PERCEPTION FOR INTELLIGENT VEHICLES/ROBOTS

Olivier Aycard
Associate Professor at University of Grenoble
Laboratoire d'Informatique de Grenoble
http://lig-membres.imag.fr/aycard/
Aycard@imag.fr

OUTLINE

Introduction

Intelligent vehicles: SLAM + DATMO & Classification (2004-2015)

Companion robot + cobotic (2015-…)

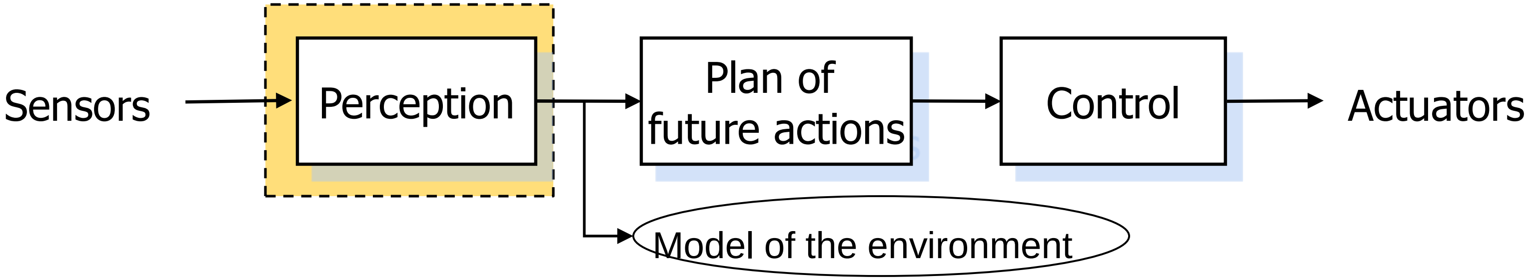
Conclusions and Perspectives

Intelligent Vehicles/robots

- What is an intelligent vehicle?
  - An intelligent vehicle is designed to:
    - Monitor and assist a human driver
    - Avoid or mitigate dangerous situations
    - Drive autonomously
  - To achieve its goals, an intelligent vehicle is equipped with:
    - Sensors – to perceive its surrounding environment
    - Actuators – to interact with the environment

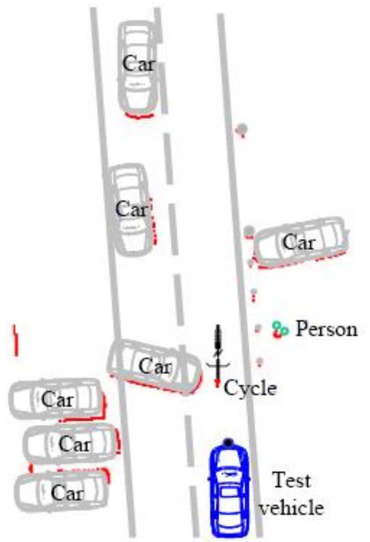
Daimler demonstrator
(European project Prevent)

Google self-driving car



Perception and its elements

- Vehicle perception in open and dynamic environments
- **Laser scanner**
- Speed and robustness



Present Focus: interpretation of raw and noisy sensor data

- Identify static and dynamic part of sensor data
- Modeling static part of the environment
  - Simultaneous Localization And Mapping (SLAM)
- Modeling dynamic part of the environment
  - Detection And Tracking of Moving Objects (DATMO)

OUTLINE

Introduction

Intelligent vehicles: SLAM + DATMO & Classification (2004-2015)

Companion robot + cobotic (2015-…)

