Physically Interacting Maintenance Drones

Ayham Alharbat

Researcher

Mechatronics Research Group

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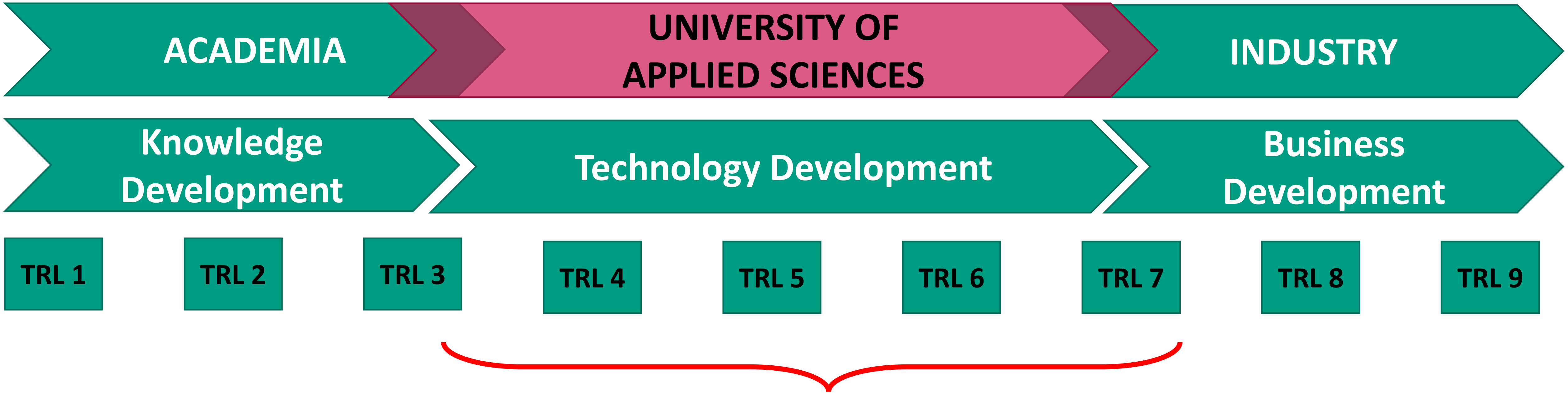
WHO ARE WE?

Saxion University of Applied Sciences



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TRL = Technology Readiness Level

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RESEARCH GROUP OF MECHATRONICS

Your reliable partner in sustainable innovation enabled by Robotics, Mechatronics and Artificial Intelligence

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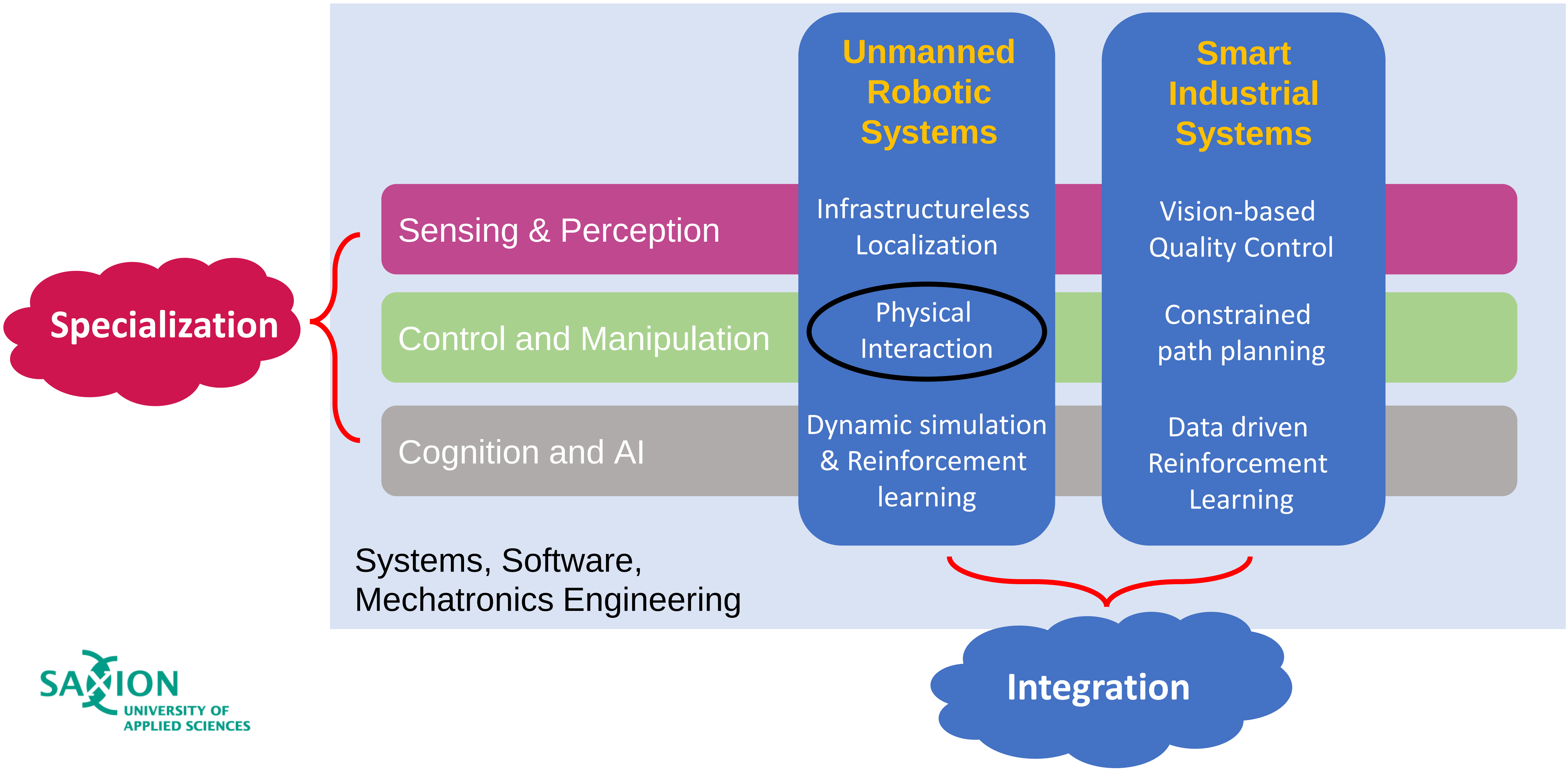
Research institutes

