

# A 79g Manipulator Prototype for E-Flap Robot: A Plucking-Leaf Application

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# Objective

- Manipulator and electronics weight: less than 100g
- Installation of the manipulator on the E-Flap and fly again!
- Perform some manipulation task  
A plucking leaf application



# Description of two-DOF robot manipulator

- Manipulator with 2 DOF
- It has two DC motors
- A gripper actuated by a servo



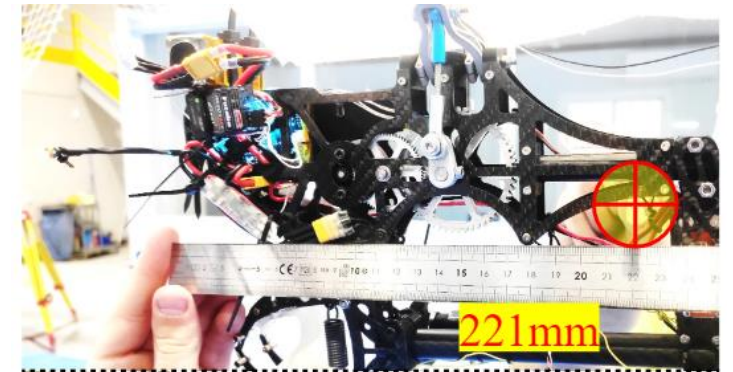
# Integration of the two-DOF manipulator in E-FLAP

Mounting it at the tip of the bird has several advantages

- It can be placed on the wings during the flight
- It also has access to the workspace in front of the bird after perching on a branch
- The CoM of the E-Flap is slightly modified



E-FLAP  
with claw



E-FLAP  
with claw  
and  
manipulator



# Nonlinear control design

Control of the manipulator  
once the system is perched

Dynamics of the manipulator

$$\mathbf{M}(\mathbf{q})\ddot{\mathbf{q}} + \mathbf{c}(\mathbf{q}, \dot{\mathbf{q}}) + \mathbf{g}(\mathbf{q}) = \mathbf{u},$$

Control design:

1. We cancel out all the nonlinearities using feedback

$$\ddot{\mathbf{q}} = \mathbf{v},$$

1. We use a PID controller for each angular position

$$\mathbf{R}(s) = \text{diag}\left(k_p + \frac{k_i}{s} + k_d s, k_p + \frac{k_i}{s} + k_d s\right)$$

# Video Attachment of: A 79g Manipulator Prototype for E-Flap Robot: A Plucking-Leaf Application

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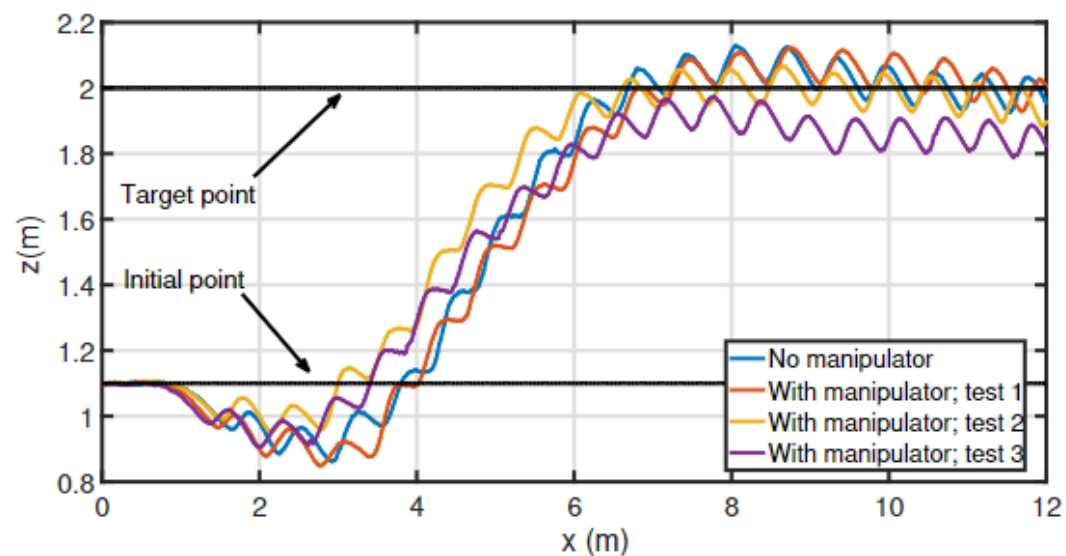