Conclusions and Perspectives

Simultaneous Localization and Mapping

- Maximum likelihood SLAM [Wang 2007, Vu 2009]
  - Probabilistic solution: $P(x_t, M_t | Z_t, U_t, x_0)$
  - Occupancy grid representation using only lidar
  - Incrementally build a single map as new sensor data arrive
  - Finds the vehicle pose x_t satisfying the vehicle motion model and the measurement model given the previous map

$$\hat{x}_t = \underset{x_t}{\operatorname{argmax}}\{P(z_t|x_t, \hat{M}_{t-1})\, P(x_t|u_t, \hat{x}_{t-1})\}$$

$$\hat{M}_t = \hat{M}_{t-1} \cup \{\langle \hat{x}_t, z_t \rangle\}$$

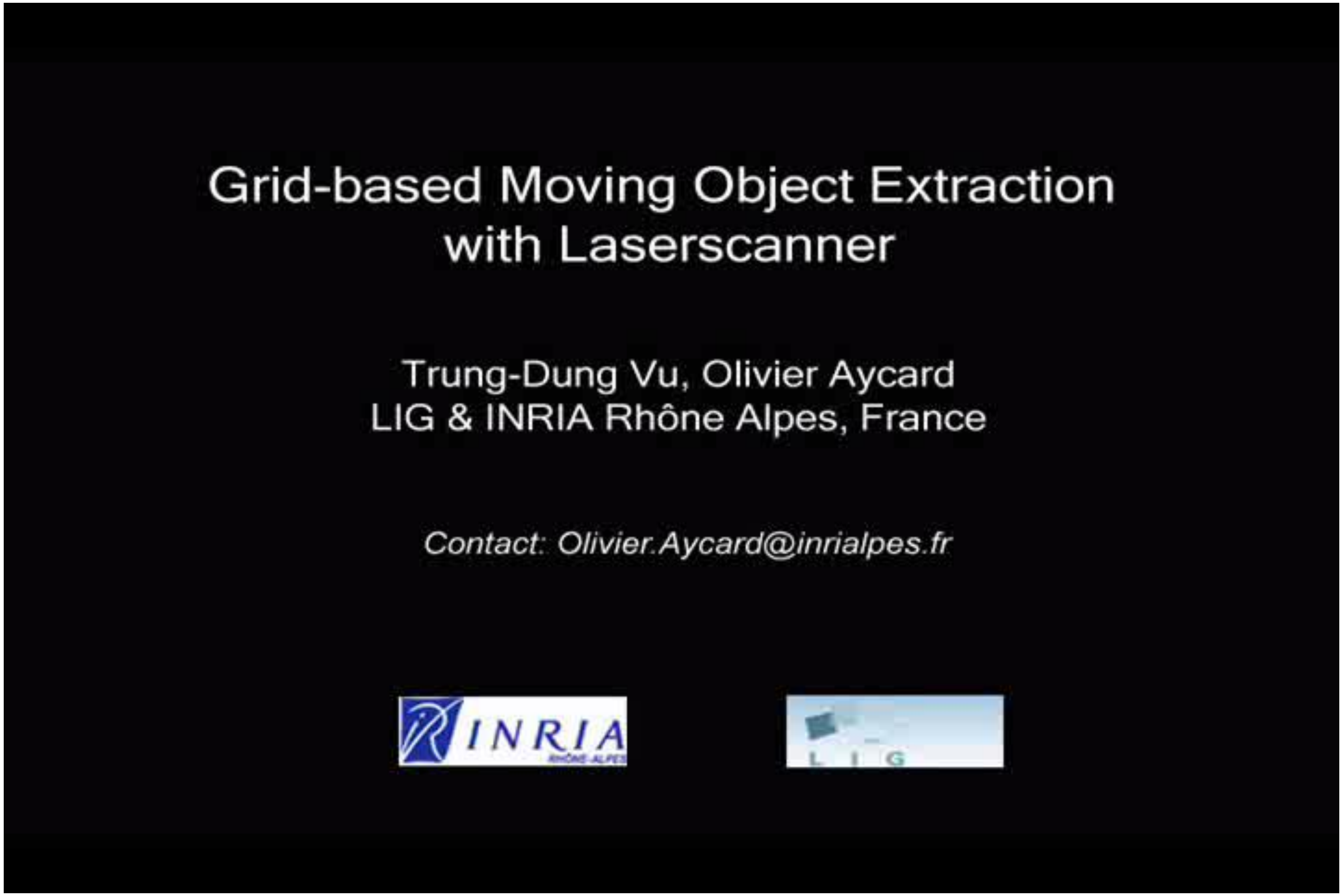
Experiments

- Daimler Demonstrator (european project PReVENT) [Vu'07]
  - Laser scanner: resolution: 1^0, range: 70m, FOV:160^0, freq: 40Hz
