



UNIVERSITÀ DEGLI STUDI DI NAPOLI  
FEDERICO II

itee<sup>PhD</sup>  
information technology  
electrical engineering



Viviana Morlando

Control of legged robotic systems

Tutor: Fabio Ruggiero

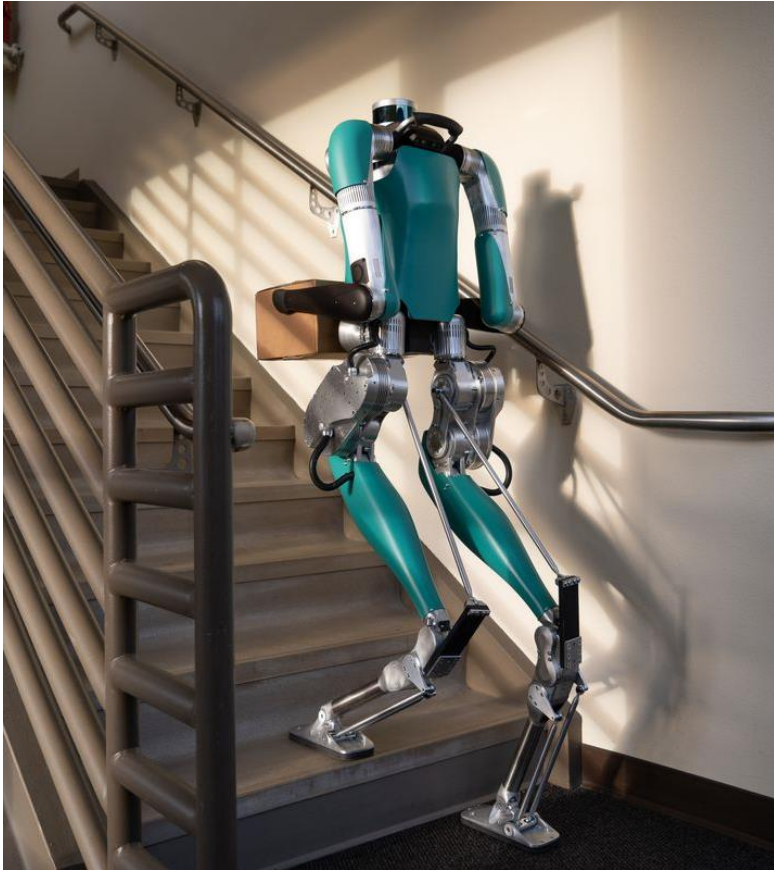
Cycle: XXXV

Year: First

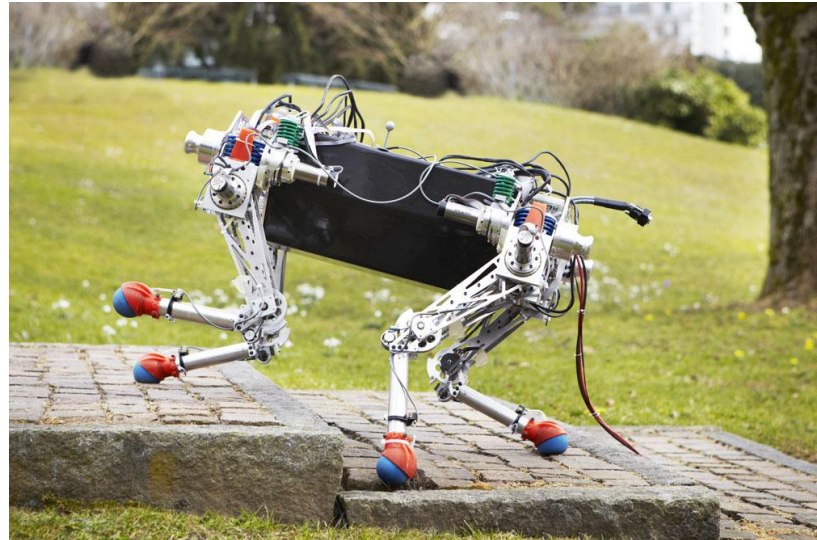
# My background

- M.Sc. in Automation Engineering Università degli Studi di Napoli Federico II
- Group: PRISMA Lab
- PhD start date: 1/11/2019
- Scholarship type: DIETI PRIN 2017 "PRINBOT"

