SBESC
IV Simpósio Brasileiro de Engenharia de Sistemas Computacionais
3 a 7 de novembro de 2014 - Studio 5 Centro de Convenções - Manaus/AM

Projeto CaRINA: Desenvolvimento de Veículos Autônomos

Manaus, November 2014

Prof. Dr. Fernando S. Osório – ICMC / USP

ESSE Minicurso

IV Escola de Sistemas Embarcados

LRM Laboratório de Robótica Móvel
ICMC/USP - São Carlos
CROB
ICMC USP SÃO CARLOS
Instituto de Ciências Matemáticas e de Computação
| Universidade de São Paulo |
INCT SEC

SBESC

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November 2014

Projeto CaRINA: Desenvolvimento de Veículos Autônomos

Presented by Prof. Dr. Fernando S. Osório **– ICMC / USP**

Authors: Prof. Dr. Fernando S. Osório, Prof. Dr. Denis F. Wolf, Profa. Dr. Kalinka Castelo Branco, Prof. Dr. Valdir Grassi Jr.

LRM

+ M.Sc. and Ph.D. Students of LRM Lab.

Center for Robotics of USP São Carlos – CRob / USP-SC

LRM Laboratório de Robótica Móvel

ICMC/USP - São Carlos

CROB

Laboratório de Robótica Móvel

ICMC/USP - São Carlos

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CARINA

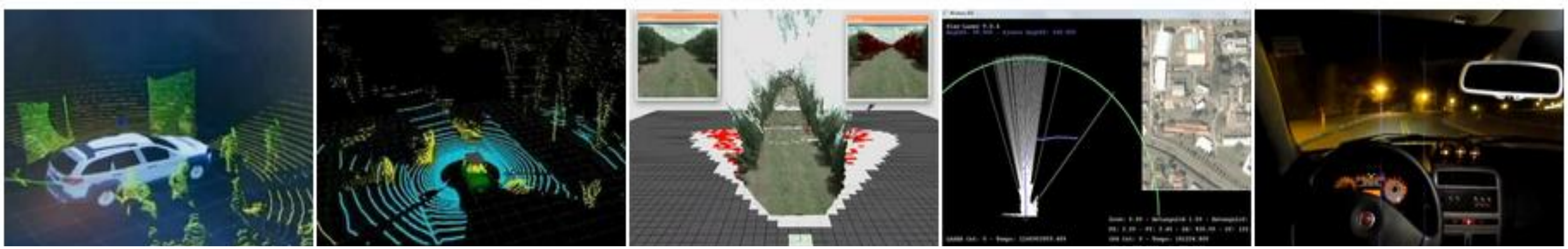
Carro Robótico Inteligente para Navegação Autônoma

Home

O Laboratório de Robótica Móvel desenvolve pesquisa em diversas áreas relacionadas à robótica. Dentre elas destacam-se: visão computacional, sistemas inteligentes, computação evolutiva, aprendizado de máquina, sistemas computacionais reconfiguráveis, robôs e veículos autônomos.

Atualmente, grande parte da pesquisa desenvolvida no laboratório está relacionada ao desenvolvimento de veículos inteligentes para ambientes urbanos e agrícolas. Mais informações sobre as linhas de pesquisa em andamento podem ser obtidas na página de projetos.

http://www.lrm.icmc.usp.br/



http://www.youtube.com/lrmicmc

ICMC USP SÃO CARLOS

INCT SEC

Instituto Nacional de Ciência e Tecnologia em Sistemas Embarcados Críticos

CROB

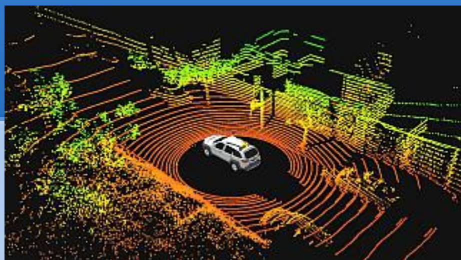
Centro de Robótica de São Carlos

Robotic Platforms

Indoor Mobile Robots

The vehicular robotic platform CaRINA I

The vehicular robotic platform CaRINA II



CARINA
Carro Robótico Inteligente para Navegação Autônoma

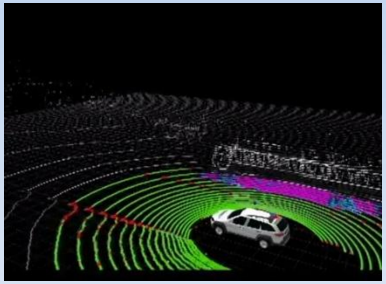
https://www.youtube.com/watch?v=IyPNdDn8Hu8

Introduction: Intelligent Robotics

How do we get there?

Technologies

- **Platforms**: Mobile Robots and Ground Vehicles
- **Perception**: Monocular and Stereo Cameras Spherical Cameras, Thermal Cameras, Radar, Laser LIDAR (Light Detection And Ranging), …
- **Localization**: GPS, IMU (Inertial Units), Encoders, …
- **Path**: Planning, Navigation, Obstacle Avoidance
- **Global** Map/Plan/Actions ; **Local** Map/Plan/Actions



Mobile Robotics: Research and Development

- Artificial Intelligence
- Machine Learning
- Computational Vision
- Pattern Recognition and Classification
- Networks, Security, RT-Operating Systems, Embedded Systems,...