  - Velocity, steering angle
  - High speed (>120km/h)
  - Camera for visual reference
  - Different scenarios: city streets, country roads, highways

- Volkswagen Demonstrator (european project Intersafe2) [Baig'09]
  - SICK laser scanner: resolution: 1^0, range: 80m, FOV: 160^0, freq: 37.5Hz
  - Odometry: rotational and translational speed
  - Camera for visual reference
  - Urban traffics

S. Pietzsch, TD. Vu, J. Burlet, O. Aycard, T. Hackbarth, N. Appenrodt, J. Dickmann and B. Radig. *Results of a Precrash Application based on Laser Scanner and Short Range Radars.* IEEE Transactions on Intelligent Transport Systems, 10(4), pages 584-593, 2009.

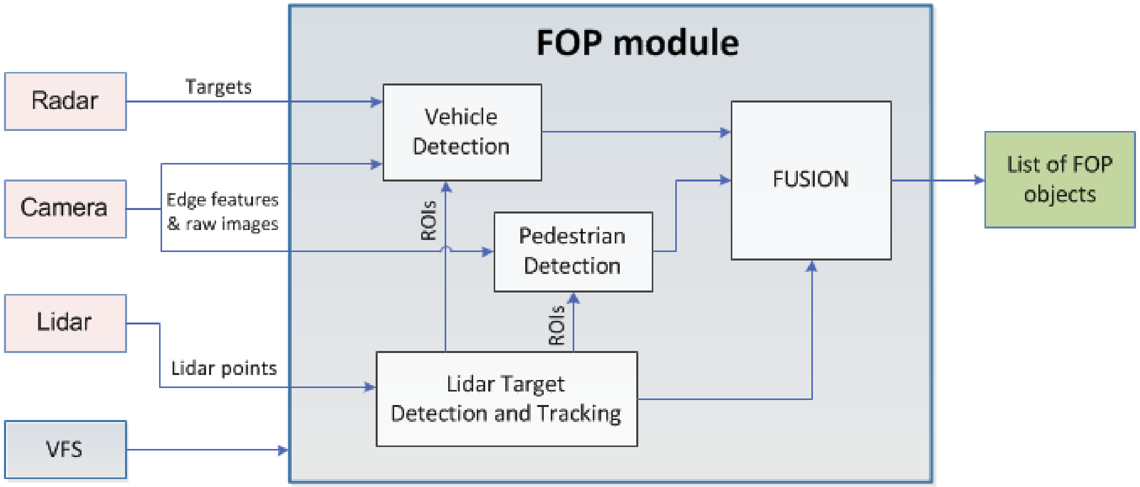
Results - SLAM + Moving object detection



