Teaching Model-Based Design at Politecnico di Torino

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The speaker

- Associate Professor
  Politecnico di Torino
  Dip. di Automatica e Informatica
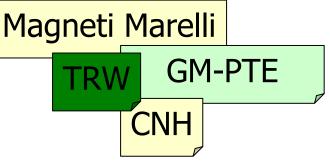
- Electronic CAD & Reliability Group
  www.cad.polito.it

- Focus: design and validation of dependable embedded systems

- Cooperates with:
  - Magneti Marelli, GM Powertrain Europe, TRW, IVECO, …
  - European Space Agency, Thales Alenia Space, EADS, …

The starting point: Torino 2011

- Compelling demand of engineers with basis on:
  - Model-based design
  - ISO 26262
  - AUTOSAR

  Magneti Marelli

  TRW   GM-PTE

  CNH

- Limited answer from university:

  - **Software Engineering**
    - Knowledge of processes but not ISO26262

  - **Specification and Simulation**
    - SystemC, VHDL, but no Simulink/Stateflow

  - **Automatic Control**
    - MATLAB/Simulink, no code generation

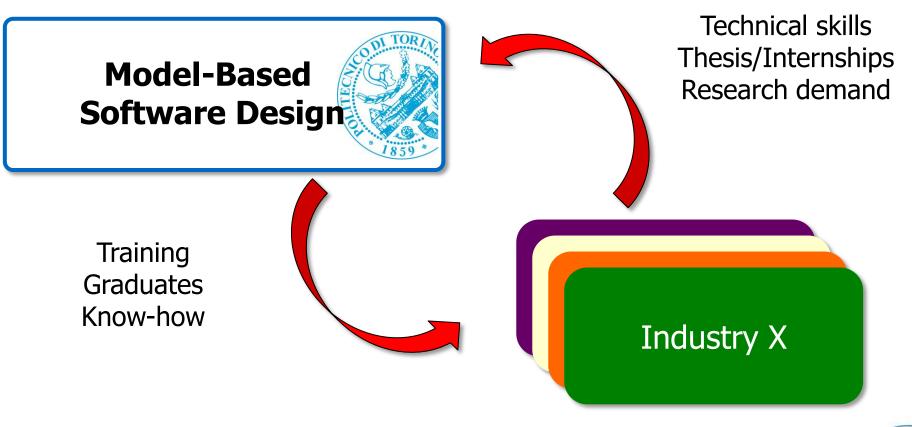# The idea

- Master course on Model-Based Design, ISO 26262, AUTOSAR

- Focus on embedded software for automotive

- Target: Master students in Computer & Electronic Engineering

- Key elements:
    - Theory + Practice
    - Link with local industries

Link with local industries

Model-Based Software Design

Technical skills
Thesis/Internships
Research demand

Training
Graduates
Know-how

Industry X

Outline

- Course organization

- Case Studies

- Results

- Conclusions

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Course organization

- II year Master program in Computer & Electronic Engineering
- Optional course
- Effort: 6 credits (60 hours)
  - 4.5 hours/week lectures
  - 1.5 hours/week labs
- Topics:
  - Model-Based Design: 25 hours
  - ISO 26262: 15 hours
  - AUTOSAR: 10 hours
  - Seminars from industry experts: 10 hours

Course organization (cont.ed)

- Model-Based Design – Theory
  - Modeling of control algorithms

  - Verification and Validation
    - Simulation (model-in-the-loop, software-in-the-loop, hardware-in-the-loop)
    - Formal verification

  - Floating Point to Fixed Point conversion

  - Automatic code generation

Course organization (cont.ed)