Public sector

Network associations

MECHATRONICS RESEARCH GROUP



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Hanieh Esmaeeli
PhD Candidate

Abeje Y. Mersha
Professor of Unmanned Robotic Systems

Ayham Alharbat
Researcher

MECHATRONICS RESEARCH GROUP TEAM

OUTLINE

- Background
- Preliminary Results
- Maintenance Drone Design & Control
- Selected Results and Challenges
- Outlook

BACKGROUND

cleaning

Maintenance

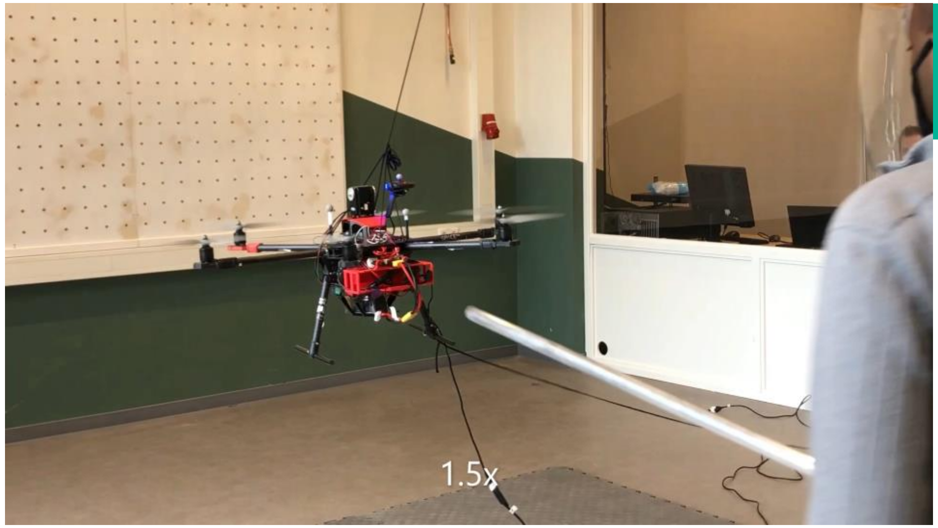
Inspection

Spraying

- Safety
- Cost-effectiveness
- Performance (speed, selectiveness, frequency, ...)

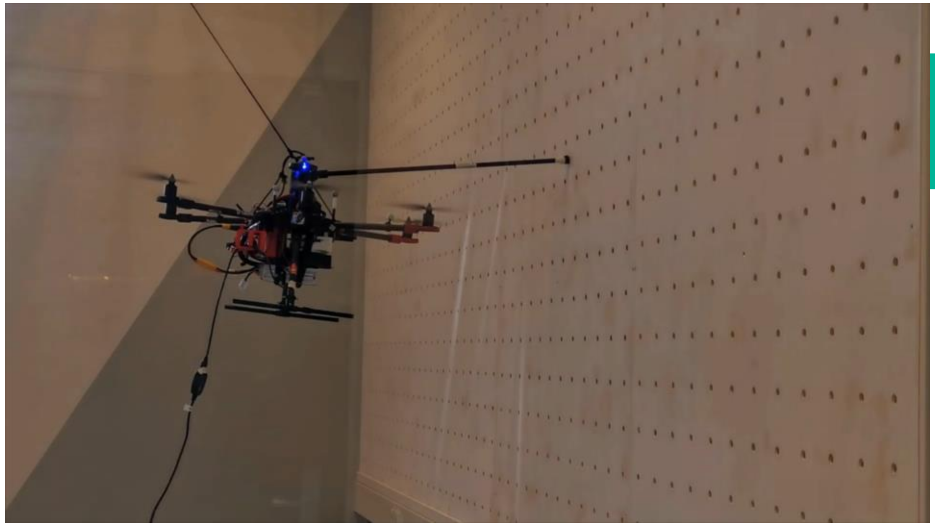
Getting the data to the people, not the people to the data