Introduction: Intelligent Robotics

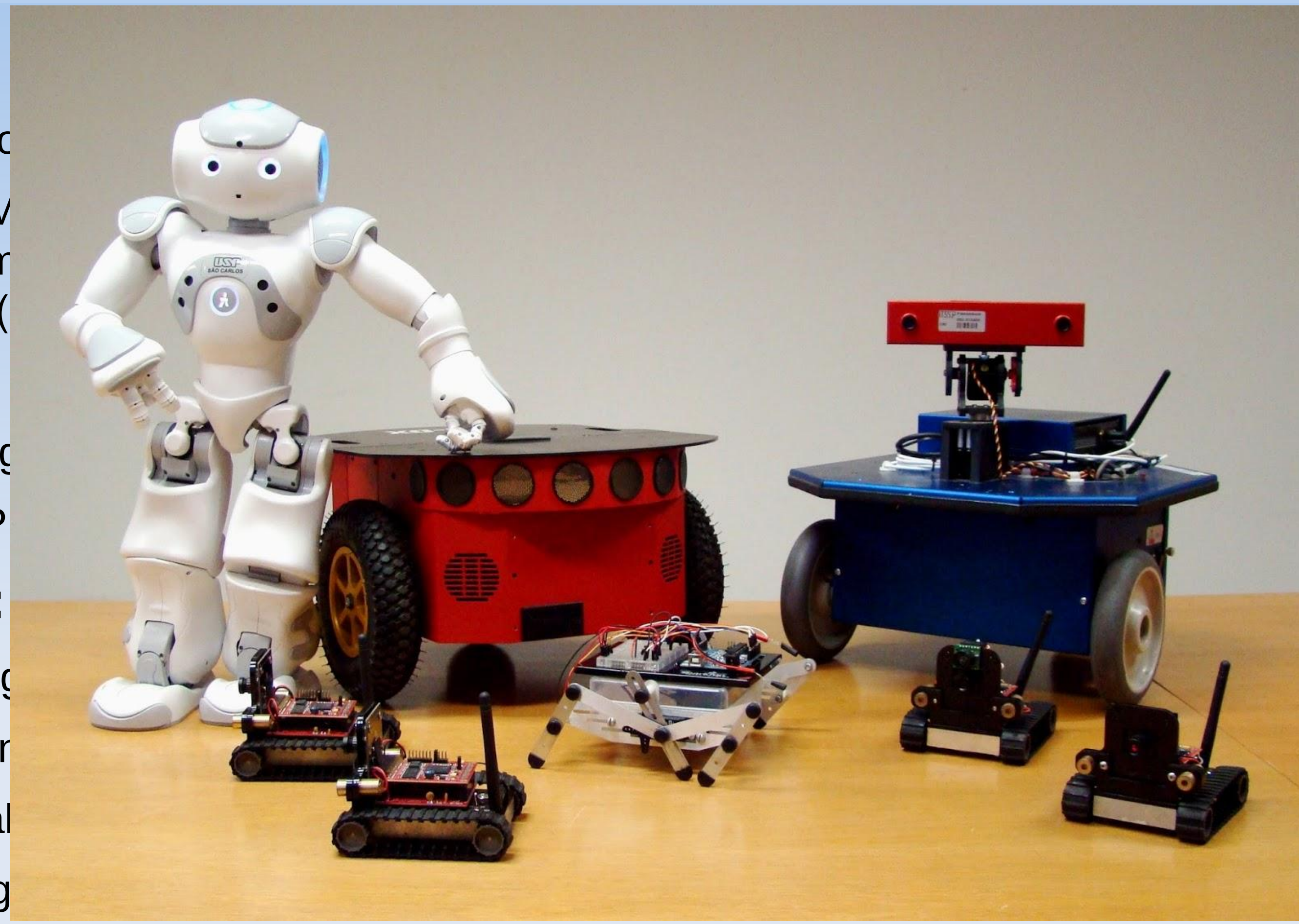
How do we get there?

Technologies

- **Platforms**: Mo
- **Perception**: M
  Spherical Cam
  Laser LIDAR (
- **Localization**:
- **Path**: Planning
- **Global** Map/P

Mobile Robotics:

- Artificial Intellig
- Machine Learn
- Computational
- Pattern Recog
- Networks, Security, RT-Operating Systems, Embedded Systems,...



Intelligent Robotics / Service Robots

Research and Development...

Service Robots / Intelligent Robots

- **Research & Development of Service Robots: Growing Market …**

“The market for personal and service robots is about $3 billion now but is expected to reach $15 billion by 2015, according to the Japan Robotics Association and market analysts like ABI Research. In 10 years or so, experts predict, sales of personal robots could surpass sales of industrial robots, now about $4.6 billion a year.”
[NewsWeek August 09, 2008 by Katie Baker]

- **Applications of this technology *:**

:: Cleaning & Housekeeping
:: Humanitarian Demining
:: Agriculture & Harvesting
:: Medical Applications
:: Automatic Refilling
:: Picking & Palletising
:: Edutainment
:: Rehabilitation
:: Lawn Mowers
:: Mining
:: Guides & Office
:: Food Industry
:: Humanoids
:: Inspection
:: Surveillance
:: Construction
:: Fire Fighters
:: Search & Rescue

*IEEE Technical Committee on Service Robots

Service Robots / Intelligent Robots

- **Research & Development of Service Robots: Growing Market …**

“The market for personal and service robots ~~is about $3 billion now but is expected to reach $15 billion by 2015, according to the Japan Robotics Association and mar~~ ~~ABI Research. In 10 years or so, experts predict, sales of pers~~ ~~ld surpass sales of industrial robots, now about $4.6 billion a year.~~”
[NewsWeek August 09, 2008 by Katie aker]

UPDATED

*CGAR: Compound Annual Growth Rate

The global service robotics market in 2011 was worth $18.39 billion.
This market is valued at $20.73 billion in 2012 and
expected to reach $46.18 billion by 2017
at an estimated CAGR* of 17.4% from 2012 to 2017.

Service Robotics Market (Personal & Professional)
Global Forecast & Assessment by Applications & Geography (2012 – 2017)
By: marketsandmarkets.com - Publishing Date: July 2012 - Report Code: SE 1146

*IEEE Technical Committee on Service Robots

Introduction: Intelligent Robotics

Amazon Acquires Kiva Systems for $775 Million - IEEE Spectrum

BLOGS // AUTOMATON

Amazon Acquires Kiva Systems for $775 Million

POSTED BY: ERICO GUIZZO / SEG, MARÇO 19, 2012

Photo: Joel Eden Photography/Kiva Systems

Intelligent Robotics:
Industry
Jobs and Companies

Looks like Amazon is getting some robots. LOTS of robots.

The giant online retailer announced today that it is acquiring Kiva Systems, a North Reading, Mass.-based company that invented a revolutionary way of managing vast warehouses by using fleets of mobile robots to sort, organize, and transport inventory.

Amazon agreed to acquire all of the outstanding shares of Kiva for approximately US $775 million in cash. The companies expect to close the acquisition in the second quarter of 2012.

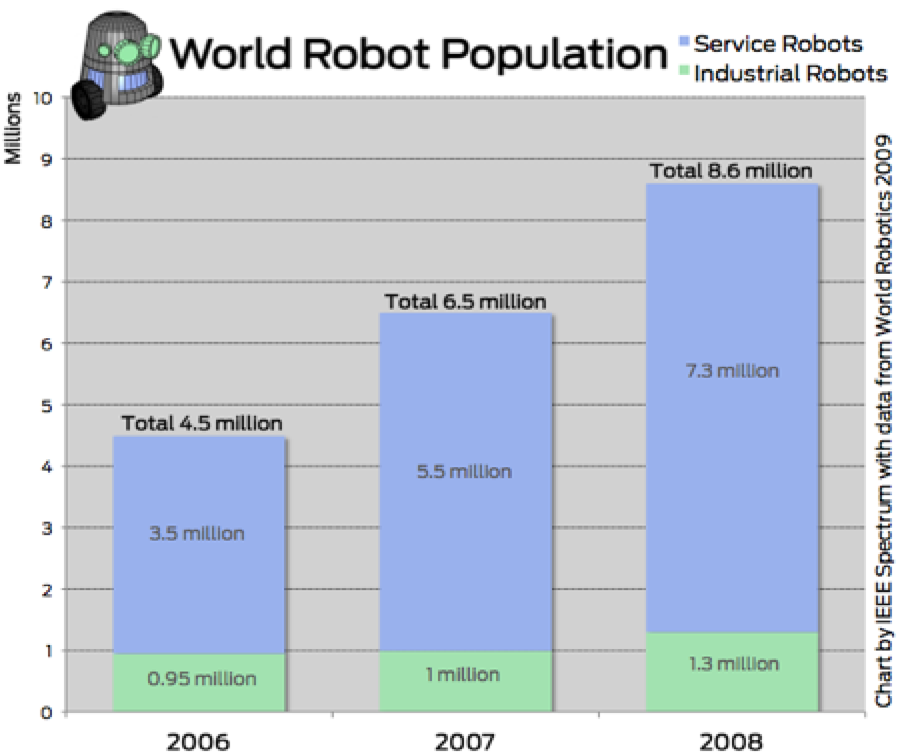
Introduction: Intelligent Robotics

AUTOMATON *The future of robots*

BLOGS // AUTOMATON

World Robot Population Reaches 8.6 Million

POSTED BY: ERICO GUIZZO / QUA, ABRIL 14, 2010



The world's robot population has reached 8.6 million. That's ~~more than one~~

TOP SELLER:

iRobot Roomba® 780

Vacuum Cleaning Robot

Intelligent Robots: Industry, Jobs, Companies & Opportunities!