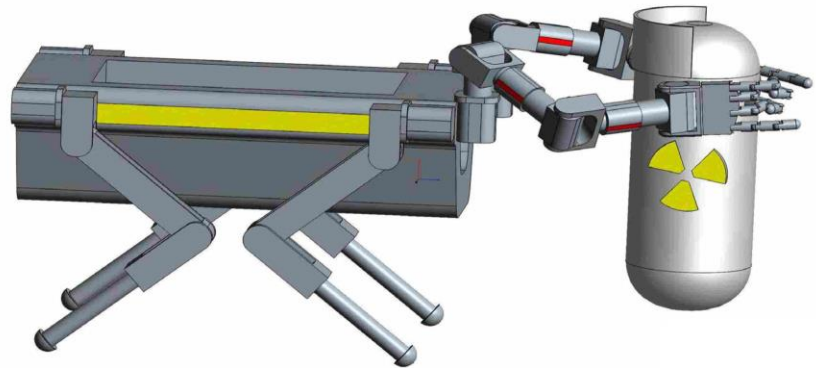
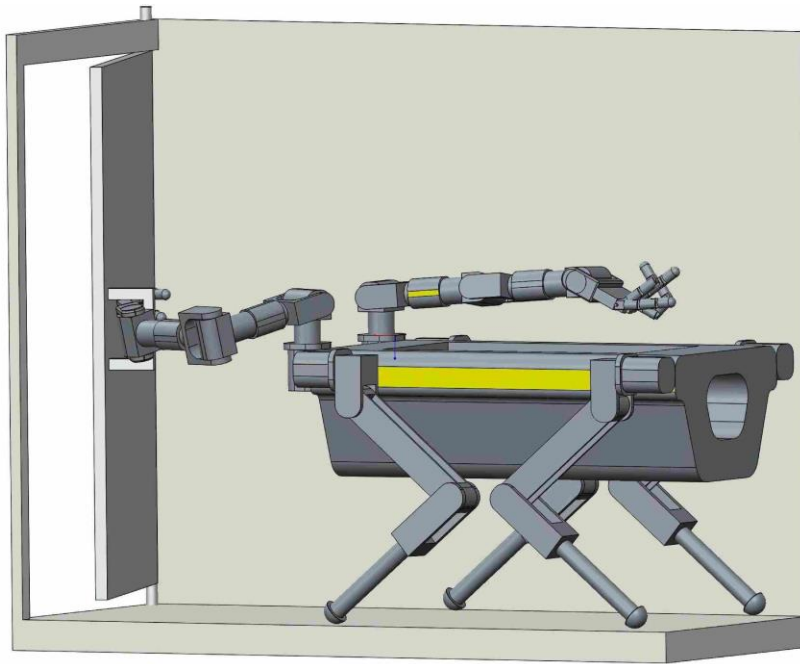
# Research field of interest



- Objective: development of autonomous systems in unstructured environments.
- Importance of legged systems: can adapt their foothold and overcome obstacles.
- Able to walk through challenging terrain inaccessible for wheeled robots.



- Number of legs: quadruped robots are the most used.
- Open challenges regarding the rejection of external disturbance and the balance.
- Quadruped with robotic arms can cooperate with humans in daily life tasks.



