POLITECNICO
MILANO 1863

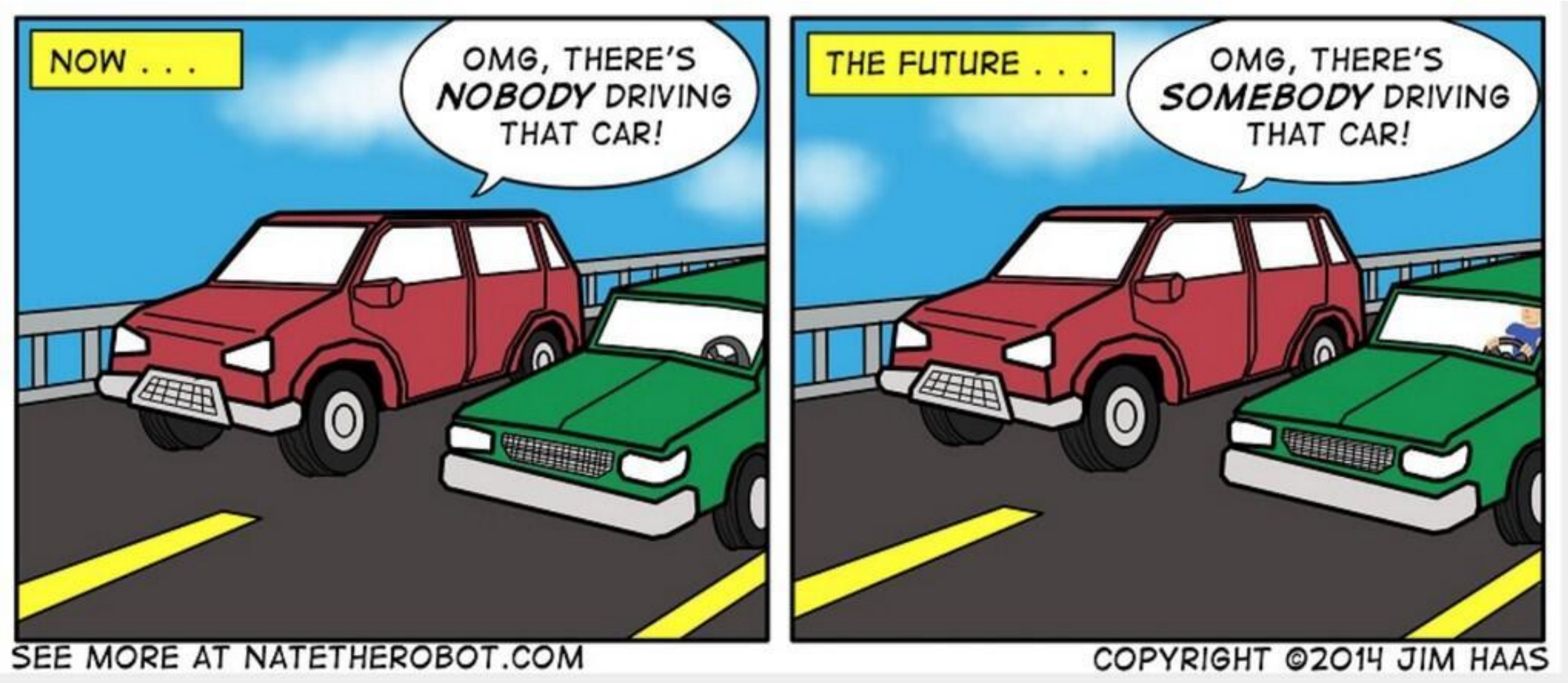
Unmanned autonomous vehicles in air land and sea

PhD Course Introduction

Matteo Matteucci
matteo.matteucci@polimi.it

Artificial Intelligence and Robotics Lab - Politecnico di Milano

Course subject



How far we are?