PRELIMINARY RESULTS

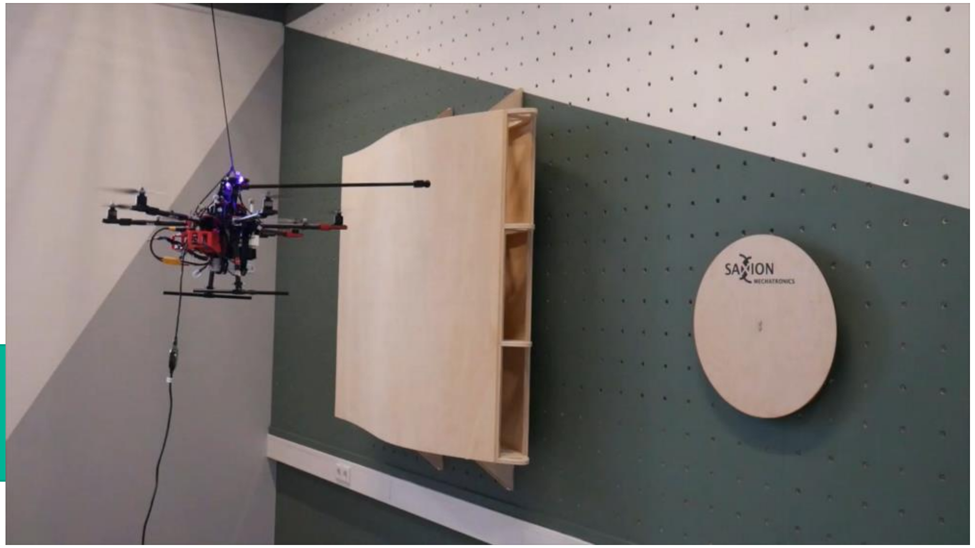


Intermittent unexpected interaction

Significant disturbance and recovery

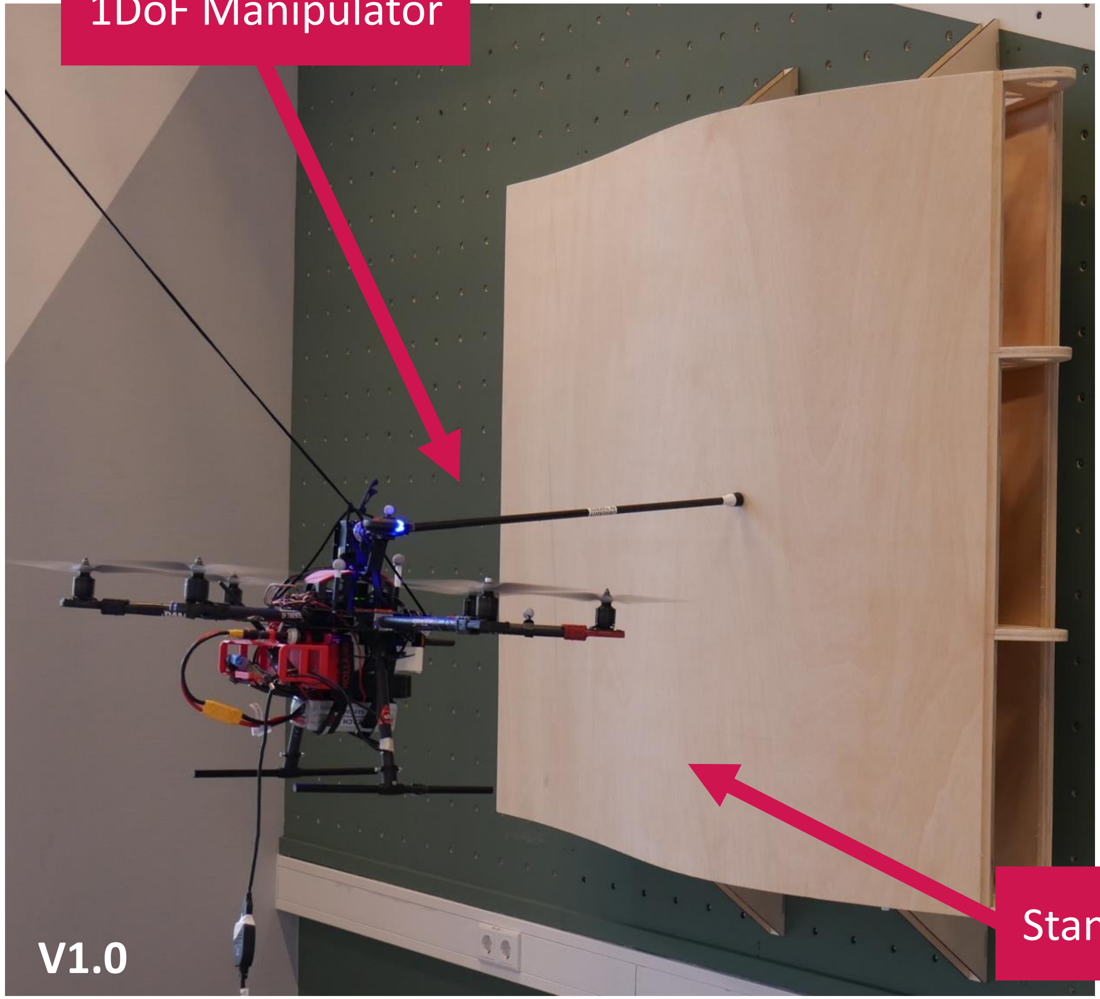


