IMARA Informatique, Mathématiques et Automatique pour la Route Automatisée
IMARA

- Project-Team – INRIA Rocquencourt
- ~32 persons + trainees (10/year)
- Research field: Intelligent Transportation Systems
  - Mobility
  - Security
- Topics:
  - Traffic simulation and modeling
  - Communications: V2V – V2I
  - Robotics: perception, planning, control,...
IMARA

• Outstanding team at l’INRIA:
  – Size
  – Profile:
    - Research lab.
    - Experimental Plateform
  – Transverse team (collaboration with 8 teams): ‘showcase’ pour l’INRIA
  – Financed research activity (today: ~20 contracts)
  – Strong involvement in European projects

• Member of the LaRA consortium: INRIA – MINES PARISTECH – IFSTTAR
**IMARA Personnel**

- **Permanent staff**: 5 people
  - Chazelas (ITA) - Fayolle (DR1 – Emeritus) - Lasgouttes (CR1)
  - Le Lann (DR1 – Emeritus) - Yvet (ITA)
- **Specialists (Expert Eng.)**: 15
- **Invited professors**: 2 (Petrov – Alessandrini)
- **Post Doc**: 3 (Samsonov – Zhang - Nogushi)
- **PhD Students**: 8
- **External collaborators / advisors**: 4 (Parent – Ernst – Noël – Bouraoui)
- **Trainees**: 10
- **« Vacations »**: 6

♫ ~53 people in 2011
IMARA Personnel

• Permanent staff
  – Nashashibi (Team Leader)
  – Chazelas (ITA)
  – Lasgouttes (CR1)
  – Yvet (ITA)
  – Fayolle (DR1) – Emeritus
  – Le Lann (DR1) – Emeritus

• Specialists
  – Parent
  – Fortelle
  – Bouraoui
  – Ernst
  – Boussard

• Doctors/Postdocs
  – Resende
  – Charlot
  – Feng
  – Nicoud
  – Lewden
  – Xie
  – Lee
  – Sandu
  – Holgin
  – Noël
  – Lefaudeux
  – Mehani
  – Li
  – Martin
  – Ben Jemaa
  – Tsukada
  – Nogushi
  – Maarouf

• Invited Professors
  – Petrov
  – Alessandrini
La Route Automatisée

- Set of techniques designed to:
  - Improve road transportation
  - Achieve sustainable mobility for people and goods
  - New transportation modes and concepts
- Based on ICST and concerns infrastructures as well as vehicles
- Ranges from driver information, to drivers assistance, to full driving automation
**CyCab (1996)**

- Small Public Urban Vehicles
- Assisted driving
- Platooning
- Automated Parking
- Automated tracks
- Complement to other modes
CyberCab Yamaha-INRIA (2000)
CYBERGO (INDUCT – 2010)
CYBUS (INRIA – 2011)
LaRA fleet
**IMARA Research Themes**

- **Driving assistance and automation**
  - Sensors and Data Fusion
  - Task & trajectory planning
  - Vehicle control (low/high levels)
  - MMI
  - Cooperative behavior

- **Modeling and control of transport systems**
  - Stochastic models
  - Operation research on logistics
  - Simulation tools

- **Communication technologies for mobiles**
  - IPv6 deployment
  - Geonetworking
  - Standardization
• **In 2011 ⇒ 21 living projects!**

• Projects financing:
  EU: 9 / Fench: 11 / Private sector: 1

Distribution by main area (or « team »):

- **MOD**: 5
  AROS / TRAVESTI / Ma Micro Planete / CATS* / PUMAS

- **COM**: 5
  Orange / SANDRA / SCORE@F / Drive-C2X* / ITSSv6* 

- **ROB**: 11
  HAVEit* / Intersafe-2* / CityMobil* / CityNetMobil* / ABV / PICAV* / AMARE / Co-Drive / Corebots / Merit
Contracts IMARA (2004-2011)

• Com2React (ICT)
• CyberCars-2 (IST)
• PReVENT (IST)
• LOVe (Predit)
• Anemone (IST)
• Cristal (FUI)
• Esteem (SST)
• GAST (DG Edu)
• CVIS (IST)
• GeoNet (ICT)
• CityMobil (EESD)
• CATS (ICT)
• HaveIT (ICT)
• CityNetMobil (SST)
• PICAV (ICT)
• InterSafe-2 (ICT)
• ABV (Predit)
• AMARE (Predit)
• ...
**IMARA Software (2004-2011)**