Execution time: ~20ms on a PIV 3.0GHz PC 2Gb RAM
Daimler demonstrator

Frontal Objects Perception + Moving Objects Classification

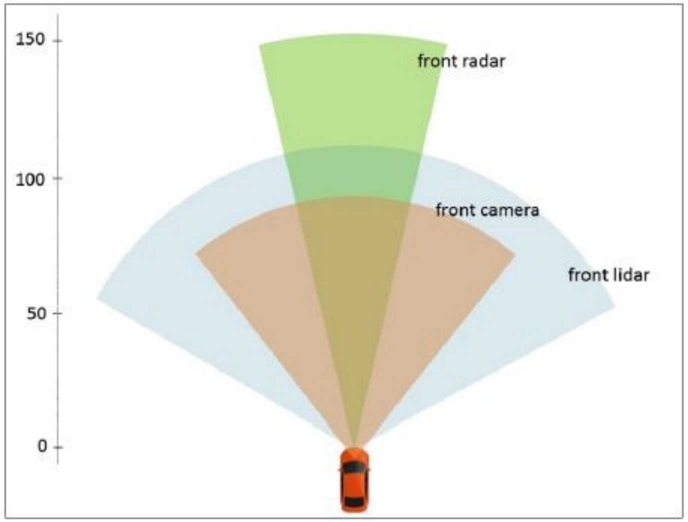
- Solve Detection, Tracking and Classification at the same time



- Lidar target detection & tracking:
  - Target dynamics + geometry estimation
  - Target class likelihood for moving targets (truck/bus, vehicle, pedestrian)
- Pedestrian detector from images
- Vehicle detector from images : vehicle, truck
- Fusion: decide the final output based on information on position and class of each object given by each sensor
- MOC is seamlessly integrated inside FOP

Experiments

- CRF Demonstrator (european project Interactive) [Chavez'15] :
  - TRW TCAM+ Camera: B&W images, FOV of ± 21°
  - TRW AC100 medium range radar: Detection range up to 150m, Velocity range is up to 250kph, FOV is ± 12° (close range) or ± 8° (medium range), Angular accuracy is 0.5°
  - IBEO Lux 2D laser scanner: Range up to 200m, Angular and Distance resolution of 0.125° and 4cm respectively, FOV is 110°
- Lidar is used for its high accuracy for moving object detection and mapping
- Camera provides a better object discrimination
- Radar detects moving objects at high-speed



Results - SLAM + FOP + MOC

O. Chavez, O. Aycard. *Multiple Sensor Fusion and Classification for Moving Object Detection and Tracking.* IEEE Transactions on Intelligent Transport Systems, pages 525-534. 2016.

OUTLINE

Introduction

Intelligent vehicles: SLAM + DATMO & Classification (2004-2015)

Companion robot + cobotic (2015-…)

Conclusions and Perspectives

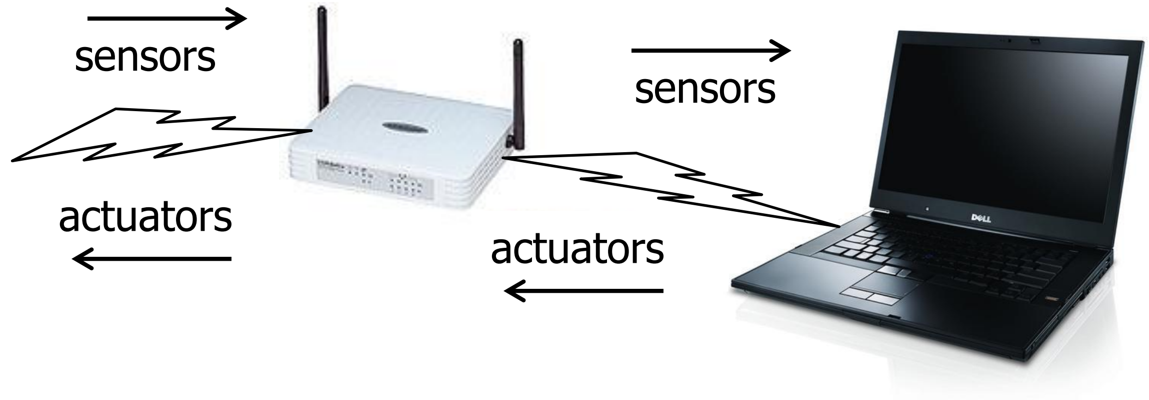
Robair project: 100% designed, built and developed in the LIG+FabLab Mstic-LIG

Research

Public events

Teaching

Robair project: some technical informations



- 1 raspberry pi3 Ubuntu + ROS
- Sensors
  - 2 laserscanners
- Actuators
  - 2 wheels driven by 2 motors + encoders

- 1 PC Ubuntu + ROS
  - In charge of sensor data acquisition, processing & visualization;
  - In charge of controlling actuators.