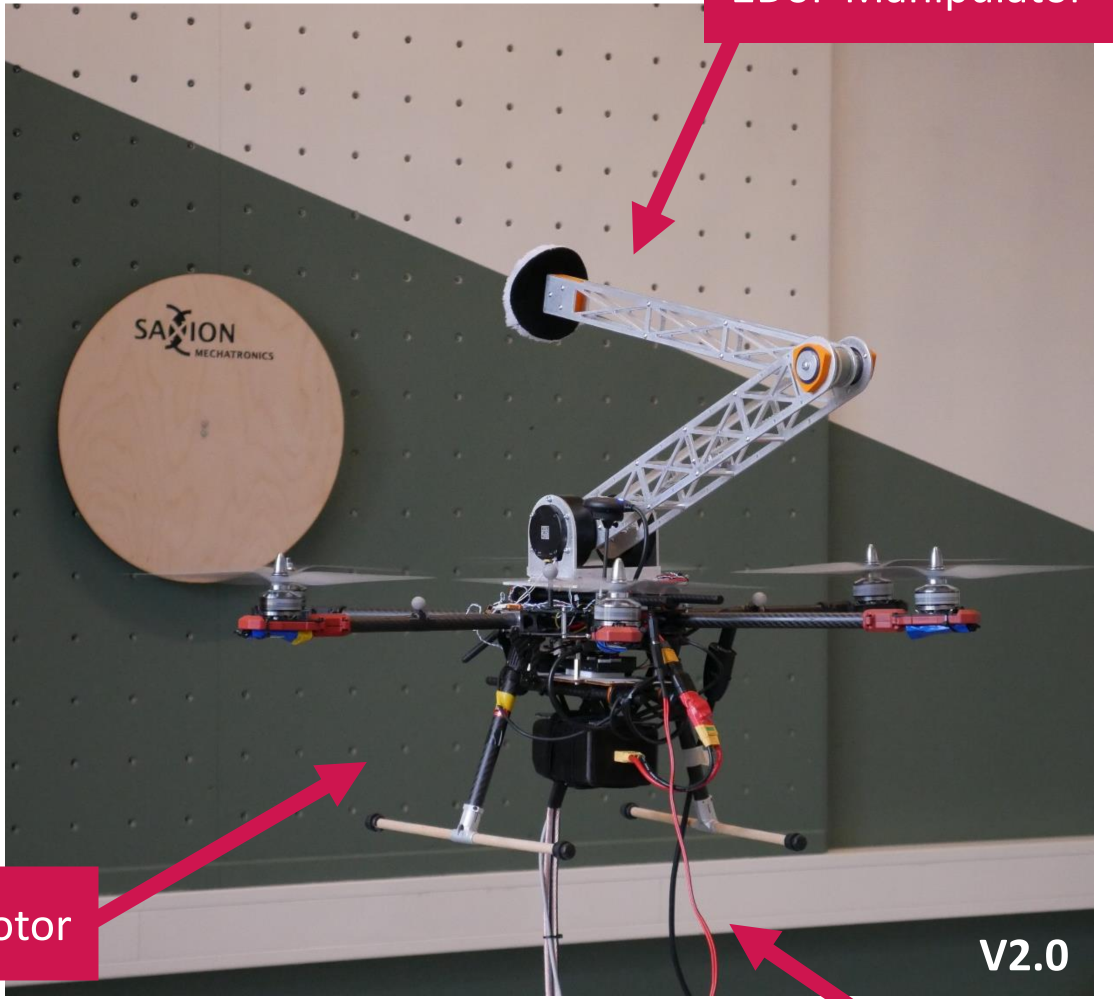
Interaction of flat surface



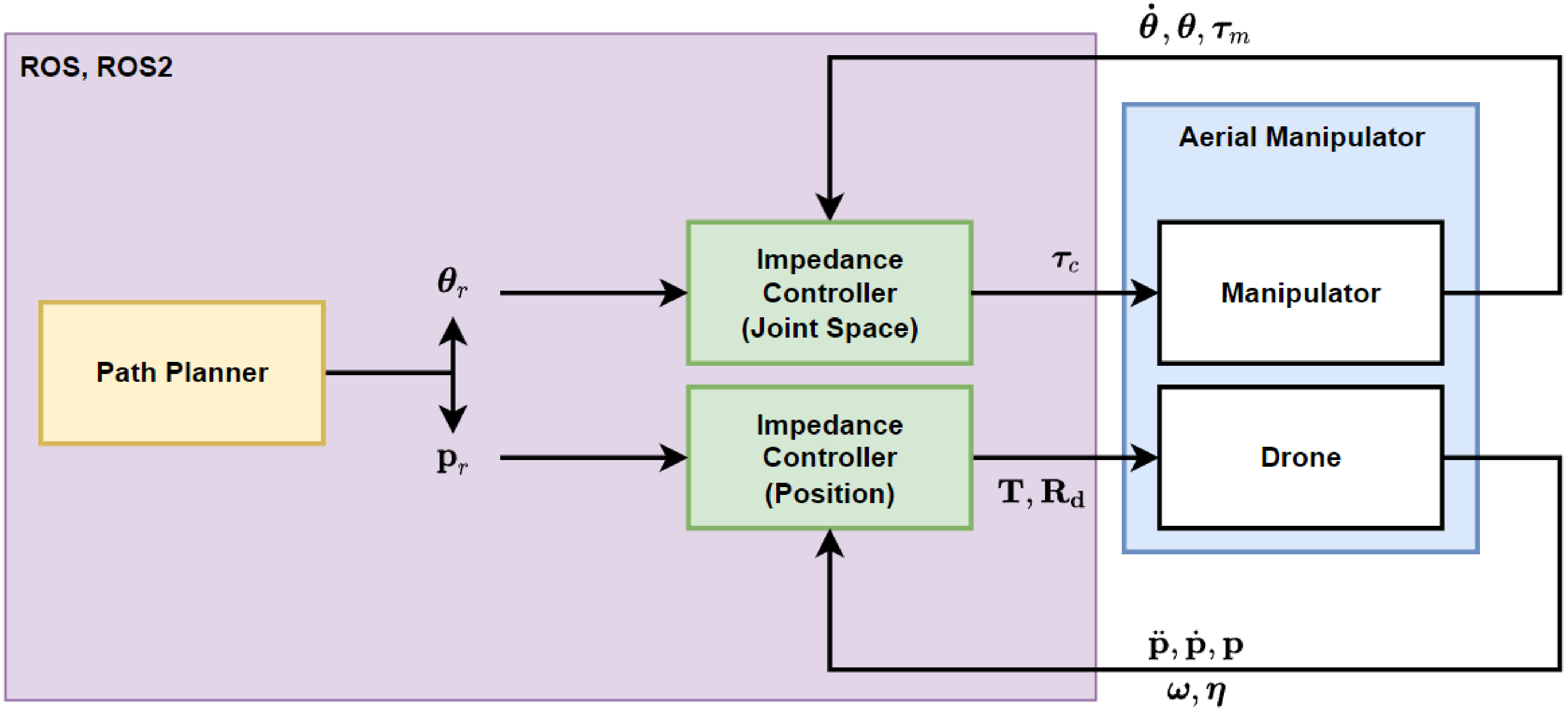
Interaction on non-flat surface