- Model-Based Design – The lab

    - Modeling→ Simulink/Stateflow

    - Floating point scaling → Fixed-Point Designer

    - Code generation→ Embedded Coder

    - Hardware validation → Freescale/Cypress evb
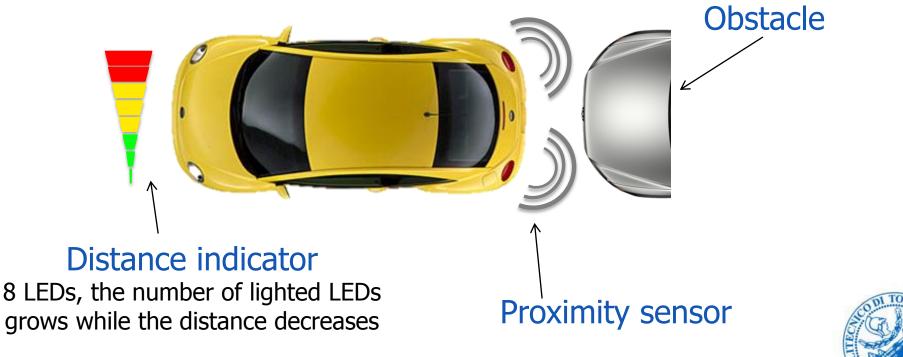
- Mandatory element to complement theory

Outline

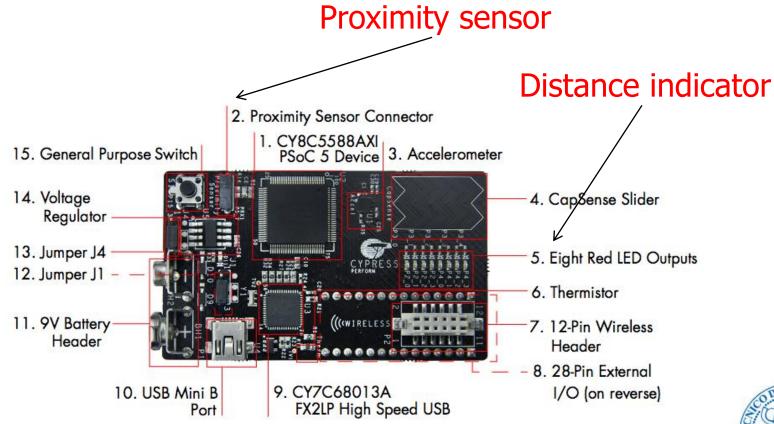- Course organization

- Case Studies

- Results

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Electronic Parking assistant

- A system has to be designed that tells the drivers the distance of obstacles following the car. A proximity sensor is used to model a radar

Obstacle

Distance indicator
8 LEDs, the number of lighted LEDs grows while the distance decreases

Proximity sensor

Hw used for the case study

- Cypress Semiconductor PSoC 5 FirstTouch Kit

Proximity sensor

Distance indicator

15. General Purpose Switch
14. Voltage Regulator
13. Jumper J4
12. Jumper J1
11. 9V Battery Header
10. USB Mini B Port
9. CY7C68013A FX2LP High Speed USB
2. Proximity Sensor Connector
1. CY8C5588AXI PSoC 5 Device
3. Accelerometer
4. CapSense Slider
5. Eight Red LED Outputs
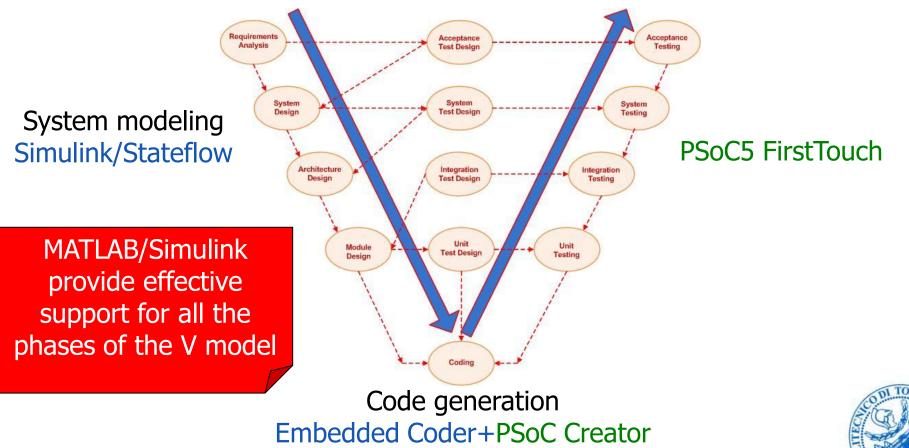6. Thermistor
7. 12-Pin Wireless Header
8. 28-Pin External I/O (on reverse)