7.5 Million home robots!

About Our Robots

iRobot has made some of the world's most important robots.

iRobot Home Robots: The smarter way to get it done

iRobot's home robots are revolutionizing the way people clean – inside and out. More than 7.5 million home robots have been sold worldwide. The award-winning iRobot® Roomba® vacuum cleaning robot is leading the charge. Roomba made practical robots a reality for the first time and showed the world that robots are here to stay. iRobot's acclaimed line of home robots also includes the iRobot Scooba® floor washing robot, the iRobot Verro® pool cleaning robot and the iRobot Looj® gutter cleaning robot.

http://www.irobot.com/filelibrary/ppt/corp/cool_stuff_ppt/cool_stuff_ppt.html

http://spectrum.ieee.org/automaton/robotics/industrial-robots/041410-world-robot-population

Introduction: Intelligent Robotics

Scientific American
January 2007

A Robot in Every Home

The leader of the PC revolution predicts that the next hot field will be robotics
By Bill Gates

Introduction: Intelligent Robotics

IEEE SPECTRUM

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Microsoft Shuts Down Its Robotics Group

By Erico Guizzo
Posted 25 Sep 2014 | 21:45 GMT

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Microsoft Shuts Down Its Robotics Group

By Erico Guizzo

Posted 25 Sep 2014 | 21:45 GMT

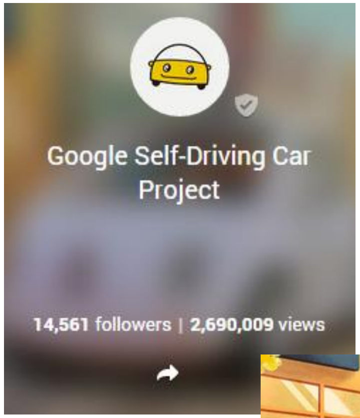
In 2007, Bill Gates wrote his influential "A Robot in Every Home (http://www.scientificamerican.com/article/a-robot-in-every-home/)" article in *Scientific American**, envisioning a future "in which robotic devices will become a nearly ubiquitous part of our day-to-day lives." The article reflected his belief that robotics was going to be hugely important, and Microsoft had to have a major role in it. Two years earlier, Gates had asked one of his top lieutenants, Tandy Trower, also a big believer in robotics, to lead a group with the bold mission of bringing robots into the mainstream (http://spectrum.ieee.org/robotics/robotics-software/robots-incorporated).

This week, word got out (http://www.neowin.net/news/microsoft-layoffs-claims-robotics-research-team-over-the-weekend) that, as part of its current restructuring (http://www.bloomberg.com/news/2014-09-18/microsoft-cuts-2-100-workers-as-part-of-restructuring.html), Microsoft decided to shut down its robotics group. (Two sources at Microsoft have since confirmed the news to *IEEE Spectrum*.) At a moment when excitement about the future of robotics seems to have reached an all-time high (just ask Google (http://spectrum.ieee.org/automaton/robotics/industrial-robots/google-acquisition-seven-robotics-companies) and Amazon (http://spectrum.ieee.org/automaton/robotics/industrial-robots/apple-amazon-and-now-google-an-exciting-time-for-robotics)), Microsoft has given up on robots.

Introduction: Intelligent Robotics

Here is the list of companies Google has acquired:

- Schaft Inc.
- Industrial Perception, Inc
- Redwood Robotics
- Meka Robotics
- Holomini
- Bot & Dolly
- Boston Dynamics
- DeepMind Technologies



http://en.wikipedia.org/wiki/List_of_mergers_and_acquisitions_by_Google

DRC Darpa Robotics Challenge

DRC – Darpa Robotics Challenge

2013-2015 / US$ 2M Prize

DRC Darpa Robotics Challenge

DRC – Darpa Robotics Challenge TASKs

- **Drive a utility vehicle at the site.**
- **Move/Walk across ruins/debris.**
- **Remove debris blocking an entryway.**
- **Open a door and enter a building.**
- **Climb an industrial ladder and traverse an industrial walkway.**
- **Use a tool to break through a concrete panel.**
- **Locate and close a valve near a leaking pipe.**
- **Connect a fire hose to a standpipe and turn on a valve.**

http://en.wikipedia.org/wiki/DARPA_Robotics_Challenge

http://www.theroboticschallenge.org/overview

DRC – Darpa Robotics Challenge

How to Win?

1. First:

   Finish the Tasks

2. Second:

   Time to Finish the Task

3. Third:

   Amount of Data Required to Finish the Task

   (bits uplinked + bits downlinked)

DRC – Darpa Robotics Challenge

How to Win?

1. First:

   Finish the Tasks

2. Second:

   Time to Finish the Task

3. Third:

   Amount of Data Required to Finish the Task
   (bits uplinked + bits downlinked)