MAINTENANCE DRONE DESIGN





MAINTENANCE DRONE CONTROL



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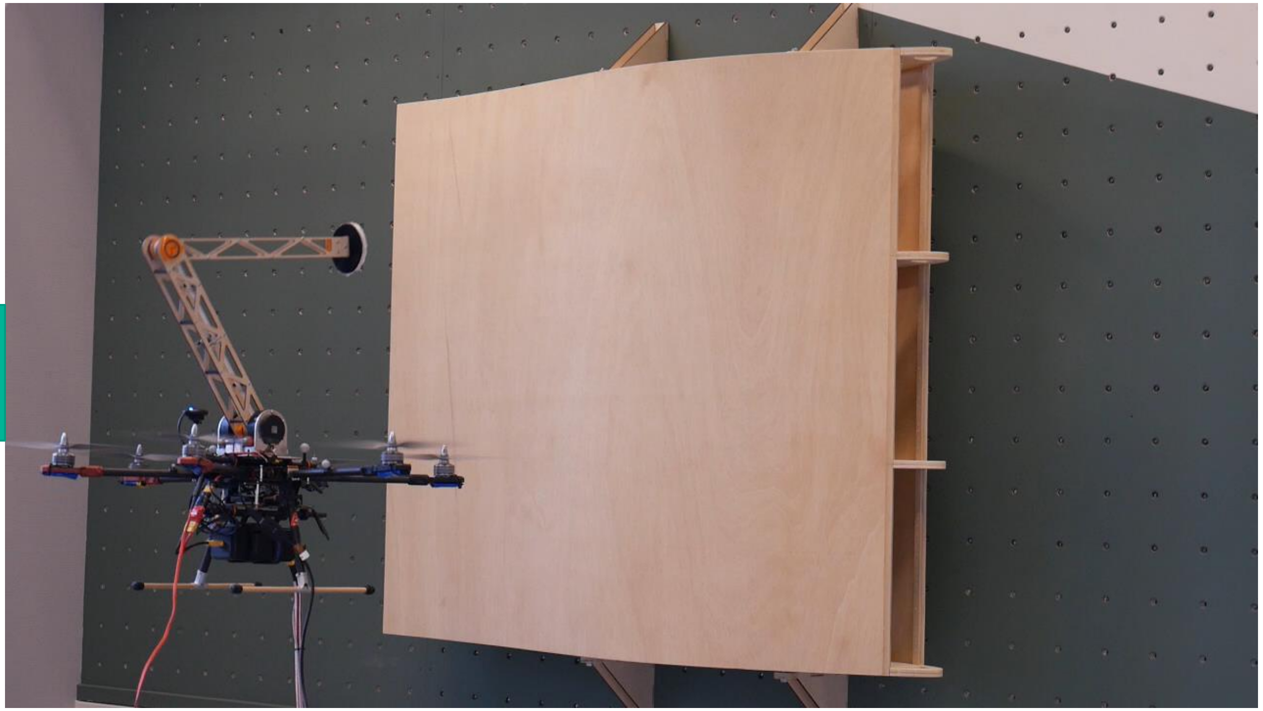
selected **RESULTS**

