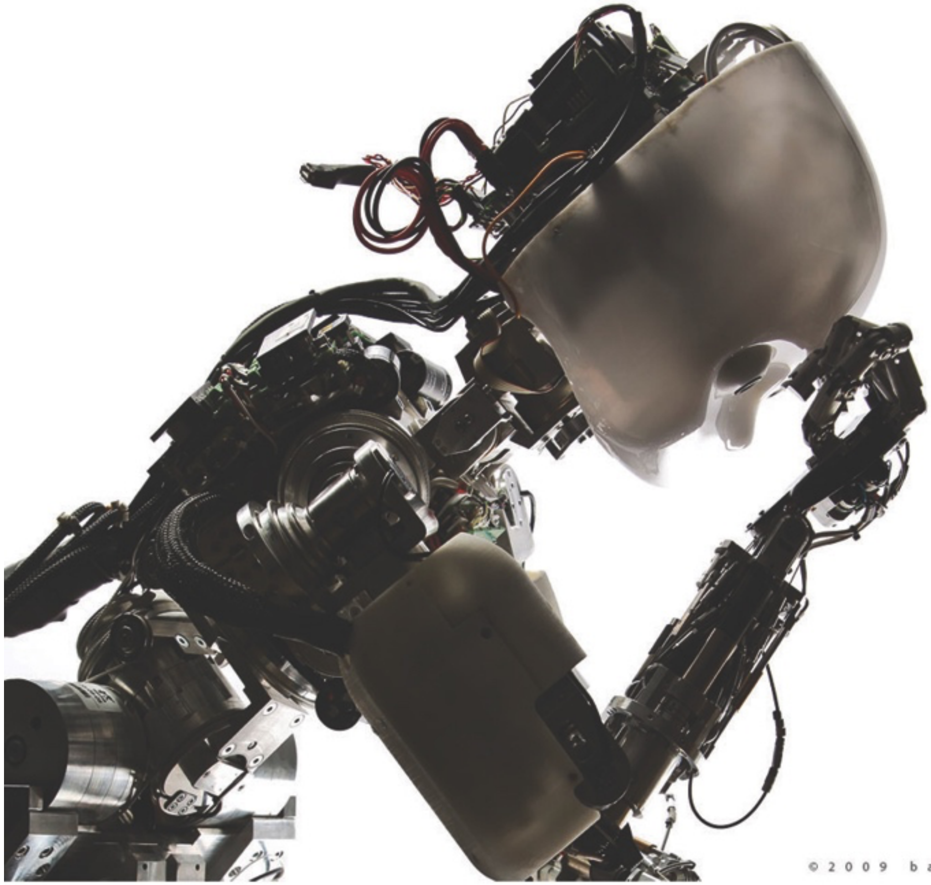

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LASA

Learning Algorithms and Systems Laboratory

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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2016

lasa.epfl.ch I EPFL-STI-IMT-LASA Station 9 I CH 1015, Lausanne, Switzerland

LASA | OVERVIEW

LASA (Learning Algorithms and Systems Laboratory) at EPFL, focuses on machine learning applied to robot control, human-robot interaction and cognitive robotics at large.

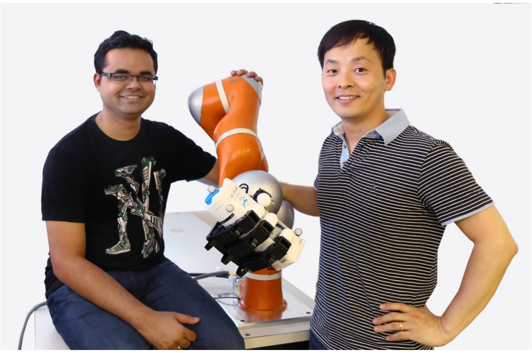
Founded in 2006 by Professor Aude Billard, research at LASA develops means by which humans can teach robots to perform skills with the level of dexterity displayed by humans in similar tasks. Our robots move seamlessly with smooth motions. They adapt adequately and on-the-fly to the presence of obstacles and to sudden perturbations, hence mimicking humans immediate response when facing unexpected and dangerous situations.

Fields Covered: Learning and Dynamical Systems, Neural Computation and Modeling, Human-Machine Interaction, Humanoids Robotics, Mechatronics, Design of Therapeutic and Educational Devices.

