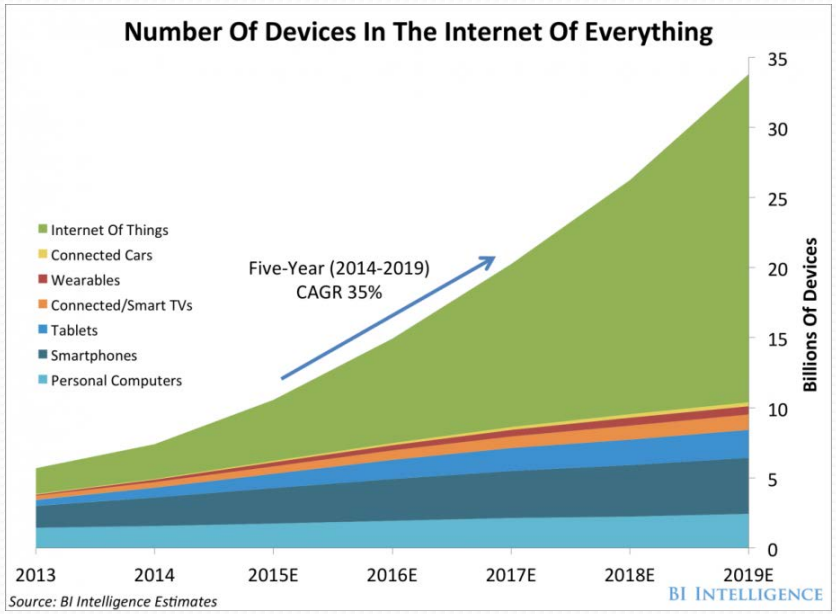
Control of Network Systems

ING-INF/04, 60 h, 6 CFU

March –May 2017

Why pick this course?

- We are witnessing an exponential growth of applications of "smart devices" (mobile robotics, smart grids, internet of things, smart homes, etc.)



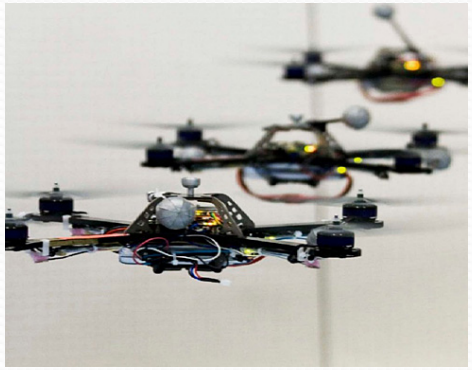
- These systems are characterized by a dynamical behavior and can interact by means of a communication network

- The general objective of this course is to present algorithms and formal methods to embed autonomous decision making capabilities into these devices and enable cooperation among them for several innovative applications, some of which will be discussed during the course.

Multi-robot systems

Single robots can:

- Observe the environment
- Communicate with other robots
- Process information
- Take decisions



How can we design simple interaction rules among mobile robots so that we obtain a desired emergent behavior?

Some examples:

100 Dancing Drones Set World Record

Amzon Warehouse Robots

Multi-robot assignment and formation

Network systems in nature

- Schools of fish
- Flocks of birds
- Swarms of insects

Is it possible to build mathematical models of their behavior?
Can we predict if a given behavior will «emerge»?

Fish school explained

Consensus and synchronization

- Under which conditions does a network of coupled systems synchronize?
- Can we exploit similar mechanisms to design distributed algorithms for control or estimation for network systems?

Sychronization of Metronomes

- In this course we will focus on consensus and distributed averaging algorithms with applications on sensor networks and coordination of mobile robots

Distributed task assignement

- Given a set of tasks to be assigned to a set of processing elements/robots or «agents», how do we design local assignment rules in absence of centralized supervisors to distribute the tasks fairly ?

- In this course we will discuss examples of algorithms for distributed task assignement on large scale networks of processing elements or robots.

Social networks

- Social networks can be modelled as networks of dynamical systems where the opinion of each individual is represented by a dynamical system and social interactions provide coupling on the opinions and are represented by a «network»

- In this course we will discuss some simplified models of social networks and their properties.
- Applications: how to predict the diffusion of innovation and which individuals are the most influent in the social network.

Objectives of the course

- Introduce the student to advanced concepts of analysis and control of dynamical systems, introduce algebraic graph theory and other formal tools for the study of networks of dynamical systems and their emergent behavior;

- Introduce the student to recent and trending research topics and improve his ability to design algorithms and simulate them numerically with the Matlab programming language;

- Develop creativity and interdisciplinary problem solving skills on trending topics of science and technology where control and systems theory plays a significant role.

General informations

- Lectures start on 01/03/2017.
- The course will be held in **English**
- Duration: 60 hours
- Evaluation: oral examination or class exercises and discussion of project work.
- Teacher: Ing. Mauro Franceschelli, email: mauro.franceschelli@diee.unica.it
- Web page: http://www.diee.unica.it/~mfrances/
- Reference book: «**Lectures on Network Systems**» F. Bullo.

  The adopted version will be distributed in class.

  The most recent version is available on the authors's web page: http://motion.me.ucsb.edu/book-lns/
- Suggested readings:

  «Graph Theoretic Methods in Multiagent Networks» M. Mesbahi and M. Egerstedt, Princeton University Press, 2010.

  Scientific papers and reading material given during the lectures.