Interaction of flat surface



Interaction on non-flat surface

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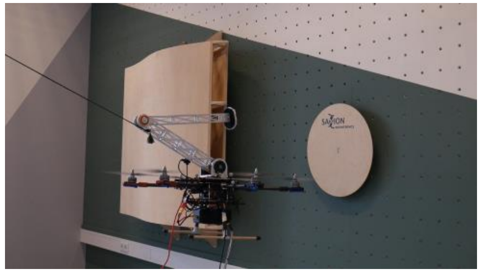
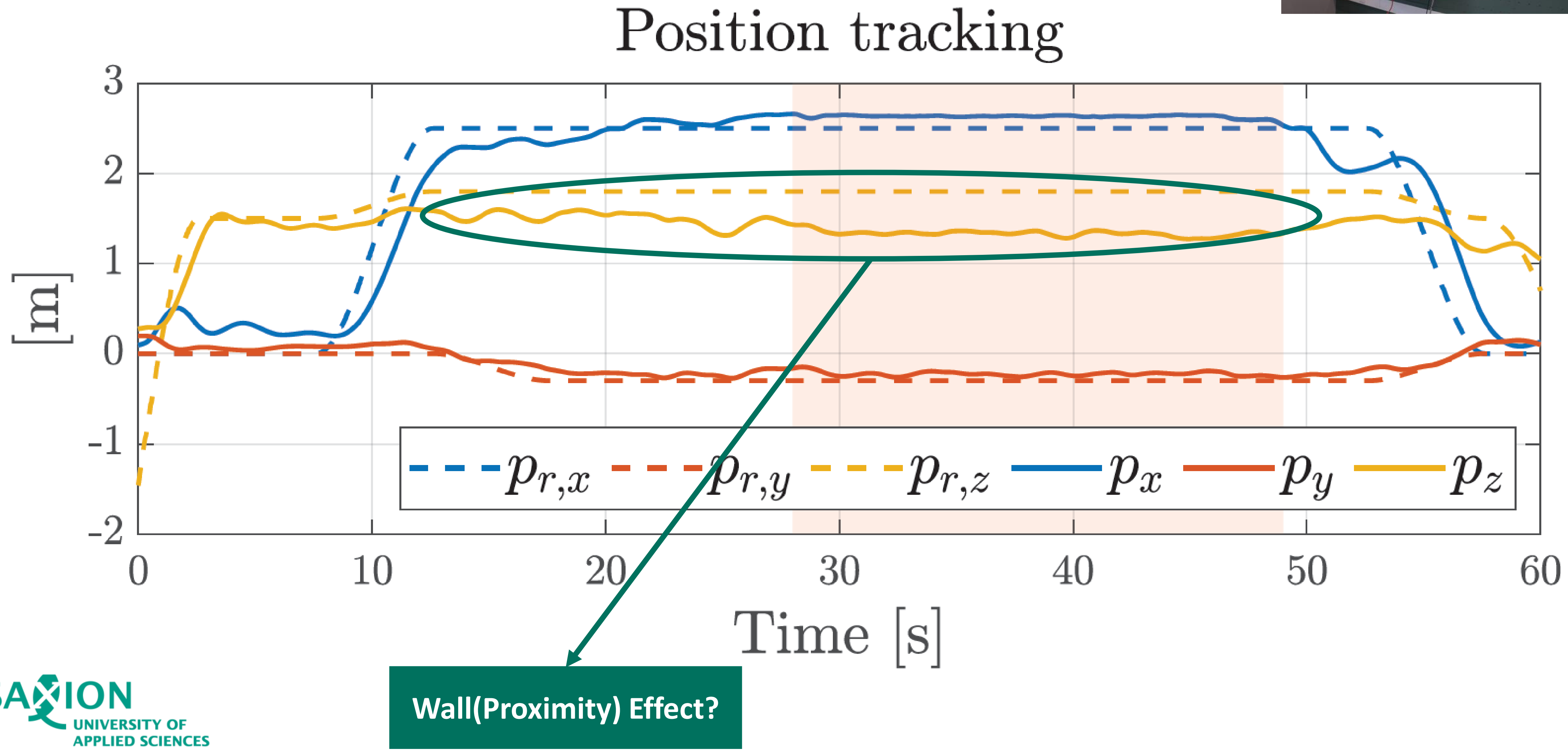
selected **RESULTS**





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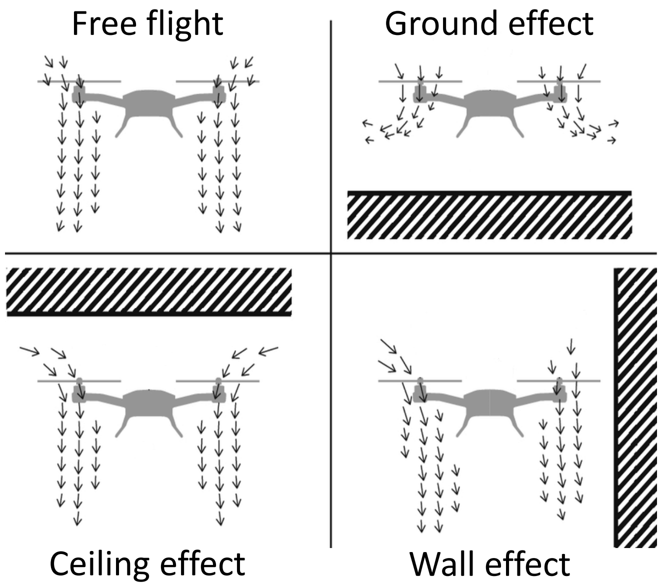
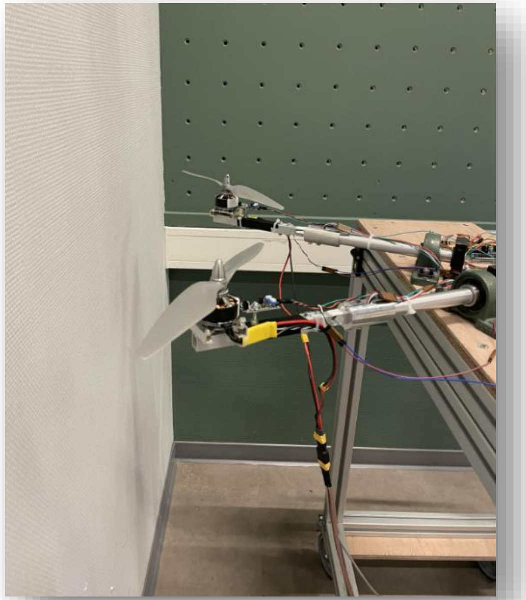
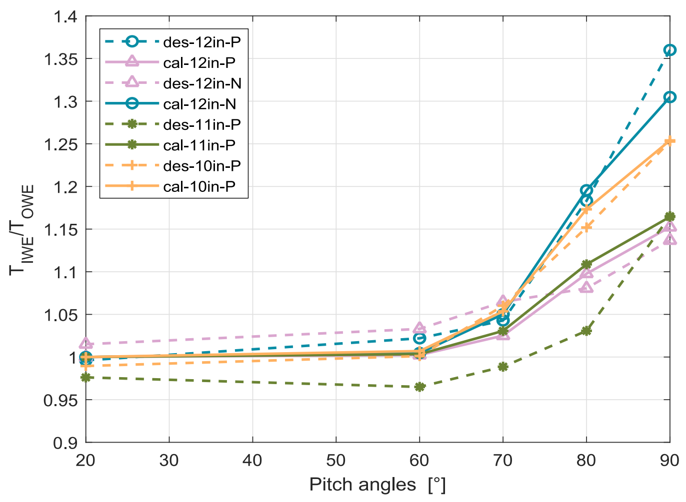
selected