Prof. Aude Billard

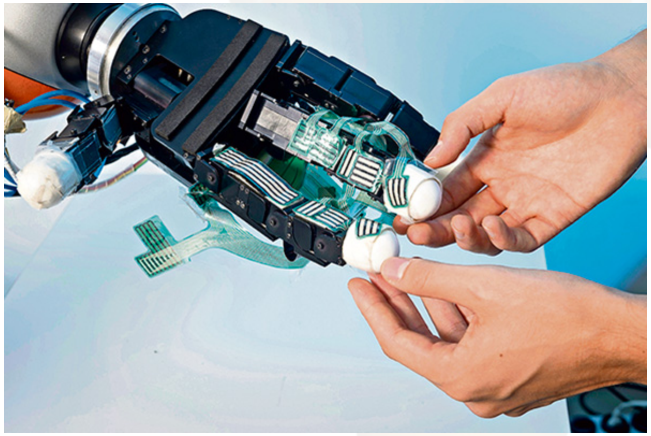
Professor Aude Billard is head of the Learning Algorithms and Systems Laboratory (LASA) at the School of Engineering at the EPFL. She received a M.Sc. in Physics from EPFL (1995), a MSc. in Knowledge-based Systems (1996) and a Ph.D. in Artificial Intelligence (1998) from the University of Edinburgh. She was the recipient of the Intel Corporation Teaching award, the Swiss National Science Foundation career award in 2002, the Outstanding Young Person in Science and Innovation from the Swiss Chamber of Commerce and the IEEE-RAS Best Reviewer Award. She served as an elected member of the Administrative Committee of the IEEE Robotics and Automation society for two terms (2006-2008 & 2009-2011). She was a plenary speaker at major robotics conferences, (ROMAN, ICRA, Humanoids, HRI) and acted on various positions on the organization committee of more than 15 International Conferences in Robotics. Her research on human-robot interaction and robot learning from human demonstration is featured regularly in premier venues (BBC, IEEE Spectrum, Wired) and received numerous best paper awards at ICRA, IROS and ROMAN, and the 2015 King-Sun Fu Memorial Award for the best 2014 IEEE Transaction in Robotics paper.

LASA CURRENT RESEARCH



Fast Adaptive Control

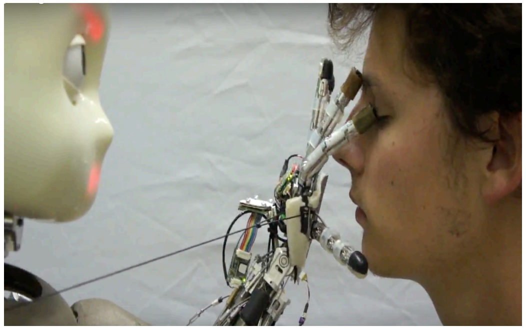
Humans exhibits remarkable abilities to react expeditiously to unexpected changes in an environment. Dynamic motions such as catching, juggling or throwing are well-known examples which need accurate motion planning and motor control and can be flawlessly executed by trained humans. This suggests that robots should be able to perform accurately such tasks. The focus on this part of our work is on providing the robot(s) the capability to manipulate fast moving agents. We develop approaches that allows us to coordinate the motion of the robot(s) with external agents and compensate for the uncertainties in the motion of the agents and the robot(s).



Dexterous manipulation and grasping

The human hand is an amazing tool that is centrally involved in most of our daily activities. We use our hands to feel, explore, grasp and manipulate objects, and further to perform cognitive skills like writing and playing music instruments. Such a variety of skills is thanks to the incredible dexterity of the human hand and in part thanks to our marvelous control strategy. The lab's research in this direction attempts to understand the mechanism behind the remarkable human hand functionality, and further to replicate this capacity on robotic hands with very different kinematics. We develop approaches that allow us to (1) generate a variety of task-oriented grasps with given hands using either off-line optimization or strategies learned from human demonstrations; (2) devise the control strategy to react intelligently to unprepared perturbations or disturbance during grasping, exploration and manipulation.