- TAXI (real-time control)
- CyberMaps (RT-Maps software suite)
- CyberFly (Genetic algo. for vision)
- CyberSim (3D Simulation for Robots)
- SPIKA (Traffic reconstruction)
- CyberCom (Fast Mobile Comm.)
- CarGeo6 (IPv6 + Geonetworking)
Technology Transfer

- Know-how transferred to VU-Log
- Know-how and software transferred to Senda
- Know-how transferred to Intempora
- Know-how transferred to Robosoft
- Patent in negotiation with Lohr Industries (Cristal Project)
- IPv6 GeoNetworking transferred to Orange
Cooperation inside INRIA

• Active cooperation with/-out financed R&D projects:

  E-Motion
  Hipercom

  Aoste
  TAO
National Cooperations

• Laboratories:
  – LaRA (Mines-Paris, INRETS, LCPC)
  – LASMEA (Clermont)
  – LITIS (Rouen)
  – UTC
  – UTBM
  – CERMICS
  – ENST Bretagne (Telecom Bretagne)
  • Institut Telecom
• Private sector:
  – VALEO
  – PSA
  – Intempora
  – Mobile Devices
  – Civitec
  – Robosoft
  – Mobile Devices
  – ADM Concept
  – …
European Cooperations

- DLR, Braunschweig
- Dimeca, Genova
- Imperial College, GB
- EPFL, CH
- ISR, Coimbra
- IKA Aachen
- ICT La Sapienza, Rome
- IAI Madrid
- FZI Stuttgart
- TRG, Southampton
- Newcastle Univ., GB
- Eurandom, Eindhoven, NL
World Cooperations

- SwRI (USA)
- UCR (USA)
- Tokyo U., NAIST, Keio U. (Japan)
- SJTU (China)
- NTU (Singapore)
- Griffith U., NICTA (Australia)
- Moscou Univ., IPPI (Russia)
- Colombia U., Berkeley (USA)
- Yeungnam / SL / ETRI (Korea)
- U. Montreal (Canada)
Activities / Objectives scientific

2008 - 2012
Topics

• Robotics vehicles:
  – ADAS for safe navigation
  – Complex and fast manoeuvres
  – Cooperative systems

• Modeling
  – Advances in modelling of very large random systems: hydrodynamic limits, phase transition, statistical physics models.

• Communications
  – Fast, robust and safe V2V / V2I communications
Vehicle Cooperation

- V2V and V2I Communications
- Passing stopped vehicles
- Overtaking slow vehicles
- Trains of cars
- Merging and splitting
- Crossings, round-abouts
Extended Sensing
Hierarchical multiresolution probabilistic SLAM

INRIA Rocquencourt: a bird view

Results with the multi-resolution probabilistic SLAM

👍 « Loop closure »
👍 Centimetric accuracy
👍 Real time
👍 Integrated on our AGV

DEMO
Slammot + PMP
Path planning & Control : HAVEit use case

(F 1.1.1) Gather information about the environment
(F 1.2) Gather information about vehicle state
(F 1.2.1) Calculate the feasible trajectory
(F 1.2.2) Define the Driver state
(F 1.2.3) Define the automation level
(F 1.2.4) Compute the vehicle action
(F 1.3.1) Calculate vehicle model
(F 1.3.2) control vehicle
(F 1.4) Integrate the driver in the control vehicle
(F 1.4.1) Gather information about the driver
(F 1.4.2) Allow the Driver to manage I/O

Datasensor Fusion
Selection of the best manoeuvres
Calculate the refined trajectories
• For each cell in the manoeuvre grid, calculate different costs:

  - 1. RISK COST = GravityOfCollision \times ProbabilityOfCollision
  - 2. SPEED COST = DistanceAtLegalSpeedLimit – RealDistance
  - 3. COMFORT COST = Sum of X and Y jerks during trajectory
  - 4. CONSUMPTION COST = Combination of X accelerations and speed
  - 5. OFFENCE COST = Penalties for right overtaking, excessive speed
  - 6. WISH COST = Cost of not following driver wishes: e.g. indicators, ...