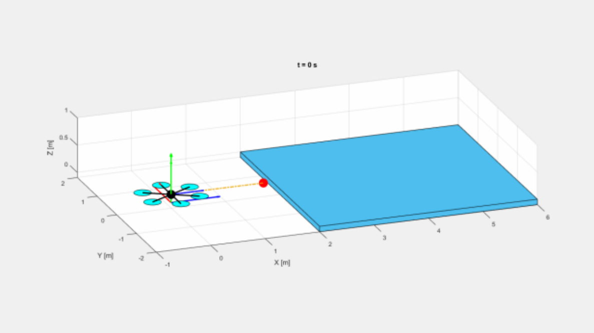
CHALLENGES - PROXIMITY EFFECT







Hypothesis → Physical Test and Data Collection → Data-driven Modelling → Exploit in Controller



AERIAL PHYSICAL INTERACTION **(APhI)** CONTROL

1. Investigating the fundamentals of **APhI** Control
2. Using Non-linear Model Predictive Control **(NMPC)**

2

Three Fundamental Paradigms for Aerial Physical Interaction Using Nonlinear Model Predictive Control

Ayham Alharbat[1], Hanieh Esmaeeli[1,2], Davide Bicego[2], Abeje Mersha[1] and Antonio Franchi[2,3]

***Abstract*— This paper introduces and compares the three most relevant approaches in which an Aerial Physical Interaction (APhI) control can include a Nonlinear Model Predictive Control (NMPC) paradigm in its design. All these methods have the advantage of being able to cope seamlessly with input and state constraints when compared to reactive controllers, however, they substantially differ in the design of the cost function. In the NMPC impedance control the cost function includes the error from the desired impedance dynamics; in the NMPC cascaded control the cost function includes the error from a reference trajectory which is generated online by an admittance filter driven by the force measurement; and in the NMPC hybrid position/force control the cost function contains both the trajectory and direct force error. The three architectures are proposed, implemented, analysed, validated, and compared with real-time simulations of interaction tasks with different environments. The numerical investigation provides a set of insights about the performances, advantages, and dependency on the design assumptions of the three methods.**

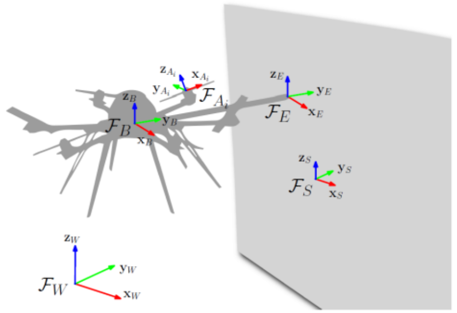


Fig. 1: Graphical representation of an interactive aerial robot, with highlighted reference frames, and a contact surface.

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Physical Interacting Aerial Robots for 'In-situ' Inspection and Maintenance of Wind Turbine Blade

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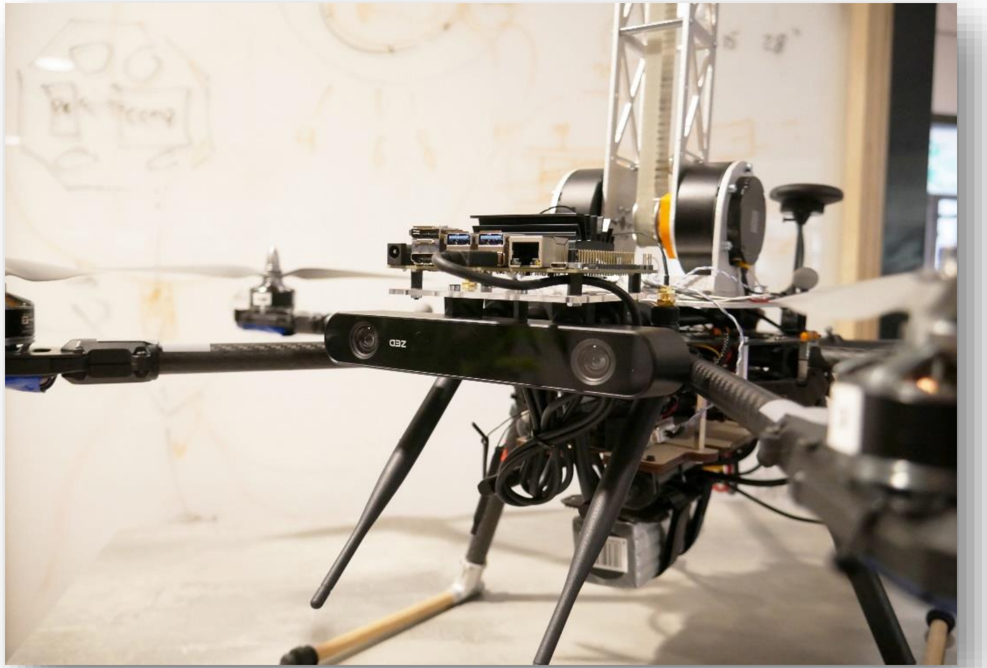
Abstract