Human Robot Interaction



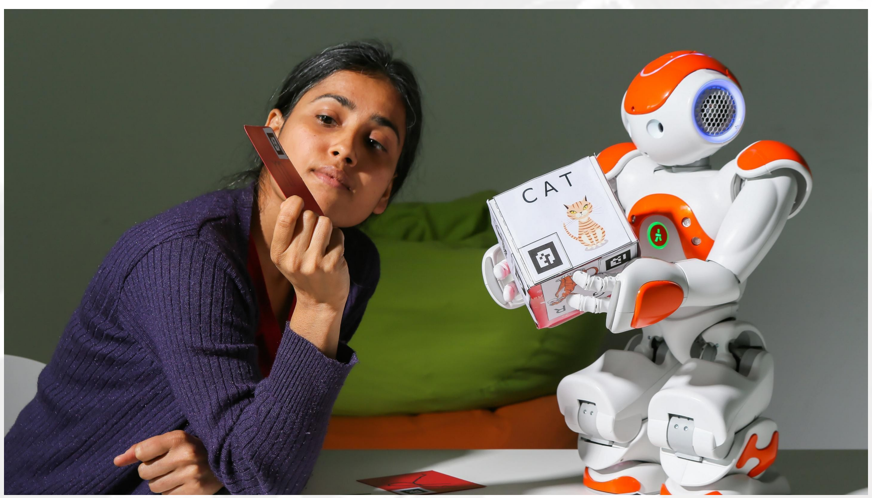
Human-Robot interaction is a rich interdisciplinary field which addresses the understanding, development and evaluation of interactions between robots and humans. Such human-robot interactions encompass applications that require social interaction, physical manipulation or human-robot mobility.

HRI-related research at LASA focuses on scenarios where robots take the roll of assistants, trainers or collaborators in order to achieve physical manipulation tasks. We develop teaching interfaces that facilitate the transfer of tasks from expert humans to robots. These involve developments in haptic interaction and machine learning algorithms that learn and infer the task goals and features. Once the robots posses the knowledge of the required task or skill, they can be used to either assist or train a novice human user while executing the required task. Furthermore, we are currently investigating ways to achieve seamless handovers of tools/objects between human and robot assistants in a pro-active manner, which involves recognizing the human's intention, human-in-the-loop control and adaptive grasping.

LASA CURRENT RESEARCH

Shared Control with EMG

This work focuses on the increase of the controllability of a wearable prosthetic device providing it with a more natural human-like behavior on grasping motions. Humans are able to control dexterously their hand and perform a large variety of grasp types. On the other side, the range of motion that someone can do while wearing a prosthetic device is constraint due to the lack of a more sophisticated control and functionality. As these devices are in direct contact with the user, they should operate in harmony with the him/her, following smoothly his movements in a natural way. Thus, it is important that the device reacts promptly to the detection of the movement intention, provided by electromyography (EMG). After decoding accurately, the intention of the user, the next step is the analysis of the motion of the human hand when reaching and grasping different objects. Following a learning-from-human-demonstration approach, we build a model which describes the dynamic behavior of the hand and the fingers during grasping motions. After the reaching phase and while in contact with the object, the device should react rapidly to the characteristics of the object, apply the necessary forces to the object concluding to a safe grasp. The actions result to a shared control scheme between the user and the wearable robotic device.



Machine learning with Applications to Robotics

The focus on this part of our work is on providing the robot the capability of understanding what a task is about, what are the important features and how these features can be applied in new contexts. We specifically look at tasks that require a sequence of actions, ranging from single arm motions to fine manipulation or even coordinated behaviors. We acquire knowledge mostly by observing humans performing the task, or by directly guiding the robot through kinesthetic demonstrations. We develop approaches that allows us: (1) to segment the task in a sequence of meaningful actions; (2) to extract task constraints that are key to successfully executing the task; (3) to learn models for each action that allow the robot to perform the task in various contexts that were not seen before. The set of actions together with their extracted features and learned models serve as a sub-symbolic representation and form a generic task prototype that can be used as a building block in high-level planning.

LASA PRESS I UPCOMING

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LASA participates in the following international scientific consortiums:

SecondHands Project

Cognitive Interaction in Motion (CogIMon)

EU Project Alterego

EU Project ROBOHOW

Swiss National Center in Robotics

Safety Enables Cooperation in Uncertain

Robotic Environments (SECURE)

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