TOTAL COST = Weighted sum of all PARTIAL COSTS

Output: the ranking of the manoeuvres
Pedestrian detection: fusion of camera and laser scanner

SLAM community

Mapping

Partial Perception Systems

Localizatio

MOT community

Detection

Tracking

Classification

[Wang et al, 2004]

[Vu et al, 2009]

[Gâté & Nashashibi, 2009]
Vision-based lane markings detection: LDWS
Vision-based Platooning
GPS and perception-based autonomous navigation
La Rochelle demonstration

- 2-3 INRIA’s CyBus (Yamaha)
- 1 INRIA CyberGo (INDUCT)
- On-demand service as an “horizontal elevator”
- Speed limited to 10 Km/h
- An operator is always on-board
- Demonstration expected to run between April and July 2011
La Rochelle: site

Paris

La Rochelle

Old city centre

Electric boat line

Demo site

BRT line
La Rochelle: site
INRIA’s CyBus vehicles

Capacity: 5 pax
Max. speed: 18 Km/h
Mass: 500 Kg

Front & rear LIDARs
Ultrasounds
Guidance: LIDAR-based SLAM

DEMO
INRIA’s CyberGo vehicle

Capacity: 8 pax
Speed: 30 Km/h
Mass: 700 Kg

Sensors:
4 LIDARs guidance
US Camera(s)
AMARE
AMARE – the concept
AMARE
PICAV
Personal Intelligent City Accessible Vehicle System

- Funded under 7th FWP (Seventh Framework Programme)
- New mobility concept for passengers ensuring accessibility for all in urban pedestrian environments.
- The transport system will ensure accessibility for everybody and some of its features are specifically designed for people whose mobility is restricted for different reasons, particularly (but not only) elderly and disabled people.
- Ergonomics, comfort, stability, assisted driving, eco-sustainability, parking and mobility dexterity as well as vehicle/infrastructures intelligent networking are the main drivers of PICAV design.
PICAV
New driving interfaces

- New interfaces & sensors
- New driving modes
1. Presentation of our platform SiVIC/RTMaps
2. Single-Track Platooning
3. Optimal Automatic Parking
4. Innovative HMI
RTMaps: Real Time Multi Applications

- Synchronized Vehicle sensor data
- Real-time data processing

[Steux, 2002]
**SiVIC: Vehicle-Infrastructure-Sensors simulator**

- Vehicle-Infrastructure-Sensors Simulator
- Dynamic Vehicle model
- Camera, odometers, IMU simulations

[Gruyer, 2005]
SiVIC / RTMaps

Sensors data

Actuator control
Cycab / RTMaps

Sensors data

Actuator control
Platform SiVIC / RTMaps

SiVIC
Platform SiVIC / RTMaps

Cycab
1. Presentation of our platform SiVIC/RTMaps
2. Single-Track Platooning
3. Optimal Automatic Parking
4. Innovative HMI
Single-Track Platooning

- **Control Objective:**
- Given the relative position and orientation between the two vehicles, the control objective is to asymptotically track the virtual reference point \( R_{1r} \) associated with the lead vehicle with the reference point \( R_{2f} \) of the following vehicle in the presence of unknown lead vehicle linear and angular velocities.
Solution Formulation

- Two virtual reference points $R_{I_r}$ and $R_{2f}$

  - $R_{I_r}$ located on the longitudinal axis of the lead vehicle at a distance $L$ behind the rear vehicle axle.
  
  - $R_{2f}$ located on the longitudinal axis of the following vehicle at a distance $L$ in front of the rear vehicle axle.
Single-Track Platooning
1. Presentation of our platform SiVIC/RTMaps
2. Single-Track Platooning
3. Optimal Automatic Parking
4. Innovative HMI
Optimal Automatic Parking

Choi, Boussard, and d’Andréa-Novel, for VALEO
Optimal Automatic Parking
... and more

- Road signs detection
  - Speed limit determination
  - Fusion with GIS
- Traffic lights detection
- Rain detection
- GIS development
- ...

... and more
Key events in 2011