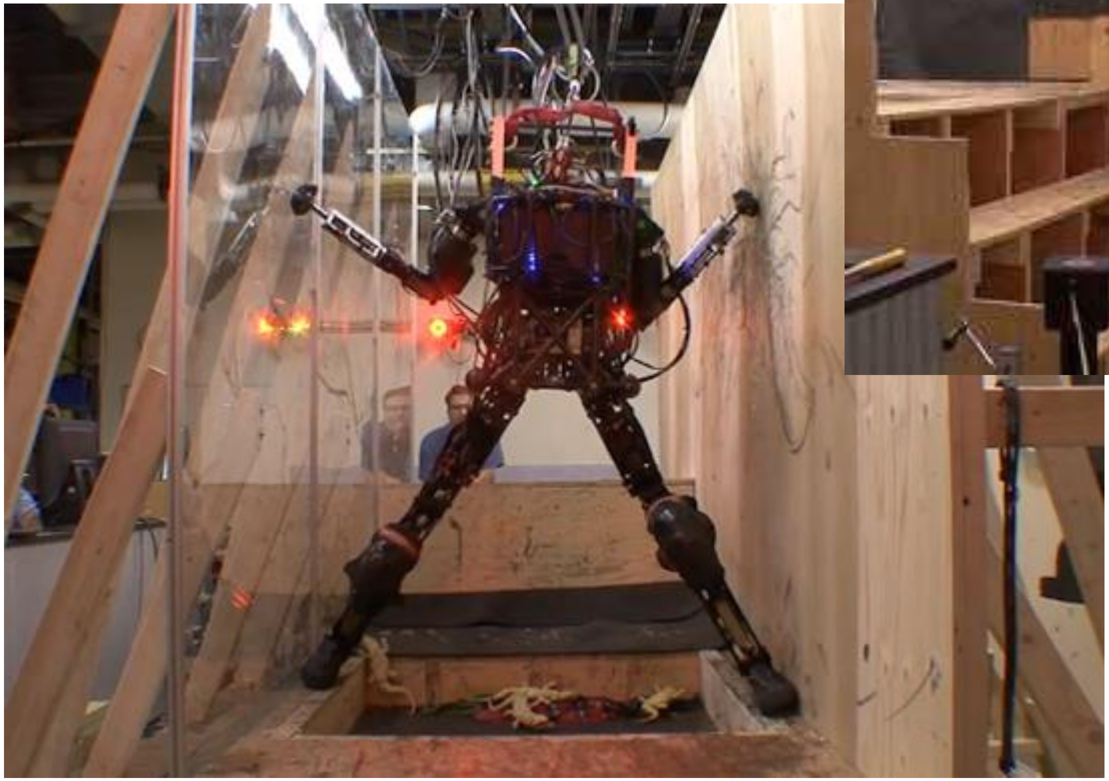
Increase AUTONOMY

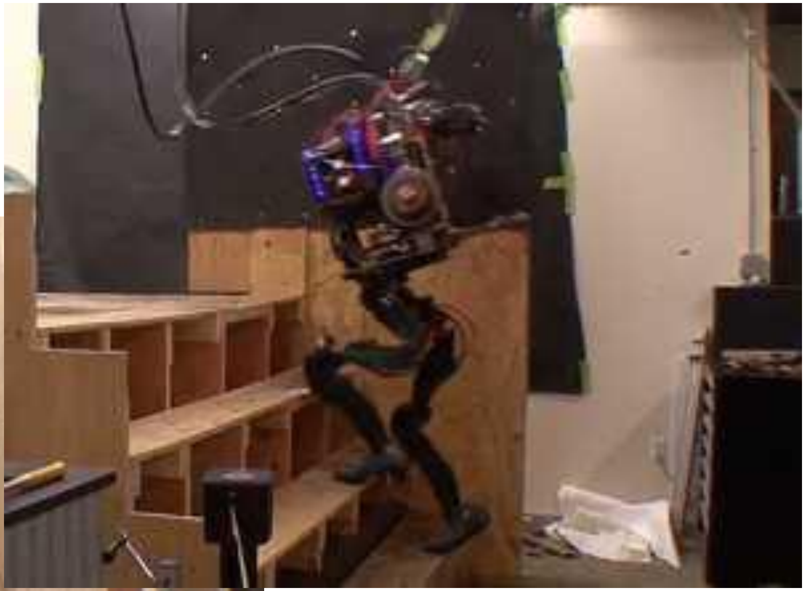
DRC – Darpa Robotics Challenge

Humanoids:

Walking, Avoid Obstacles, Stairs

Use tools, Manipulate objects





DRC Darpa Robotics Challenge

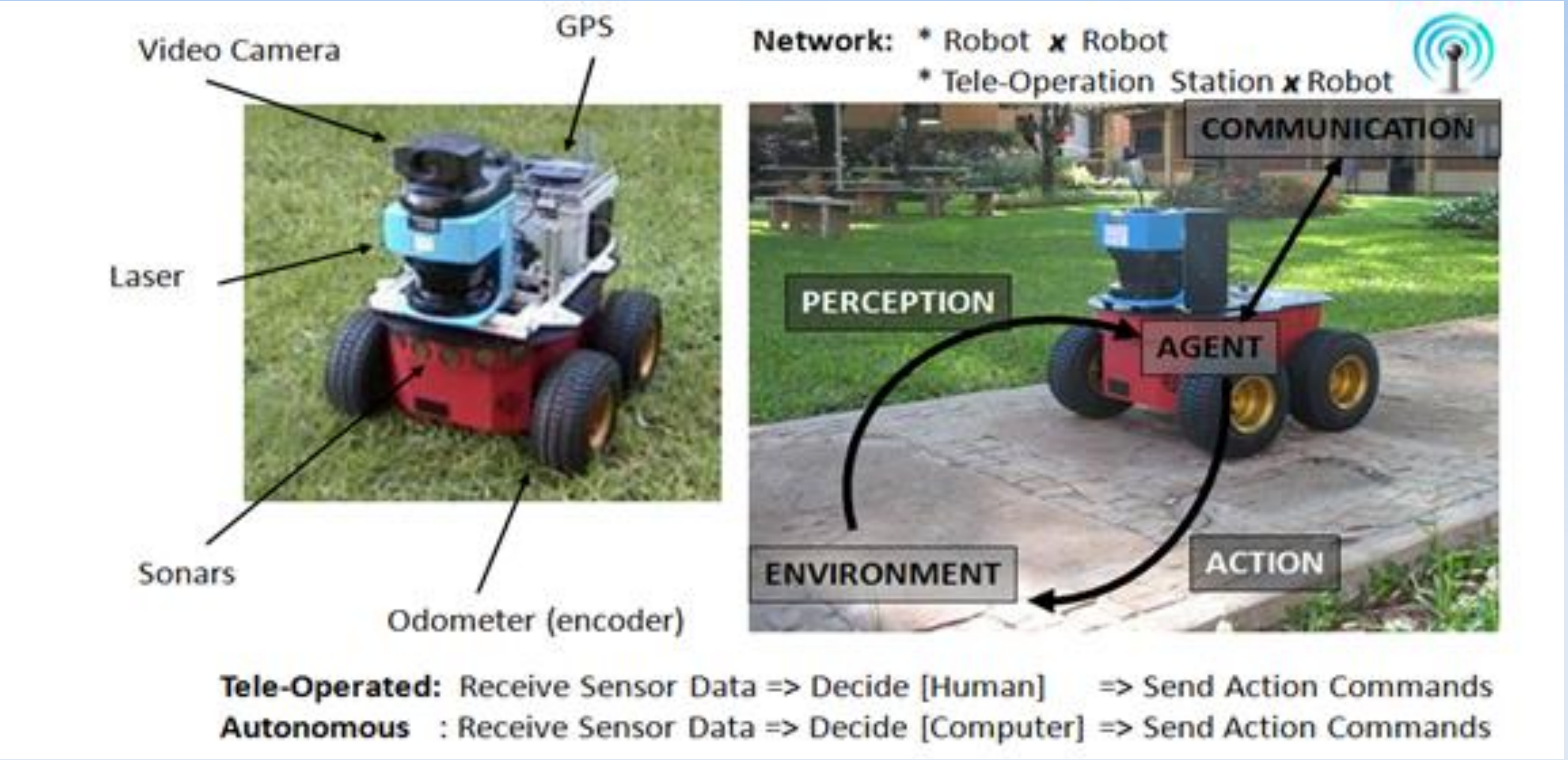
DRC – Darpa Robotics Challenge

Humanoids:

Driving Cars

Intelligent Robots

Sensors + Agent (Knowledge, Planning, Decision) + Action

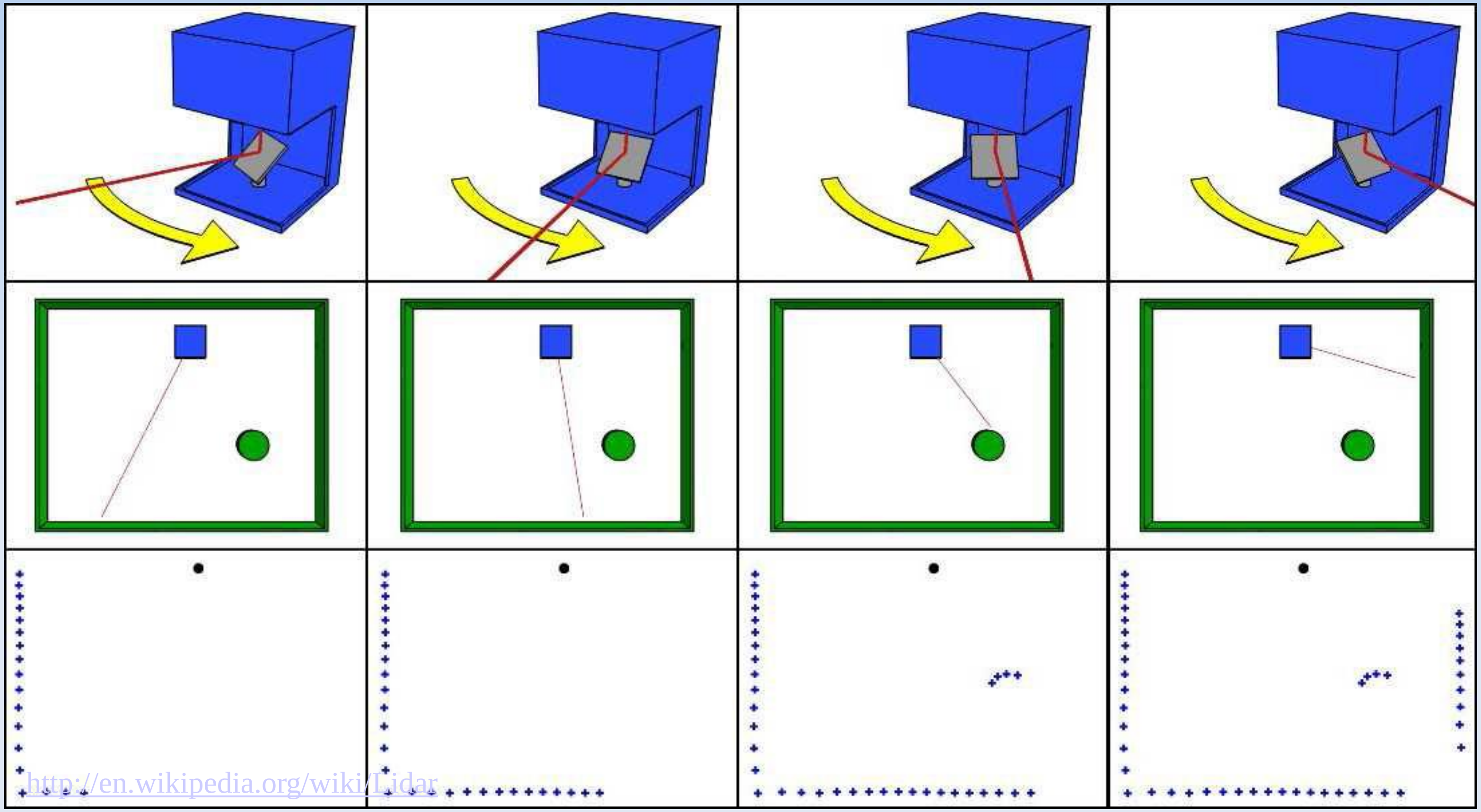


Intelligent Robots

Sensors

Sensors

Laser LIDAR (LIght Detection And Ranging) – SICK LMS 200
Single Laser Beam – Max. Distance: 80 mts – Max. Speed: 75 Hz
View of 180º degrees – Resolution: 0.5 degree (360 scans) – Precision > 0.5 cm