Source: MIT TECHNOLOGY REVIEW VOL. 116 | NO. 6

BMW

5 Series (modified)

- Video camera tracks lane markings and reads road signs
- Radar sensors detect objects ahead
- Side laser scanners
- Ultrasonic sensors
- Differential GPS
- Very accurate map

Mercedes-Benz

S 500 Intelligent Drive Research Vehicle

- Stereo camera sees objects ahead in 3-D
- Additional cameras read road signs and detect traffic lights
- Short- and long-range radar
- Infrared camera
- Ultrasonic sensors

Nissan

Leaf EV (modified)

- Front and side radar
- Camera
- Front, rear, and side laser scanners
- Four wide-angle cameras show the driver the car's surroundings

Google

Prius and Lexus (modified)

- LIDAR on the roof detects objects around the car in 3-D
- Camera helps detect objects
- Front and side radar
- Inertial measuring unit tracks position
- Wheel encoder tracks movement
- Very accurate map

General Motors

Cadillac SRX (modified)

- Several laser sensors
- Radar
- Differential GPS
- Cameras
- Very accurate map

"Mercedes's autonomous driving on highway"
http://www.youtube.com/watch?v=4jW0fJ80VG8

- Several producer are expected to launch their products in 2020
- Close-to-market solutions, e.g. automated highway driving, automated parking

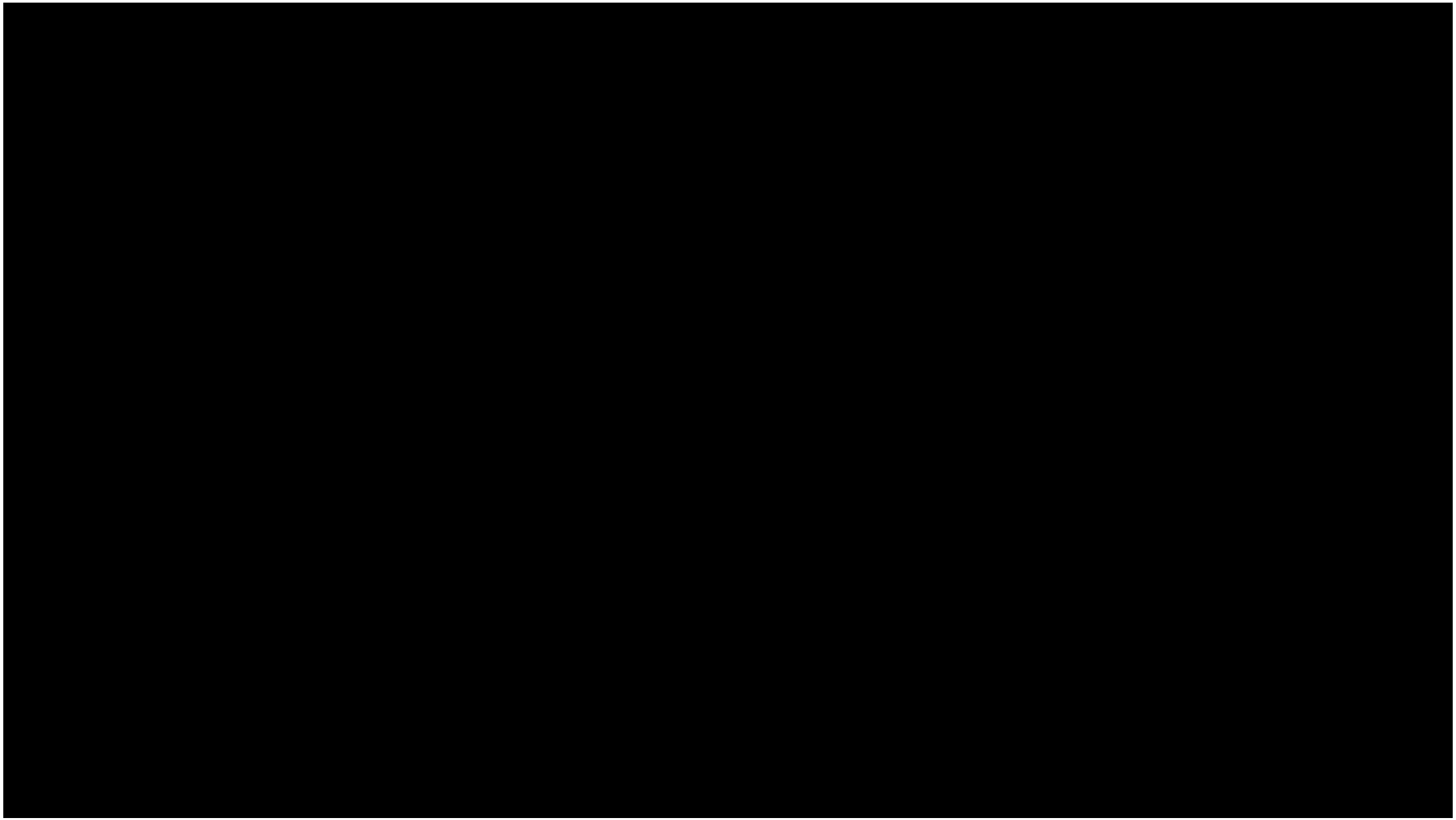
Why all this fuzz?