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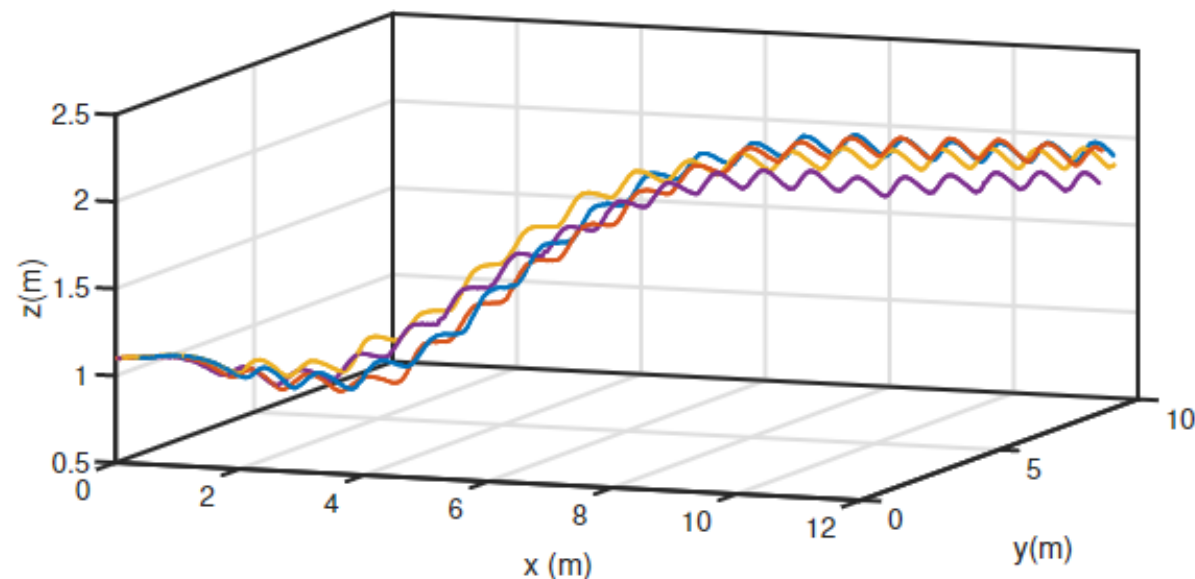
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# Results of the flights

