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Diploma Thesis

DEVELOPMENT AND FABRICATION OF A GRIPPER FOR A PERCHING UAV

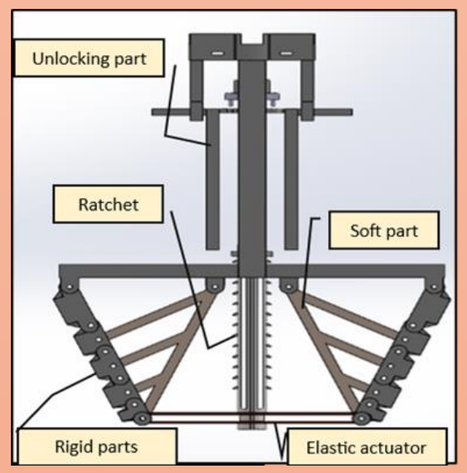
Abstract

This thesis aims at the development of a gripper for a perching UAV, providing an overview of the process from conceptual design to the fabrication of the mechanism. The final product includes flexible-rigid material integration and passive operation for low energy consumption. Kinematic analysis and simulations were run to test its strength and 3D printing was used for manufacturing. Finally, tests were conducted on various objects, in order to assess the gripper's performance, while revealing areas for design improvements.

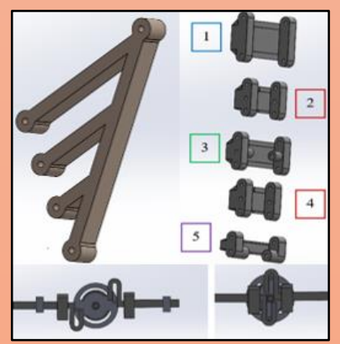
Process:

Detailed design → Kinematic analysis → Simulations → Fabrication → Assembly → Tests

Design Analysis



- The completed design includes fingers based on the Fin Ray® design
- Incorporates both soft and rigid
- An elastic part assumes the role of the actuator, bringing the fingers together through its tension.
- The mechanism locks in many different positions, depending on the diameter of the target, with a linear ratchet
- It includes an unlocking mechanism, inspired by the scotch yoke.

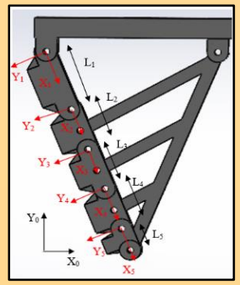


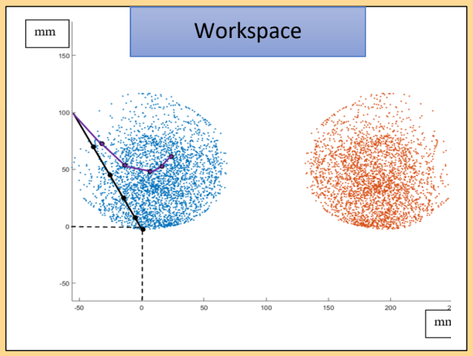
The result of the above is a simple, lightweight gripping system, that consumes very little power due to its passive actuation. As such, it does not burden a UAV, but enriches its capabilities and functionality.

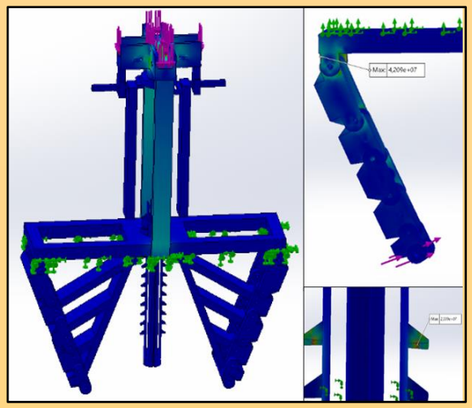
Kinematic and Strength Analysis

- The Denavit - Hartenberg table was used to form the workspace
- The denser areas signify the most possible position of the fingers.

i	a_{i-1}	L_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	0	L_1	0	θ_2
3	0	L_2	0	θ_3
4	0	L_3	0	θ_4
5	0	L_4	0	θ_5



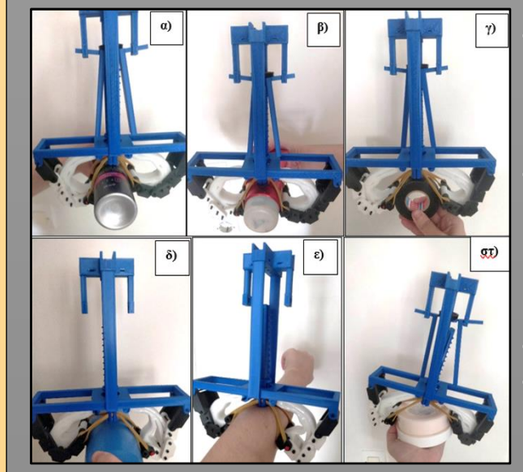


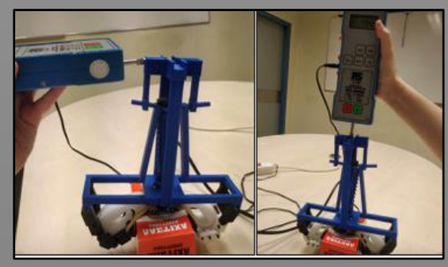


- The simulations were focused on the rigid parts (phalanges, ratchet and base)
- The gripper received both forces and torques and performed remarkably well
- The maximum stress never exceeded the material's yield point.

As a result, the material for the rigid parts was decided to be PLA+ (used in the simulations), but, since it was not feasible to simulate the soft parts, a fabricated protype was necessary for further testing. The methods used were 3D printing for the rigid parts and silicone molding for the soft ones.

Experiments





- The gripper's perching capability was tested on cylindrical objects
- Varying material (mainly plastic and metal), compliance and diameter (50-97mm).
- Successful perching
- More stable on objects with a diameter of 55-80mm and rough surfaces.
- High sensitivity to disturbances, highlighting the need for increased gripping force.

Conclusions

From the experiments we can infer that the gripper, while it does not fully encompass the target object, as initially intended, was able to perform in its tasks. It perched in many different objects and had similar results in object pick up. As a future work, improvements could be made, regarding its elastomer parts. A soft finger, for example, of higher shore hardness could contribute in higher griping forces. All in all, the gripper has high endurance and satisfactory functionality. It constitutes an easily fabricated, cost-effective and low consumption solution in aerial manipulation.