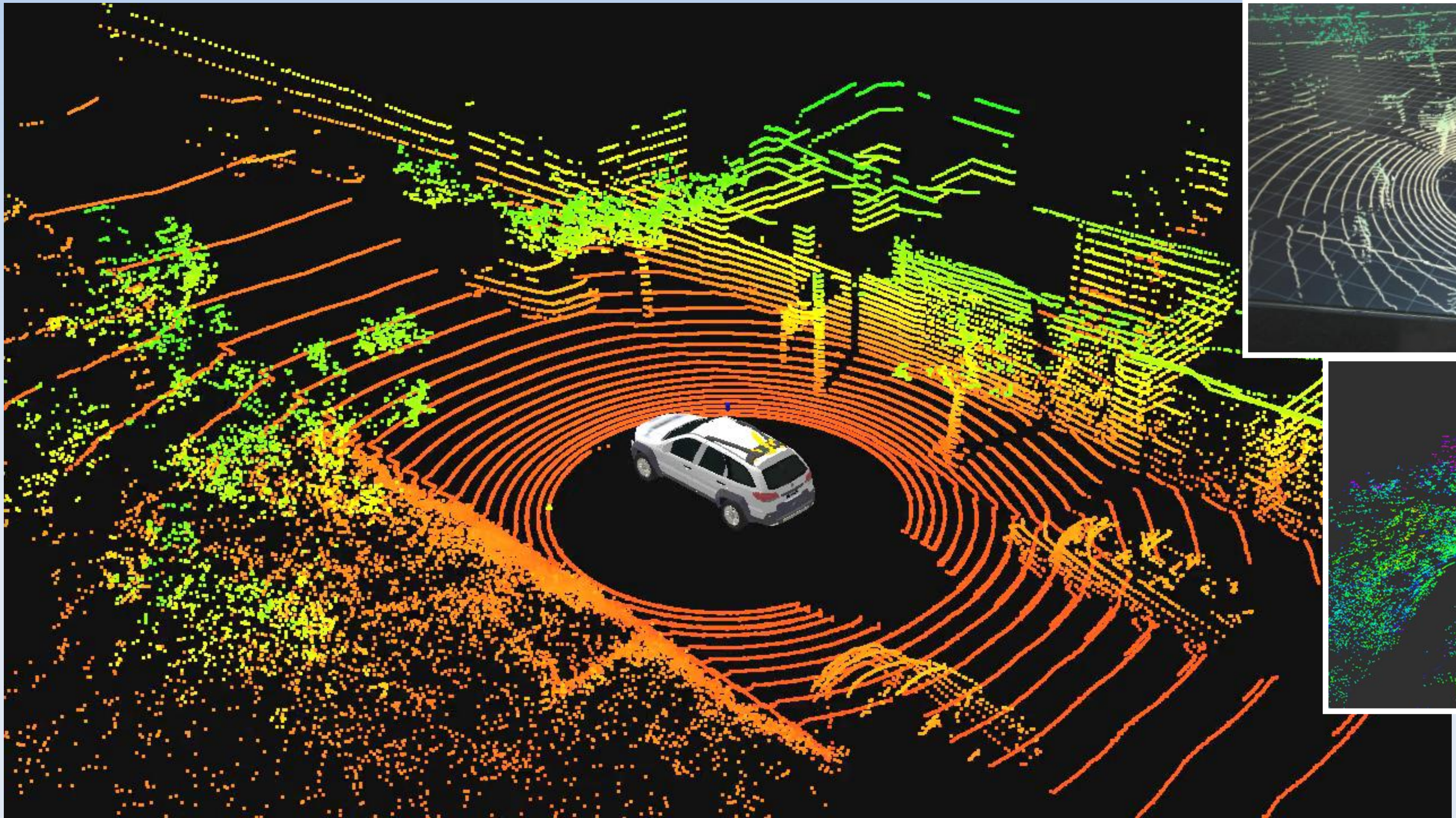


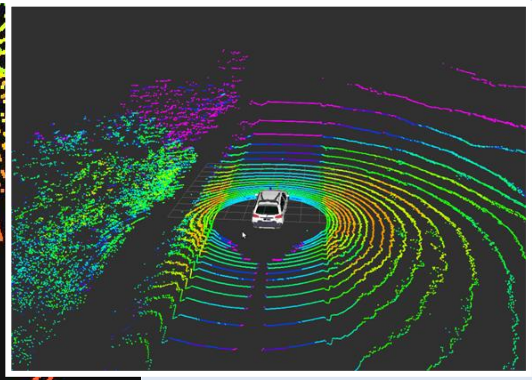
http://en.wikipedia.org/wiki/Lidar

Intelligent Robots

Sensors: Velodyne

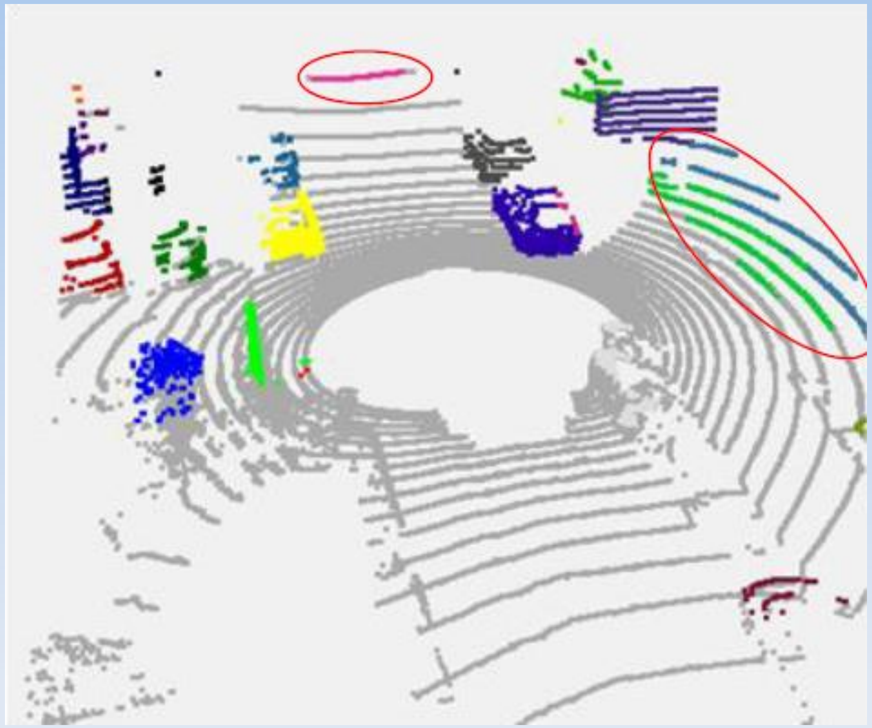
Laser LIDAR (LIght Detection And Ranging) – Velodyne HDL32
32 Laser Beams – Max. Distance: 100 mts – Speed: 10 Hz - 700.000 points/sec
View of 360º degrees – Resolution: 70.000 Points3D (XYZ) per frame

