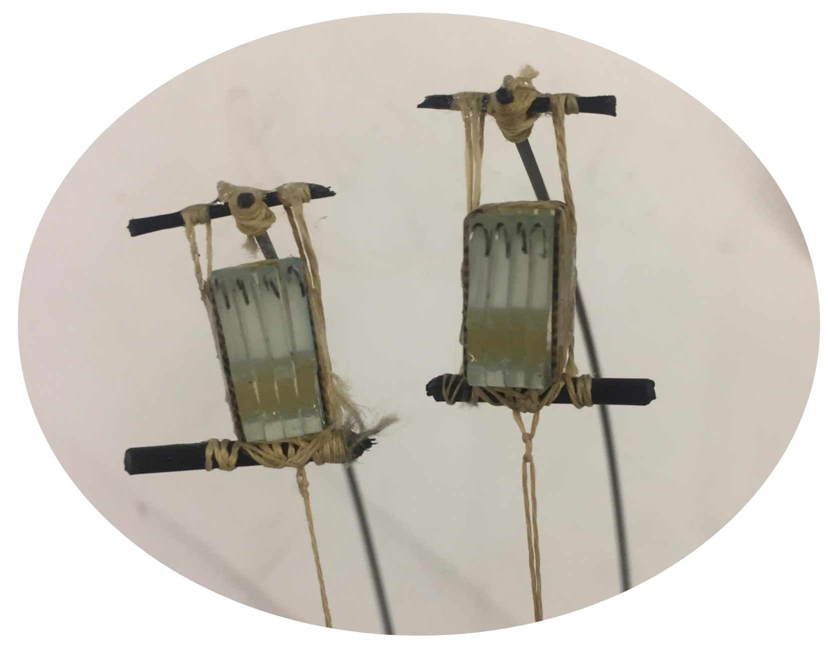
Solutions:
Condensed the frame and built it with thicker carbon fiber stock to prevent the activation of vibration modes.

Discarded the supplementary features to reduce weight (i.e., extend/retract arm size, in/out motor, etc.).

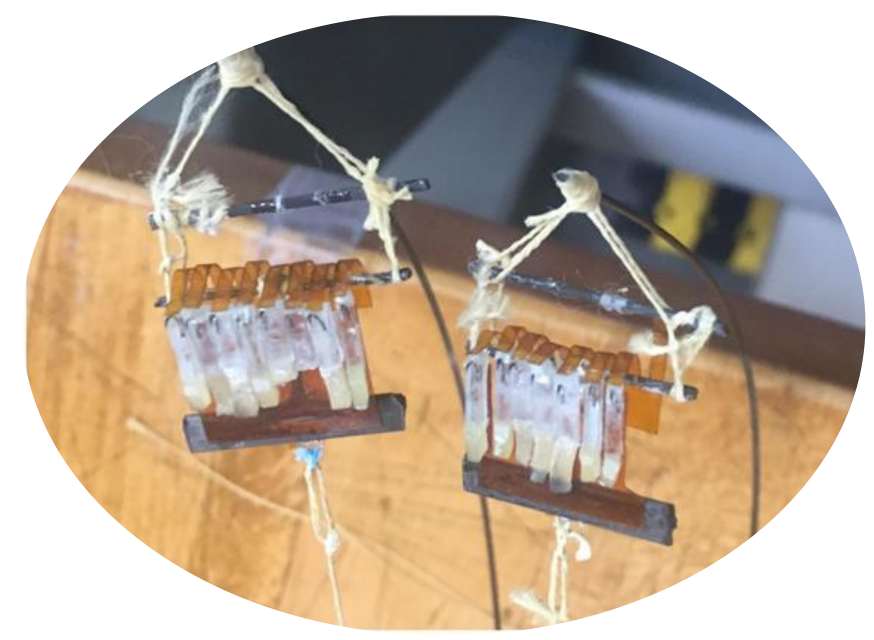


MICROSPINE DESIGN

Original SCAMP Microspines
Perching and climbing failure due to maximum load limits



Kapton Microspines
Perching success, but climbing failure due to flat-foot design



Combined SCAMP Microspines
Perching success, but climbing failure due to maximum load limits

Redesigned Kapton Microspines
Predicted perching and climbing success

CONCLUSION

We settled on a light and durable design that prevents the mechanism's body from adding external vibration disturbances to the quadrotor's flights, allowing us to maintain stable flight until perching. Once perched, we developed a robust microspine design using 0.05-inch Kapton sheet that is compliant in the normal direction to allow individual spine movements, but stiff in the axial direction to support the weight of the new platform. The larger spines on the platform will increase the likelihood of successful perching and climbing on surfaces with larger-sized asperities, such as the roofing shingles we are using for the experiments during this project. Future work for this project may include continuing to scale platforms to larger quadrotors to determine the weight limits and constraints on perching and climbing with spines.

ACKNOWLEDGEMENTS

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REFERENCES

[1] M. T. Pope et al., "A Multimodal Robot for Perching and Climbing on Vertical Outdoor Surfaces," IEEE Transactions on Robotics, vol. 33, no. 1, pp. 38-48, February 2017.