What students do

- Design using the standard automotive development flow: V model

System modeling
Simulink/Stateflow

PSoC5 FirstTouch

MATLAB/Simulink provide effective support for all the phases of the V model

Code generation
Embedded Coder+PSoC Creator

Implementation

- AUTOSAR-like structure

Generated automatically by Embedded Coder

Application Logic

Developed manually

Basic Software

Scheduler

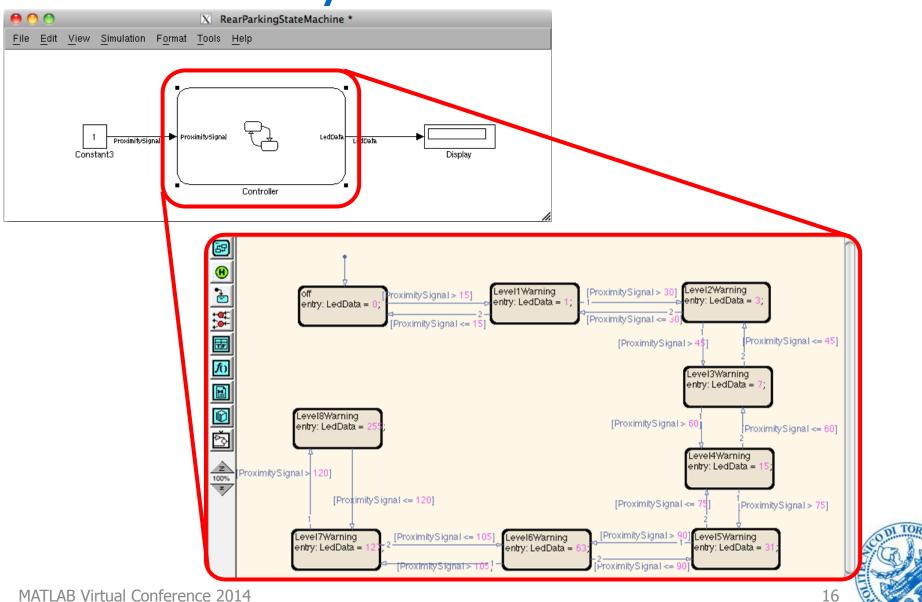Custom drivers generated automatically by Cypress PSoC 5 Creator
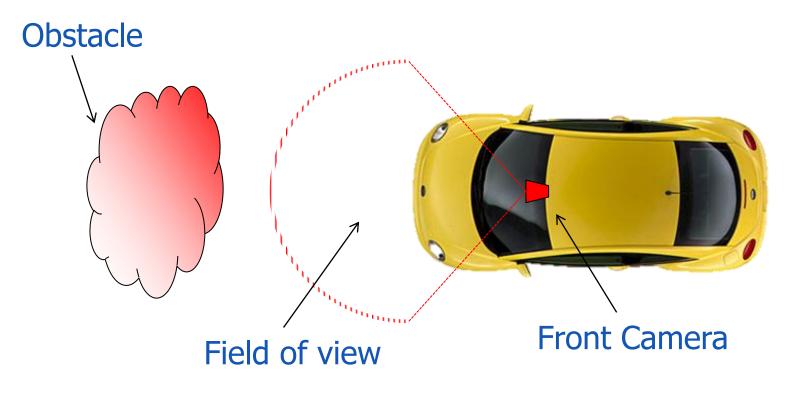
Proximity Sensor API

LED API

Hardware

System Model

Autonomous emergency brake

- Develop a system that automatically brake the car when an obstacle is detected. A line scan sensor is used to model a front view camera.
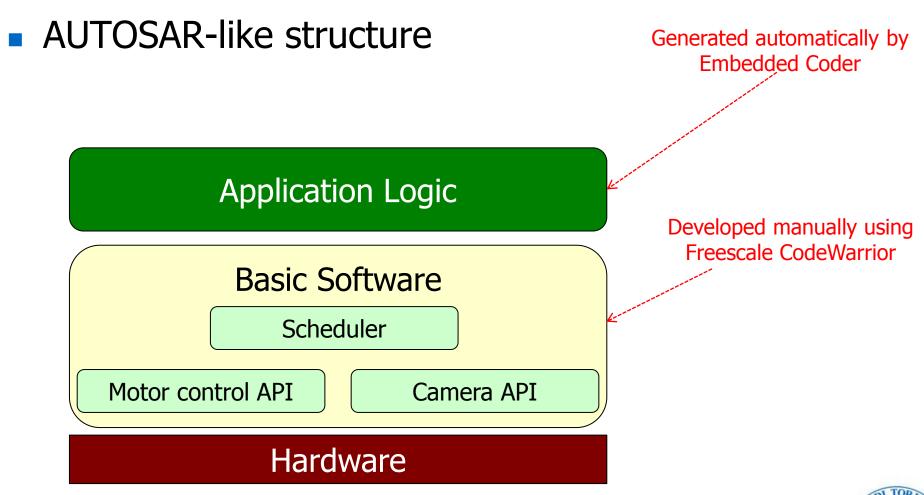
Obstacle