# Summary of study activities

- **PhD school:** “*EECI- International Graduate School on Control 2020- M10 Model Predictive Control*”, 8/06/2020-11/06/2020 **Lecturer:** Prof. Eduardo F. Camacho : Model Predictive Control is one of the most used control for legged robots, given the possibility to define a control strategy based on the prediction of the movements over a finite horizon .
- **M.Sc. Courses:**
  1. “*Field and Service Robotics*”, **Lecturer:** Dr. Fabio Ruggiero : The course provided an overview of the tools employed to model, plan, and control wheeled robots, unmanned aerial, underwater vehicles and legged robots
  2. “*Robotics lab*”, **Lecturer:** Dr. Vincenzo Lippiello: The course gave an overview of the fundamental tools and techniques used to program advanced robotics systems.
- **Conference attended :**
  1. “*2020 IEEE International Conference on Robotics and Automation, ICRA 2020*”, Virtual Conference, May 31- August 31
  2. “*IEEE ICRA Workshop: Towards Real-World Deployment of Legged Robots, ICRA 2020*”, Virtual Workshop, June 22-July 3 : The workshop focused on recent developments and future challenges regarding legged robots and control algorithms, with particular attention on the progress towards the goal of operating in human spaces

# Research activity: Overview

## Main problems about dynamic walking of a quadruped robot:

- Complexity given using a full dynamic of the robot.
- Disturbances applied on swing legs.
- Push recovery strategy
- Decouple the dynamic of a robotic arm from the dynamic of the quadruped.



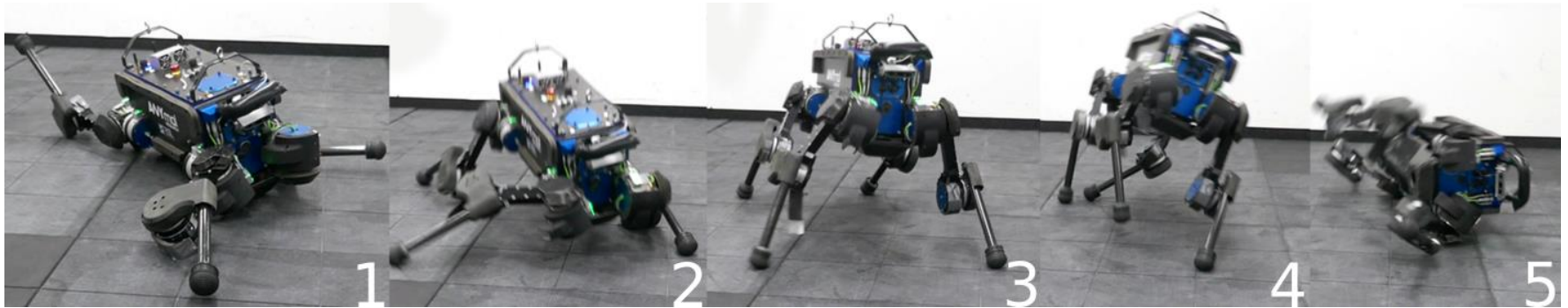
## Research activity during the First Year:

- Study of the state of art of the locomotion of quadruped robots.
- Development of a whole-body controller .
- Realization of a momentum-based observer as a solution of the problem regarding external disturbances, comparison with other observers.
- Simulations of the control framework using the Dynamic Simulator Gazebo.



## Intended Contributions:

- Modify the Whole-Body Controller realized during this year in a Model Predictive Controller, improving the results thanks the prediction of the state.
- Working on a control framework for a quadruped endowed with a robotic arm using the observer realized this year or a Model Predictive Control
- Working on the push recovery of the quadruped:
  1. Recognize a sliding situation and recover the balance.
  2. Recognize an unavoidable fall and bring the robot in the position of minimum damage.





# Products

[J1]

Viviana Morlando, Ainoor Teimoorzadeh, Fabio Ruggiero, “Whole-body Control with Disturbance Rejection through Momentum-based Observer for Quadruped Robots”, submitted to : “Robotics and Automation Letters (IEEE RAL)”, 2020

Thank you for the attention!