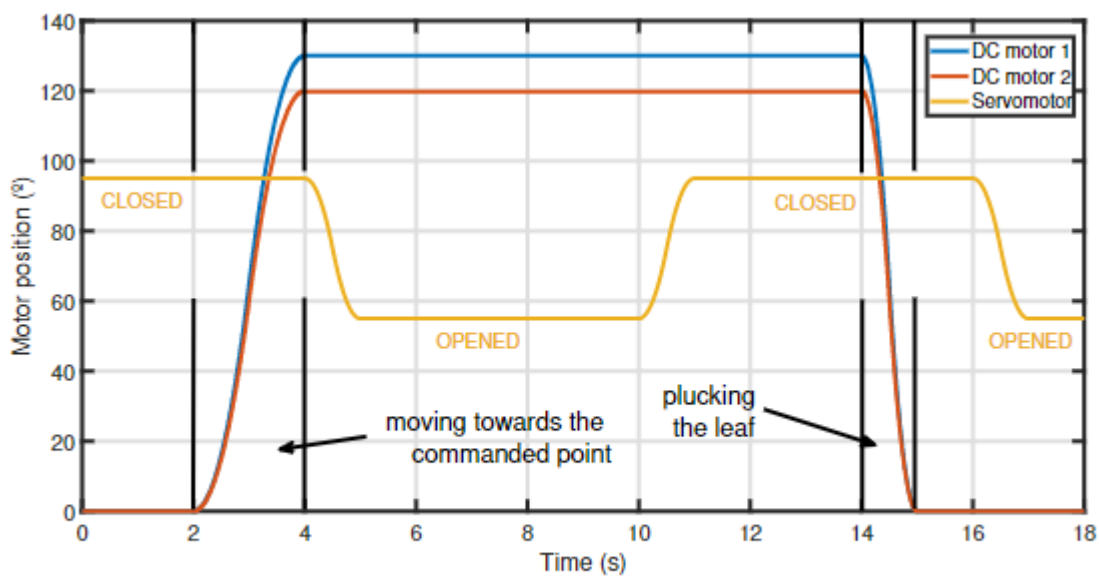


Robot's trajectory in the XZ plane with and without the manipulator.

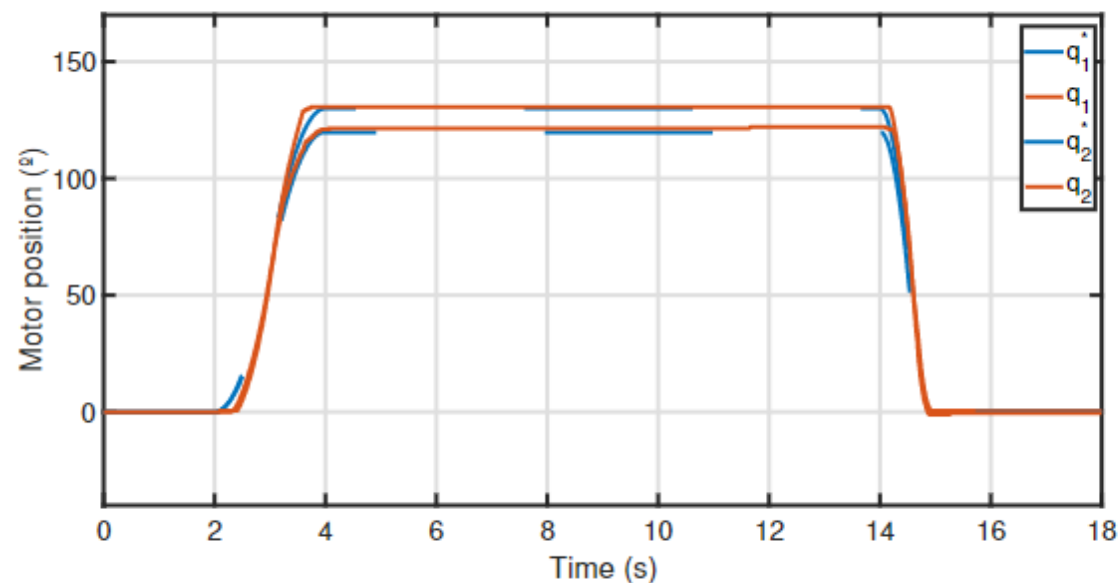


Robot's 3D trajectory with and without the manipulator;

# Results of the manipulation



(a) Position of the DC motors and the servomotor.



(b) Trajectory tracking of the DC motors.



# Conclusions and future works

- Presents the design of a ultra lightweight manipulator (79.7g) for flapping wing flying robots to sample/pluck leaves from a branch or tree after perching
- A plucking a leaf experiment has been shown. This approach could also be used to carry some medicine in rescue missions
- In future works, we will increase the number of arms in order to perform dual manipulation and also we will add vision to the system to perform autonomous tasks