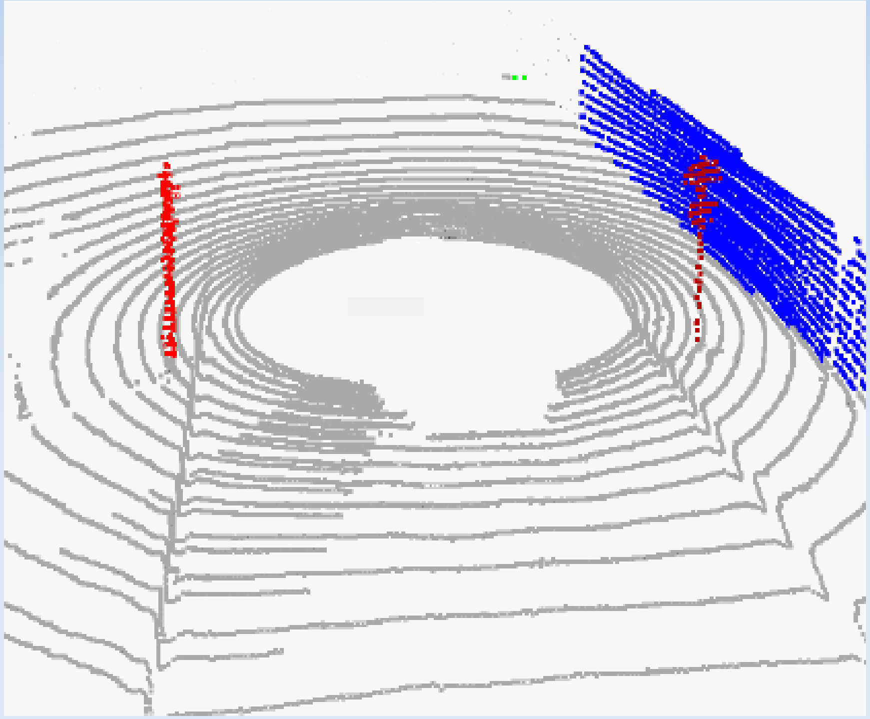




Intelligent Robots

Velodyne: Obstacles Recognition

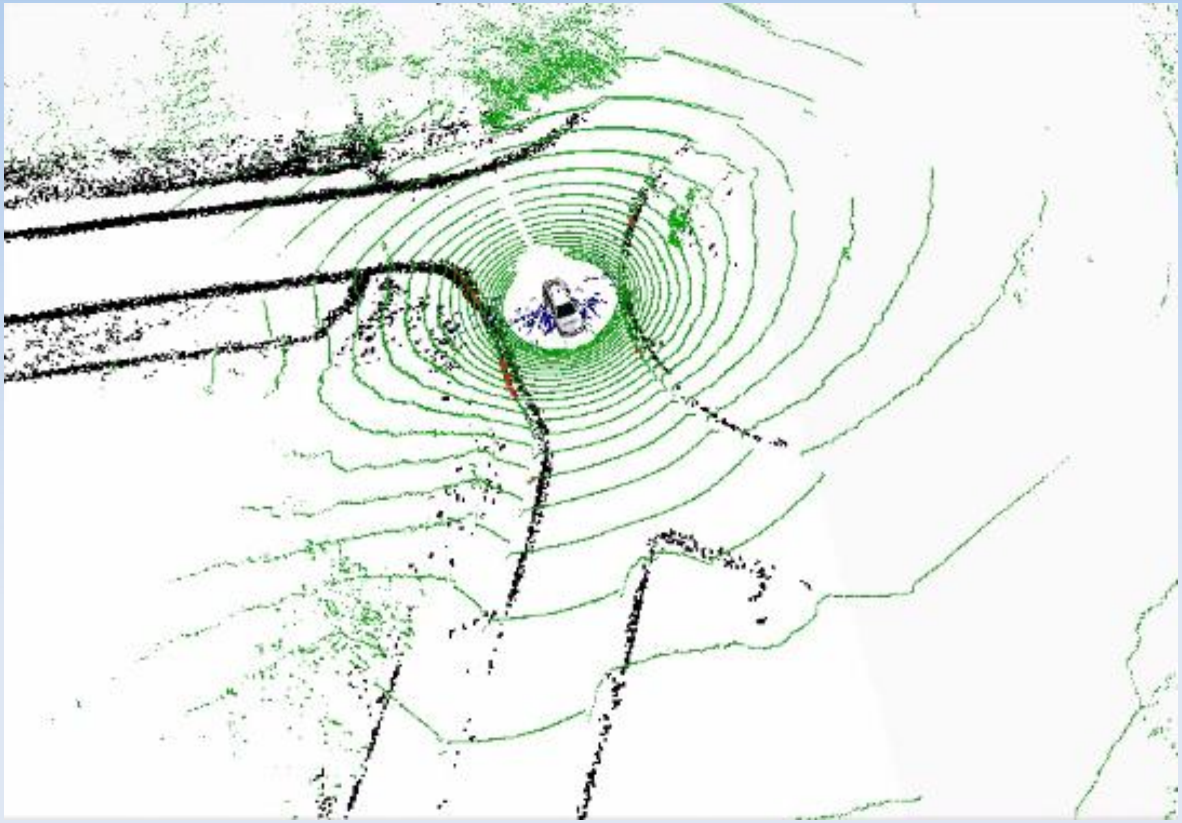




[D. Habermann]

Intelligent Robots

Velodyne: Curb Detection, Localization, Maps

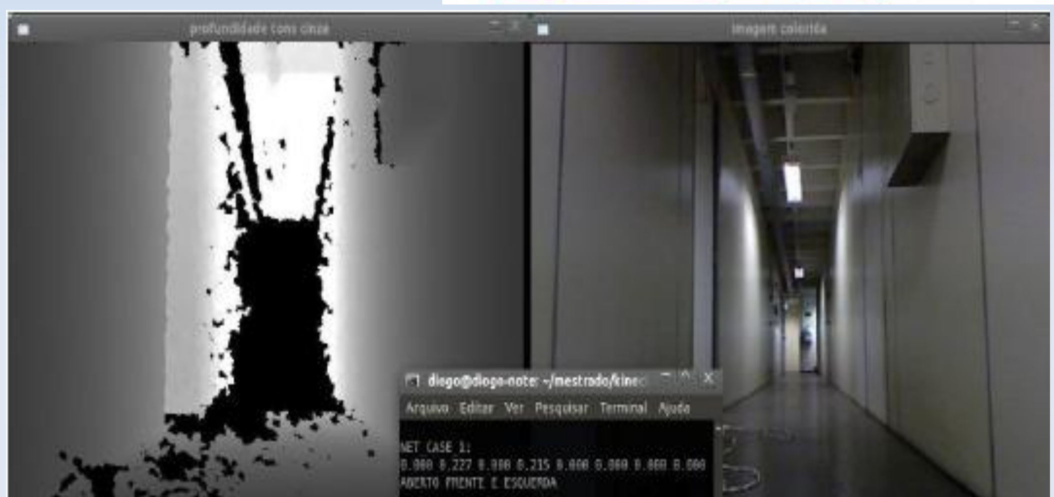


[A. Hata]

Intelligent Robots

Robots and Sensors: Kinect

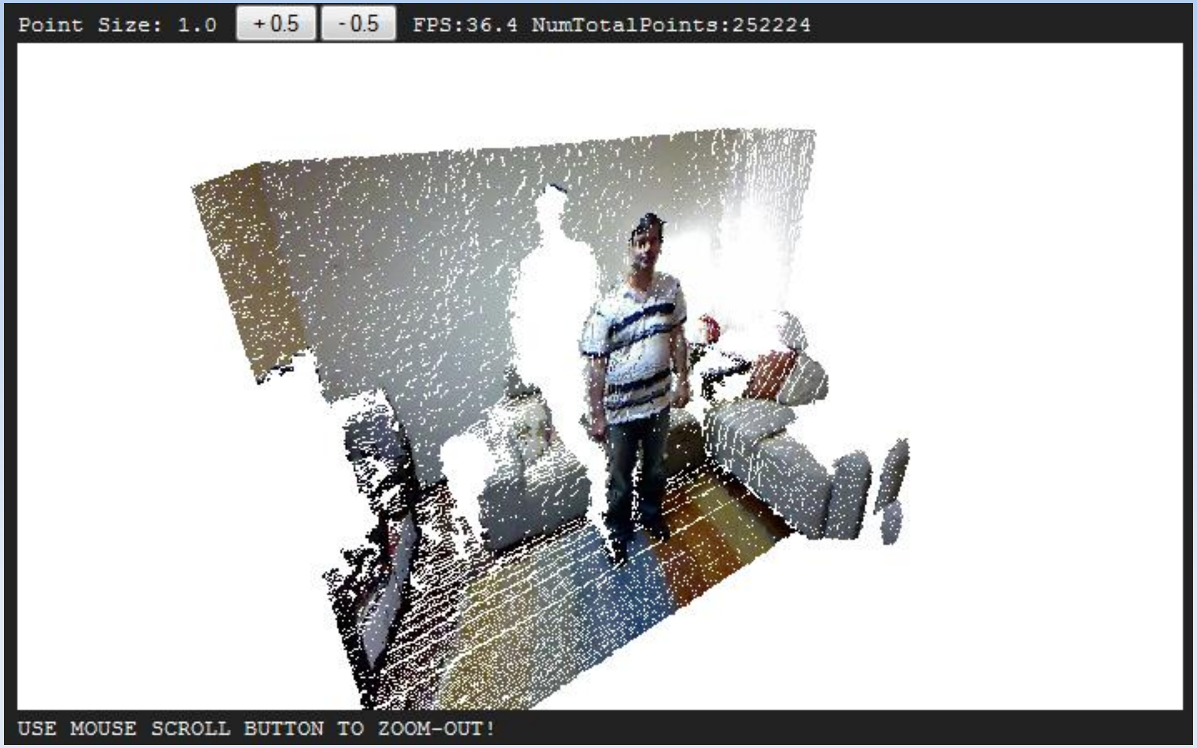
Kinect



[D.Correa]