Cross Disciplinary Project CIRCULAR (future of industry) funded by IDEX Grenoble

Exclusive vs. Collaborative Operations

Today - Static

Fully Automated – No Humans

Human operations – No Robots

The new ISO 10218: "Robots and robotic devices - Safety requirements for industrial robots" is addressing this type of applications

← Exclusive Spaces →

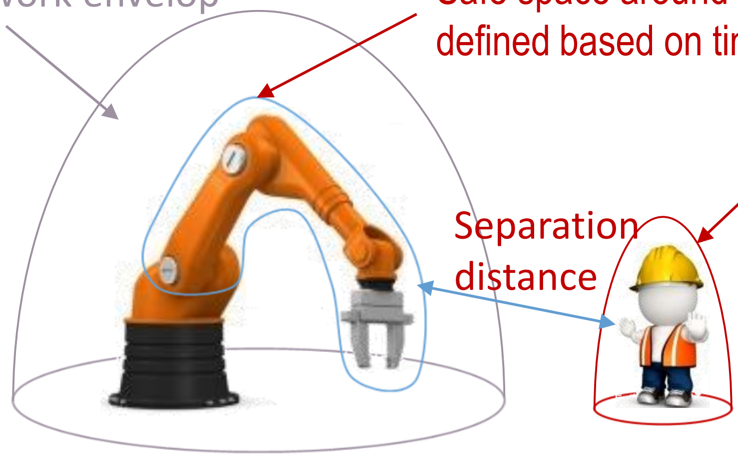
In the Future - Dynamic

If robots were able to interact safely with human it will create opportunities for new more efficient and productive applications

3D - Collaborative Environment (PhD Thesis starting in 10/2018 in collaboration with PB. Wieber (LJK))

Allowed work envelop

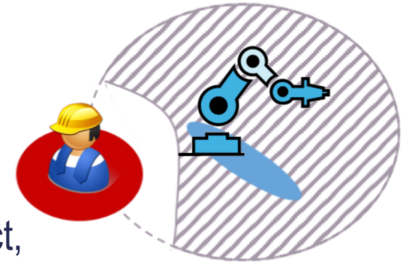
Safe space around the robot arm defined based on time to stop



Safe space around the person defined based on reach and max velocity

Person far away from robot
Robot allowed full access

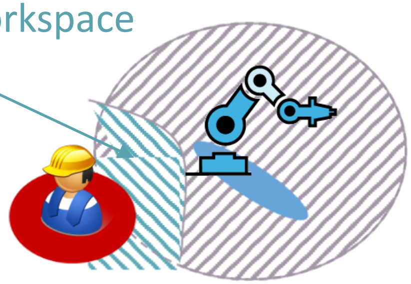
Situation 1



Situation 2

Person entering the work envelop of the robot
Robot allowed working area is restricted
If the two safe spaces (person and robot) intersect, the robot stops

Collaborative Workspace



Person and robot are working together, maintaining the minimum separation distance at all time
Robot is in Collaborative Mode

Situation 3

OUTLINE

Introduction

Intelligent vehicles: SLAM + DATMO & Classification (2004-2015)

Companion robot + cobotic (2015-…)

Conclusions and Perspectives

Conclusions and perspectives

- Intelligent vehicles + ADAS (Advanced Driver Assistant System)
  - Preindustrial prototype:
  - 10 years of R & D in collaboration with automotive industry
  - Based on low cost sensors and affordable CPU
  - Software modules (FOP & MOC) have been protected
  - 4 PhD Thesis & 4 Post Doctorals students
  - 21 publications cosigned with industrial partners

- Extension of previous researches for companion/service robots + cobotics