Field of view

Front Camera

Hw used for the case study

- Freescale Cup electric car kit

Freedom board + motor shield

Propulsion ctrl

Steering ctrl

Road image

Chassis+servo+motor

Line scan camera

Implementation

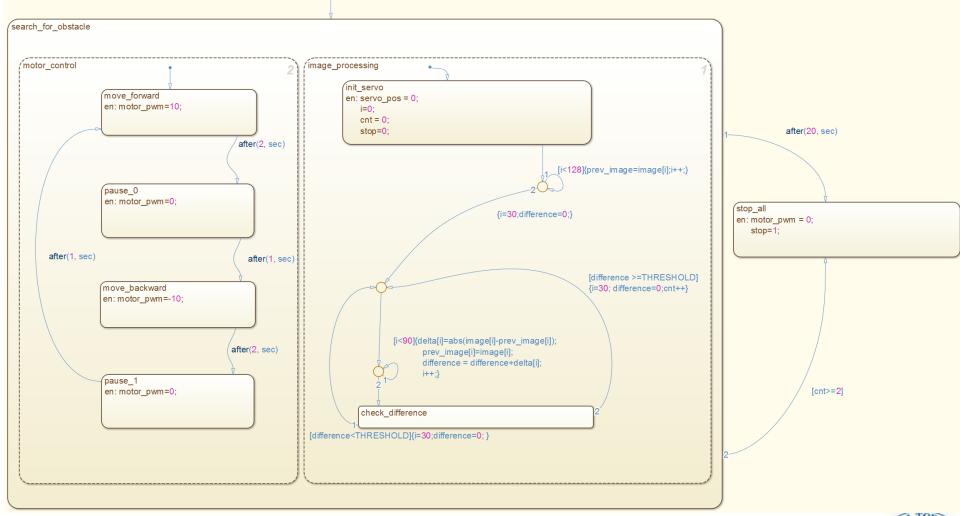- AUTOSAR-like structure

Generated automatically by Embedded Coder

Application Logic

Developed manually using Freescale CodeWarrior

Basic Software

Scheduler

Motor control API   Camera API

Hardware

System Model

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- Course organization

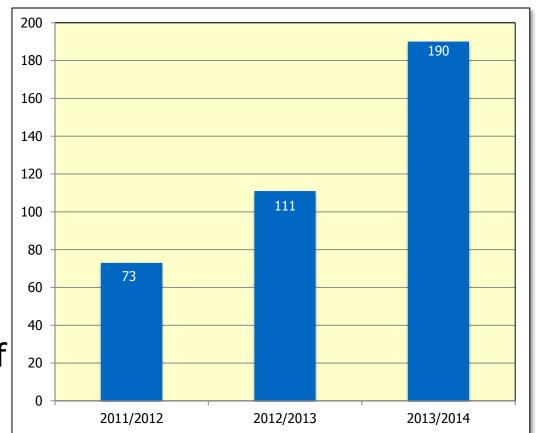- Case Studies

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Interest from industries/students

- **Automotive firms**
  - 4 seminars/year
  - 16 MS thesis
    - 6 in progress
    - 10 newly employed
- **Students**
  - Growing number of enrolled students
  - 5x times the num. of students of similar courses

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Conclusions

- The course fills a gap in the ICT engineering curricula at Politecnico di Torino:
  - Excellent impact on students
    - Lab is crucial
    - Lectures are recorded and set available via streaming
  - Very promising feedback from local industries
- Key collaborations with:
  - The MathWorks
  - Freescale University Program/Cypress University Alliance
  - Local industries