Challenges

Several open challenges are still there in autonomous driving

- Coping with high-complexity urban environments
- Accounting for dynamics
  - Combustion engine effects
  - Kinematic vehicle constraints
  - Other cars, pedestrians, cyclists
- Dealing with uncertainty
  - Jumping localization
  - Uncertain perception
- Real-time operation

"A Ride in the Google Self Driving Car"
http://www.youtube.com/watch?v=TsaES--OTzM



Challenges (continued)

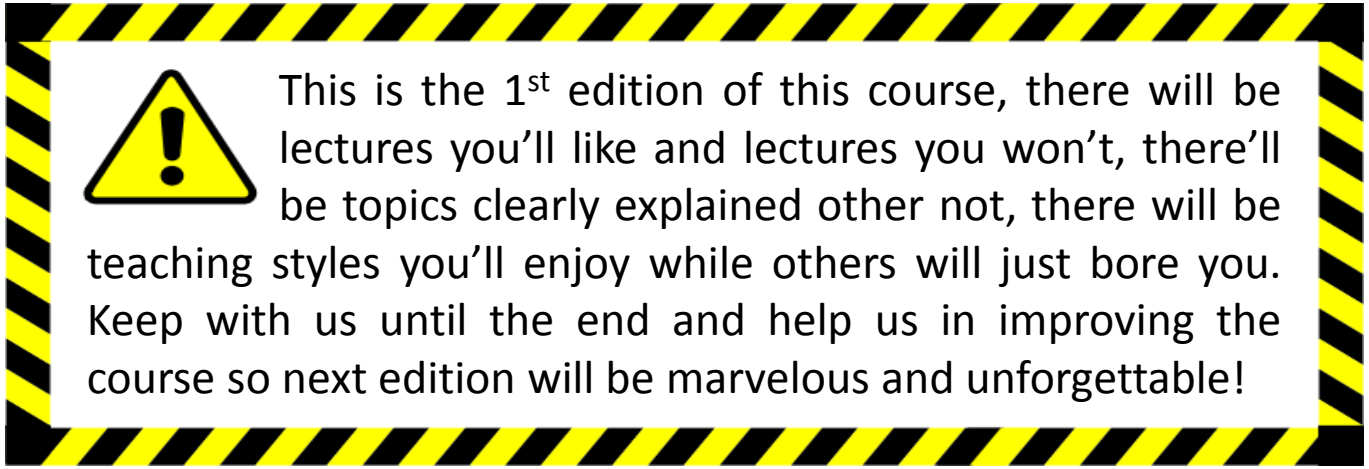
Non technical challenges in autonomous driving exist as well

- How to proof safety of automated vehicles?
  - World contains infinite amount of different situations
  - 100% safety impossible in urban environments
- Legal Issues
  - Vienna Convention on Road Traffic (1968, article 8, paragraph 5):
  - *“Every driver shall at all times be able to control his vehicle or to guide his animals.”*

“Autonomous Crash in DARPA Urban Challenge”
http://www.youtube.com/watch?v=bnv5JP8gL_k

Course objectives and disclaimer

"The course presents the knowledge required to better understand commonalities and specificities of unmanned autonomous vehicles design in the different domains of air, land, and sea."



Course teachers

Mon 6th June	Mon 6th June	Tue 7th June	Tue 7th June	Wed 8th June	Thu 9th June
					
Luca Bascetta	Matteo Matteucci	Marcello Farina	Marco Lovera	Alfredo Martins	Jose' Almeida
Politecnico di Milano				Instituto Superior de Engenharia do Porto	

Course schedule

Monday Matteo Matteucci (also on behalf of Luca Bascetta) will present:

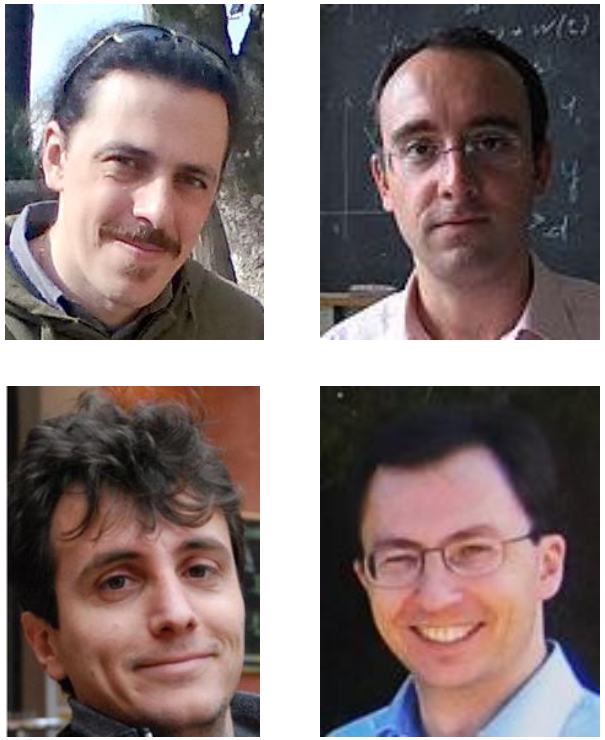
- An introduction to robot control architectures
- Land robot kinematics
- Planning and control for land robots
- Some examples from the DARPA Urban Challenge 2007

Tuesday morning Marcello Farina will present:

- Model Predictive Control
- Feedback linearization for MPC
- Examples with unicycle and single track

Tuesday afternoon, Marco Lovera will present

- Aerial vehicle modeling
- Attitude estimation for aerial vehicles
- Attitude control for aerial vehicles
- Trajectory control for aerial vehicles



Course schedule

Wednesday morning Alfredo Martins will talk about:

- Introductory overview of unmanned current systems and applications on marine robotics
- Developing maneuvering models for marine vehicles
- Standard open water tests, parameter determination techniques and empirical methods for hydrodynamic force modeling
- Control and guidance of unmanned surface vehicles and unmanned submarines
- Simulation tools for marine robotics development

Wednesday afternoon Alfredo Martins will present:

- Practical case study in control and guidance of unmanned marine autonomous robots
- Sensors for unmanned underwater robots
- Underwater environmental modeling and mapping
- Navigation of autonomous underwater vehicles

Course schedule

Thursday morning Jose Almeida will talk about:

- Applied filtering and estimation
- Practical example with field mission data

Thursday afternoon Jose Almeida will talk about:

- Coordination of multiple autonomous vehicles at sea
- Interoperability of unmanned systems
- Autonomous underwater vehicle case study
- Current emerging applications and challenges

Friday (for the interested readers) DEIB - PT1 Room, June 10th, 2016, 2.00 pm

- Supervisory control for intersection collision avoidance using scheduling
  Heejin Ahn, PhD Candidate Massachusetts Institute of Technology

Course evaluation

To pass the course and get the grade both PhD and MS students will have to:

- Write a short review paper on a topic related to the course among those covered or not covered and possibly related to their interests
- Code a simple MATLAB/Python/C++ demo to visualize the content of the paper
- Give a 20-30 minutes presentation in the form of a seminar/lecture about the content of the report with slides and live demos

Some logistics aspects you might be interested in

- Project could be done in groups of max 2 students
- We let the student chose the topic but this has to be confirmed by the teachers
- The public presentation of the report is used for evaluation
- In case the topic is not suitable for a demo … let's discuss about it

Course evaluation ... some examples

Line detection for land autonomous vehicle: the report reviews current approaches in computer vision and Kalman filtering for line and road boundary estimation, the demo uses OpenCV to perform line segmentation and filtering, the slides present this review with some examples from the literature and from the demo

Search based planning in autonomous vehicle: the report reviews current approaches in search based trajectory planning for nonholonomic vehicles, the slides present this review with some examples from literature and from the demo (a C++ code using SBPL which implements the 4D trajectory planning from the DARPA Challenge winning team).

Model Predictive Control for lateral control of land autonomous vehicles: the report describes the problem of lateral control in non holonomic vehicles and a technique based on feedback linearization to perform it, the slides present an introduction to lateral control and the proposed method together with some MATLAB code to simulate the vehicle and the control