I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Mobility and autonomous vehicles

Research themes

The main goal of the Mobility and Autonomous Vehicles curriculum is to train scientists and researchers capable of working in multidisciplinary teams on topics related to state-of-the- art solutions for mobility and intelligent vehicles on land, water or air. Specific areas of research may include:

1. Development of control algorithms to allow, starting from sensory data, to plan and control vehicle dynamics, also in relation to the assignment of vehicles to transport service requests.

2. Development of sensors and sensor data processing algorithms for an accurate perception of the vehicle's surrounding environment, both fixed and dynamic.

3. Integration and coordination of human and artificial intelligence to facilitate coexistence both between driverless and human-guided vehicles, and between driverless vehicles and other users in the shared environment.

4. Development of a reference regulatory framework regarding the objectives to be optimized in emergency situations where the possibility of a complete solution without harm to people, animals or things does not eventually exist.

5. Study of how to ensure the safety of the vehicle, of its passengers (if any) and of the people, animals or things around it, in all conditions.

6. Development of technologies for autonomous freight, off-highway, unmanned vehicles for last-mile delivery and for agriculture.

The ideal candidates are students with a Master (or equivalent/higher) STEM (Science, Technology, Engineering, and Mathematics) degree and possibly a possibly background in Robotics.

The students will perform their research project at the hosting institution (as described in the research project sheet). Applicants are encouraged to contact the tutors and/or the Unit's PI for clarifications before submitting their application.

International applications are encouraged and applicants will receive logistic support with visa issues, relocation, etc.

1. Design of Embedded Systems for Robotics - Universita' della Calabria (DIMES)

Curriculum: Mobility and autonomous vehicles

Hosting Institution
Università della Calabria

Department:
Dipartimento di Ingegneria Informatica, Modellistica, Elettronica e Sistemistica – DIMES
https://dimes.unical.it/

Tutor(s):
Prof. Marco Lanuzza
Prof. Giuseppe Fedele
Prof. Francesco Tedesco (esterno al collegio DRIM)

Description:
Robotics has made significant progress over time, and a noteworthy transformation is being witnessed in the field of mobile robots. Today, it's possible to construct compact mobile robots equipped with a plethora of sensors and actuators that can be controlled by low-price, lightweight embedded computer systems located on the robot itself. This PhD topic aims at the design for low-cost low-power embedded systems for robotics.
The PhD candidate is expected to develop high-fidelity, low-cost and low-power embedded systems targeted for mobile robots. These systems will implement simultaneous localization and mapping (SLAM) algorithms that allow an autonomous system to determine its position within an environment through complex processing of data from multiple sensors. This is also one of the main challenges in the development of robots capable of moving in unknown or partially unknown environments. Moreover, such robots will be used as a test-bed for implementing resilient control strategies and carrying out experiments that envisage the presence of cyber-attacks aimed at corrupting information exchanged among the vehicles.

Requirements:
Applicants are expected to have good skills in the following areas: embedded system design, electronics. Furthermore, good attitude for experimental work is mandatory. The candidates need to also have good programming skills with different languages (including Matlab); and be capable to conduct experiments; attitude to problem solving and be strongly motivated for team working.

References:
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Company name and link (for industrial projects):
-

Number of positions available: 1

Main Research Site
Dipartimento di Ingegneria Informatica, Modellistica, Elettronica e Sistemistica – DIMES, Cubo 42C, Arcavacata di Rende (CS)

Contacts:
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2. Control of agile motions in legged robots – Sapienza Università di Roma (DIAG)

Curriculum: Mobility and autonomous vehicles

Hosting Institution
Sapienza University of Rome

Department:
Department of Computer, Control and Management Engineering (DIAG)

Tutor(s):
Prof. Giuseppe Oriolo

Description:
The focus of this PHD project is on planning and control of agile motions for legged robots, such as humanoids and quadrupeds. This class of mobile robots, which has been traditionally considered of interest mainly for service robotics applications, is increasingly being considered also for industrial contexts, such as large-scale manufacturing workshops or logistic sites where access is difficult or impossible using wheeled or rail-ported vehicles [1].
While achieving basic locomotion capabilities for legged robots can be considered as a solved problem, generation and execution of agile motions is still beyond the state of the art. This class of motions includes robust locomotion under perturbations (such as external pushes or model perturbations), dynamic gaits such as running and jumping, but also transitions between postures or between different gaits. While acrobatic feats have been experimentally demonstrated on extremely high-end platforms (such as Atlas by Boston Dynamics), a general design approach with strong theoretical properties does not exist in the literature.
The objective of this PhD project is to develop a robust framework for planning and control of agile motions based on Model Predictive Control (MPC). MPC is a control technique which is emerging as a de facto standard in robotics, due to its capability to optimize short-term performance while satisfying generic constraints (kinematic, dynamic, safety, etc); in particular, IS-MPC [2] is a LIP-based gait generation method for legged robots that achieves strong theoretical properties (internal stability and recursive feasibility). The plan is therefore to build upon IS-MPC to address several research challenges, among which we mention:

- Considering more complete sophisticated models suitable for highly dynamic motions [3], such as the VHIP (Variable-Height Inverted Pendulum) and the SLIP (Spring-Loaded Inverted Pendulum, and consequently generalizing IS-MPC to the nonlinear setting, using stable inversion techniques from control theory.
- Characterizing the feasibility region of the MPC algorithm and constructively exploiting such information for optimal footstep planning and reaction to disturbances (e.g., step time adaptation [4]).
- Augmenting the basic model-based framework by data-based techniques to ensure the kinematic feasibility of the generated trajectories, using priors from human observations, and performing model-free motion refinement through machine learning.

All the developed methods will be validated via experimentation on biped and quadruped robotic platforms.

Requirements:

Applicants are expected to have a background in robotics and automatic control. Knowledge of optimization methods and software platforms such as MATLAB, ROS, DART, Gazebo, CoppeliaSim is considered a plus.

References:

[1] A. Kheddar, S. Caron, P. Gergondet, A. Comport, A. Tanguy, C. Ott, B. Henze, G. Mesesan, J. Englsberger, M.A. Roa, P-B. Wieber, F. Chaumette, F. Spindler, G. Oriolo, L. Lanari, A. Escande, K. Chappellet, F. Kanehiro, and P. Rabaté, "Humanoid robots in aircraft manufacturing: The Airbus use cases", IEEE Robotics & Automation Magazine, vol. 26, no. 4, pp. 30-45, 2019.

[2] N. Scianca, D. De Simone, L. Lanari, G. Oriolo, "MPC for humanoid gait generation: Stability and feasibility", IEEE Transactions on Robotics, vol. 36, no. 4, pp. 1171-1188, 2020.

[3] F. M. Smaldone, N. Scianca, L. Lanari, G. Oriolo, "From walking to running: 3D humanoid gait generation via MPC," Frontiers in Robotics and AI, vol. 9, pp. 1-18, 2022.

[4] F. M. Smaldone, N. Scianca, L. Lanari, G. Oriolo, " Feasibility-driven step timing adaptation for robust MPC-based gait generation in humanoids," IEEE Robotics and Automation Letters, vol. 6, no. 2, pp. 1582-1589, 2021.

Number of positions available:
1

Main Research Site
DIAG Robotics Laboratory

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