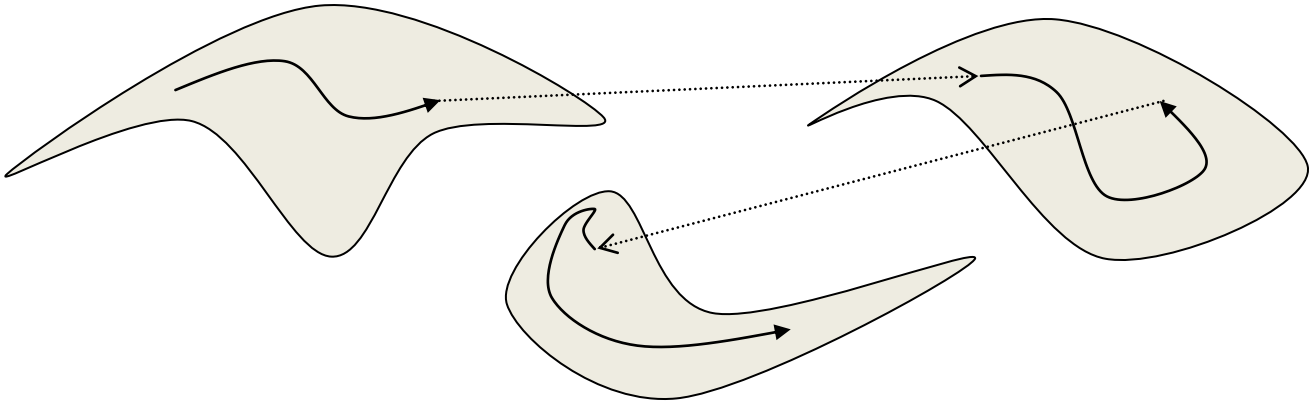
THREE KICK-OFF SEMINARS

for the project

OptHySYS Optimization Techniques for Hybrid Dynamical Systems:

from theory to applications



West Side Seminar (DISI)
Wednesday May 27th 2015, 10:30-12:00, meeting room "Levico", Polo Ferrari 2, Povo.

DANIELE FONTANELLI: *Hybrid systems in practice: some wheeled mobile robotics examples*

East Side Seminar (DIPMAT)
Wednesday June 3rd 2015, 9:30-11:00, mathematics seminar room, Povo 0, Povo.

MARCO SABATINI: *Stability theorems for switched systems*
FABIO BAGAGIOLO: *Hysteresis and hybrid systems*

West Side Seminar (DII)
Friday June 5th 2015, 14:30-16:00, industrial engineering seminar room, Polo Ferrari 2, Povo.

ENRICO BERTOLAZZI: *Numerical optimal control*

- **Wednesday May 27th 2015, 10:30-12:00, meeting room "Levico", Polo Ferrari 2, Povo**

DANIELE FONTANELLI: *Hybrid systems in practice: some wheeled mobile robotics examples*

Abstract: The main characteristic of hybrid systems is to have a continuous dynamic that may experience jumps in the continuous evolution. Such behaviours may emerge from the intrinsic characteristics of the modelled system. For example, a continuous-time system may have its dynamic governed by different phenomena taking place at very different rates, such as an object having collisions with the surrounding environment. Sometimes the switching in the system dynamics may arise from the particular control problem to solve, in which the jumps are forced by an internal logic. In such a situation the differential equations are not able to describe the overall system behaviour.
A class of systems in which this behaviour emerges is the wheeled mobile robots. Indeed, mainly due to mechanical design simplicity, such systems are intrinsically nonholonomic. As a consequence, wheeled mobile robots are not locally controllable, even though global reachability is preserved. The distinctive characteristic of this kind of systems is indeed to have constraints in the velocity space, which are not integrable. Therefore, closed loop control is achieved by means of manoeuvres, which obey to the controller logic. In this talk, after a brief introduction to this class of systems, some practical examples involving nonholonomic vehicles, whose dynamic is ruled by a hybrid controller, will be presented. A special emphasis will be devoted to the testbed we are planning to use throughout the OptHySYS project.

- **Wednesday June 3rd 2015, 9:30-11:00, mathematics seminar room, Povo 0, Povo.**

MARCO SABATINI: *Stability theorems for switched systems*

Abstract: We review some basic definitions and theorems about stability. Then we introduce switched systems, showing that the classical Lyapunov method is applicable to a very restricted class of systems. We conclude describing a recent stability result which presents a specific approach to cope with some of the typical features of switched systems.

FABIO BAGAGIOLO: *Hysteresis and hybrid systems*

Abstract: Hysteresis is an input-output relationship between time-dependent quantities which shows a particular type of memory effect, the so-called rate independent one. Many physical, engineering, biological, economical and social model can be described by an evolution which may consist of a continuous part (for example, governed by an ODE) and of a hysteretic part. Sometimes, a hysteretic behavior is artificially introduced in the model, in order to prevent some undesirable fast oscillating effects, or to approximate some discontinuities of the data. By its very nature, the hysteresis relationship is often prone to be described by some logical rules (*if-then*), rather than by differential ones. Hence, it is an example of hybrid system. Optimal control problems for system exhibiting hysteresis are not so intensively studied in literature, in particular for what concerns the dynamic programming approach. We will give some examples on that, and possibly some applications.

- **Friday June 5th 2015, 14:30-16:00, industrial engineering seminar room, Polo Ferrari 2, Povo.**

ENRICO BERTOLAZZI: *Numerical Optimal Control*

Abstract: Optimal control is an important field of applied mathematics with application in many science areas. The numerical approximation of the solution of an optimal control problem is a challenging task for many interesting problems, especially if the solution must be accurate and/or computed in little time.
In this talk the principal techniques used for the numerical approximation of optimal control problems are presented and discussed. In particular direct methods based on reduction to nonlinear programming and indirect methods based on the maximum principle of Pontryagin will be discussed and compared.