ISTITUTO ITALIANO DI TECNOLOGIA | PhD@IIT

Research Topics for
Doctorate in Robotics and Intelligent Machines, curriculum in **Robotics and Intelligent Machines for Hostile and unstructured environments**

The main goal of the curriculum "Robotics and Intelligent Machines for Hostile and unstructured environments" is to address problems related to the study and development of enabling technologies and complex systems that will allow robots and intelligent machines to work in situations where the environment is dynamic, partially or totally unknown, hard to predict in advance, and possibly very challenging. The general objective of the curriculum is to form scientists and research technologists capable of working in multidisciplinary teams on projects where the interaction with a complex environment play a crucial role in technological development and design.
The two fellowships offered in the second call of this year by the Istituto Italiano di Tecnologia, will be assigned to the best applicants to each of the two themes offered.

Theme number 1 addresses the problem of developing models to specify a robot's software and deliberation mechanisms as well as relevant features and properties of the environment as the basis for formal verification.

Theme number 2 investigate advantages and disadvantages of event-driven cameras with respect to frame-based cameras in object detection problems, and investigate methods that take advantage of the visual information that can be obtained from both type of sensors.

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

Research Topics

1. Machine learning for mobile manipulation in dynamic environment

Tutor
Lorenzo Natale

Research Line
Humanoid Sensing and Perception, IIT, Genova

Description

Humanoid robots are expected to successfully navigate and perform useful tasks like grasping, object manipulation in unstructured environments and in close interaction with humans. To be able to navigate in such situations robots need to be able to adapt online to cope with unexpected, dynamic, obstacles and the presence of humans. In addition the robot should be endowed with algorithms that allow to successfully interact with objects, grasping and manipulating them depending on the task to be performed (i.e. object affordances).

The goal of this project is to advance the capabilities of humanoid robots to interact with the environment, possible topics are:

- detect humans and anticipate their movement, perform trajectory planning and re planning for safe navigation;
- learning how to grasp objects taking into account the task at hand (i.e. object affordances in relation to the task to be performed);
- learning complex tasks which involve physical interaction with the environment (opening door or a drawer, operating a switch, pushing objects).

This work will be carried out on the humanoid robots available in the Humanoid Sensing and Perception group, the R1 robot, iCub and/or the Panda Arm from Franka Emika.

Requirements

The ideal candidate would have a degree in Computer Science, Engineering, or related disciplines, with a background in Robotics. They would also be highly motivated to work on robotic platform and have computer programming skills.

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2. Scene perception with frame-based and event-driven visual sensors

Tutors

Lorenzo Natale, Chiara Bartolozzi

Research Lines

Humanoid Sensing and Perception, IIT, Genova
Event-Driven Perception for Robotics, IIT, Genova

Description

To effectively interact with the environment and adapt to different contexts and goals, robots need to be able to recognize, detect and estimate the pose of objects. Modern deep architectures provide great performance but at high computation cost. Especially with cost effective hardware, deep architectures provide inference at relatively slow frame rate, which is

unsuitable in dynamic situations. Event-driven sensors have been proposed as an alternative paradigm to conventional frame-based cameras, because they provide efficient encoding and rich temporal information that can be exploited in those situations in which either the camera or the objects move at fast speed. The goal of this project is to investigate advantages and disadvantages of event-driven cameras with respect to frame-based cameras, and investigate methods that take advantage of the visual information that can be obtained from both type of sensors to solve perception tasks that involve camera or objects motion at high speed. We will investigate methods for multi-modal fusion based on machine learning as well as Bayesian frameworks. Methods will be validated on the iCub humanoid robot.

Requirements

The ideal candidate would have a degree in Computer Science, Engineering, or related disciplines, with a background in Robotics. They would also be highly motivated to work on robotic platform and have computer programming skills.

References

- Benosman, R.; Clercq, C.; Lagorce, X.; Sio-Hoi Ieng; Bartolozzi, C., "Event-Based Visual Flow," Neural Networks and Learning Systems, IEEE Transactions on, vol.25, no.2, pp.407,417, Feb. 2014, doi: 10.1109/TNNLS.2013.2273537
- Piga, N., Onyshchuk, Y., Pasquale, G., Pattacini, U., and Natale, L., ROFT: Real-time Optical Flow-aided 6D Object Pose and Velocity Tracking, IEEE Robotics & Automation Magazine, vol. 7, no. 1, pp. 159-166, 2022
- Vasco, V., Glover, A., Mueggler, E., Scaramuzza, D., Natale, L., and Bartolozzi, C., Independent Motion Detection with Event-driven Cameras, in Proc. IEEE International Conference on Advanced Robotics, Hong Kong, 2017, pp. 530-536

Contacts

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