Wind turbines are green energy sources that have a great potential in playing a crucial role in mitigating climate change. Regular 'in-situ' inspection and maintenance of wind turbines, especially the leading edge, is needed to ensure system efficiency and durability. Typical inspection and maintenance activities consist of a set of physical tasks, such as sanding, brushing, or painting at high altitudes, which are dangerous for human operators, time-consuming, and can only be carried out under certain conditions. If such activities are not done timely and steadily, it may result in significant downtime to the system due to the maintenance and even replacement which is also very expensive for the owner. The use of aerial robots with the ability of physical interaction that perform a variety of maintenance tasks proposes an advanced and consistent inspection and maintenance technique that mitigates limitations of the current approach. Although currently aerial robot applications to maintenance beyond monitoring and inspection tasks are not

OUTLOOK

- Over-actuated systems
  - Tiltable rotors
  - More control authority
    - Proximity effect

- Outdoor testing
  - Localization issues
  - ~~Motion Capture system~~
  - Visual Odometry + GPS



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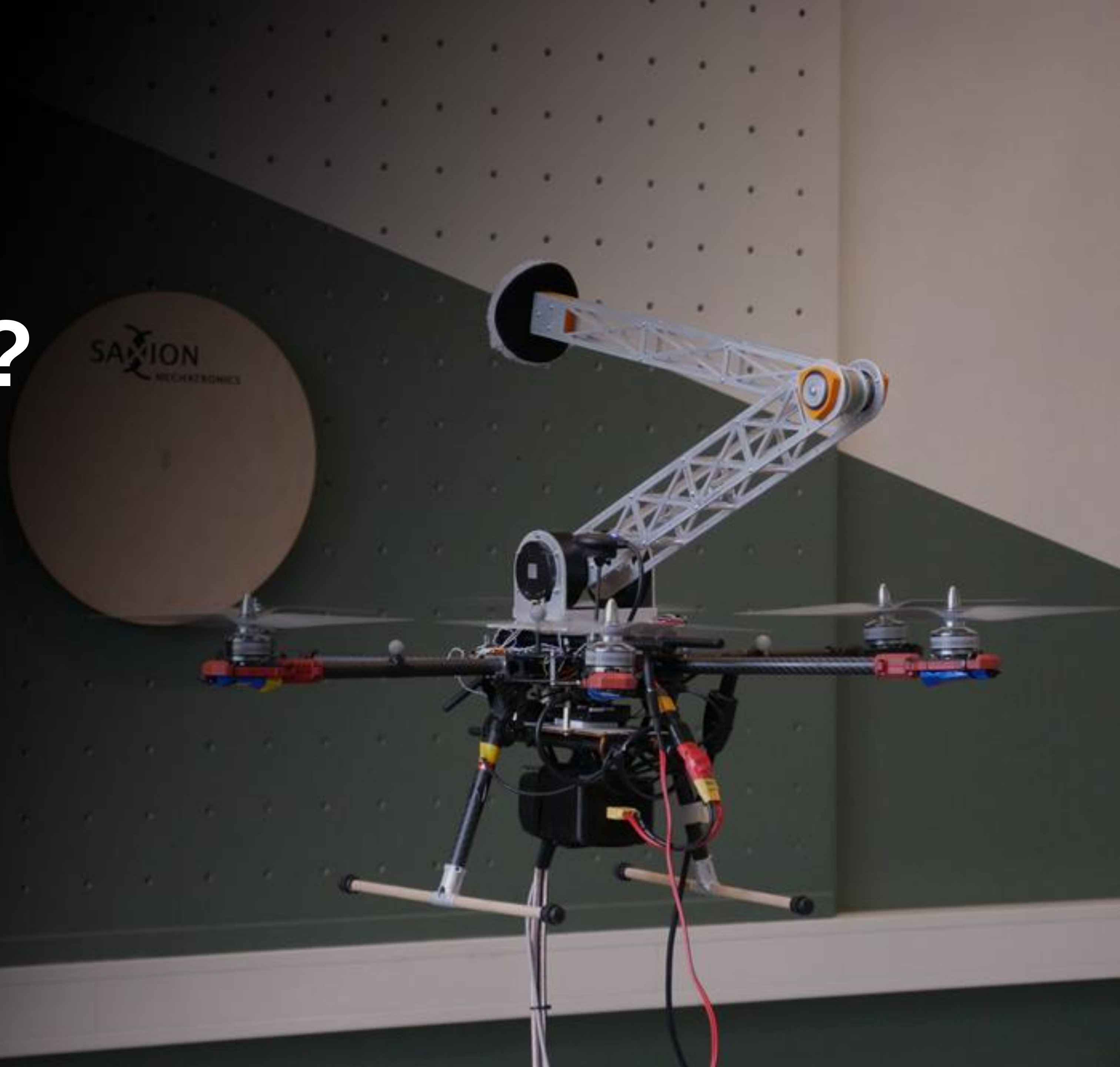
Thank you!

Any Questions?



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