Intelligent Robots

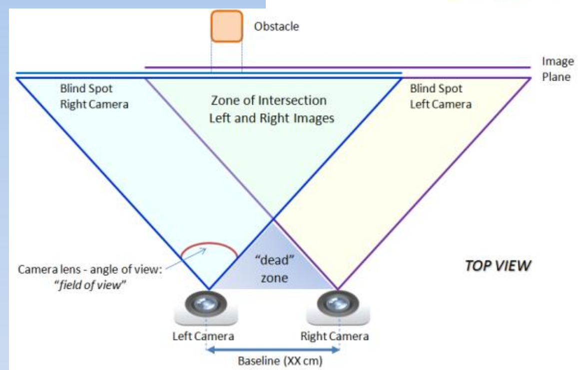
Robots and Sensors: Kinect



http://www2.icmc.usp.br/~fosorio/webgl/
or http://www.icmc.usp.br/~fosorio/

Intelligent Robots

Robots and Sensors: Stereo Vision



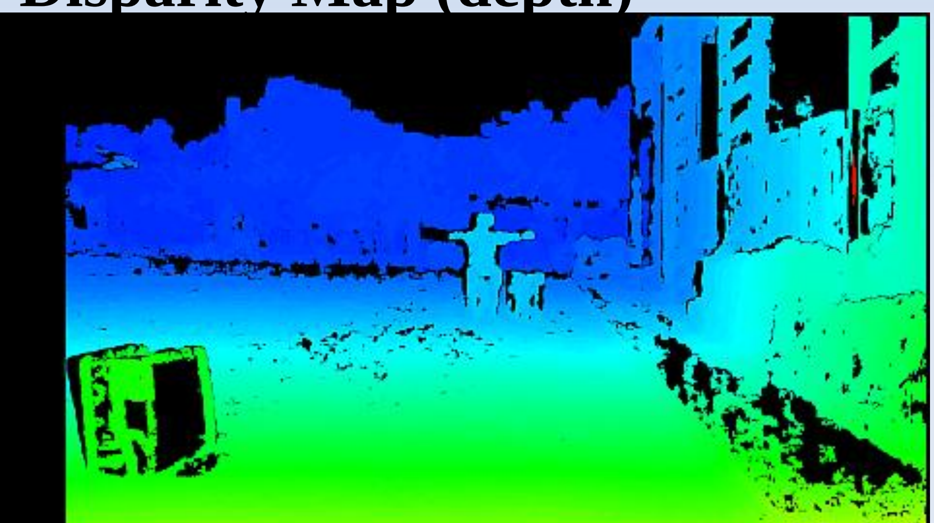
Stereo Vision

Closer objects
+ displaced

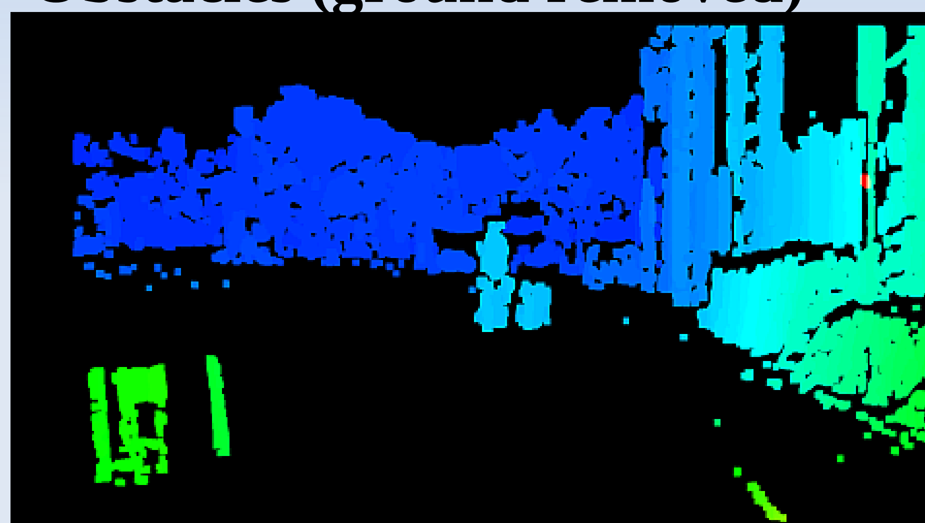
Distant objects
- displaced

Original scene

Disparity Map (depth)



Obstacles (ground removed)

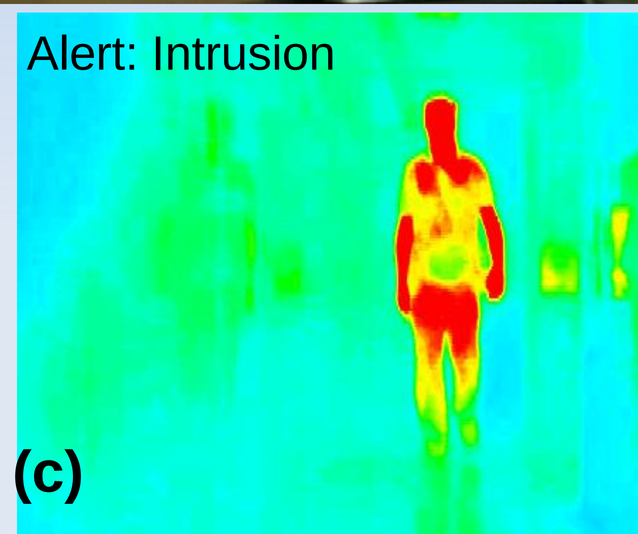


Intelligent Robots

Robots and Sensors: Thermal (FLIR)

Intrusion Detection

Thermal Camera:
(a) Color Image
(b) Thermal Image
(c) Segmentation of “hot spots”
    Detection of abnormal situations

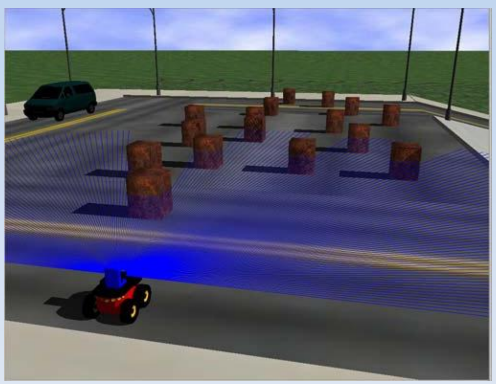


Intelligent Robots

Research and Development

Design of Intelligent Robots:

1. **Modeling (sensors, actuators, kinematics, dynamics)**
2. **Virtual Simulation**
3. **Real Robots Validation**



Simulation

Small Robots
Test / Validation

Large Scale Robots
Tests / Sw Validation

TOOLS:

Simulation: Player-Stage, Gazebo, ROS

Small Robots: OpenCV, Player, ROS

Large Scale Robots: OpenCV, ROS, [Player]

Intelligent Vehicles

Why to do it ?

Problems:
Drink & Drive!
Sleepiness / Tired!
Sickness!

Problems: **Age**!
Difficulties of
elderly people
(vision, perception, fast reaction)

Handicaped people,
Machine and Human Fails,
Vision problems:
Occlusion, Fog, Dark, Rain, ...

- Road traffic injuries are the leading cause of death among young people, aged 15–29 years (WHO 2012).
- In Brazil, number of car accidents:1,5 million per year, with ~ 35.000 deaths.
- Motorcycles in Brazil:
  43 thousand deaths/year.
  Same as we have 215 big airplane crashes every year in brazil!

Intelligent Vehicles

Why to do it ?

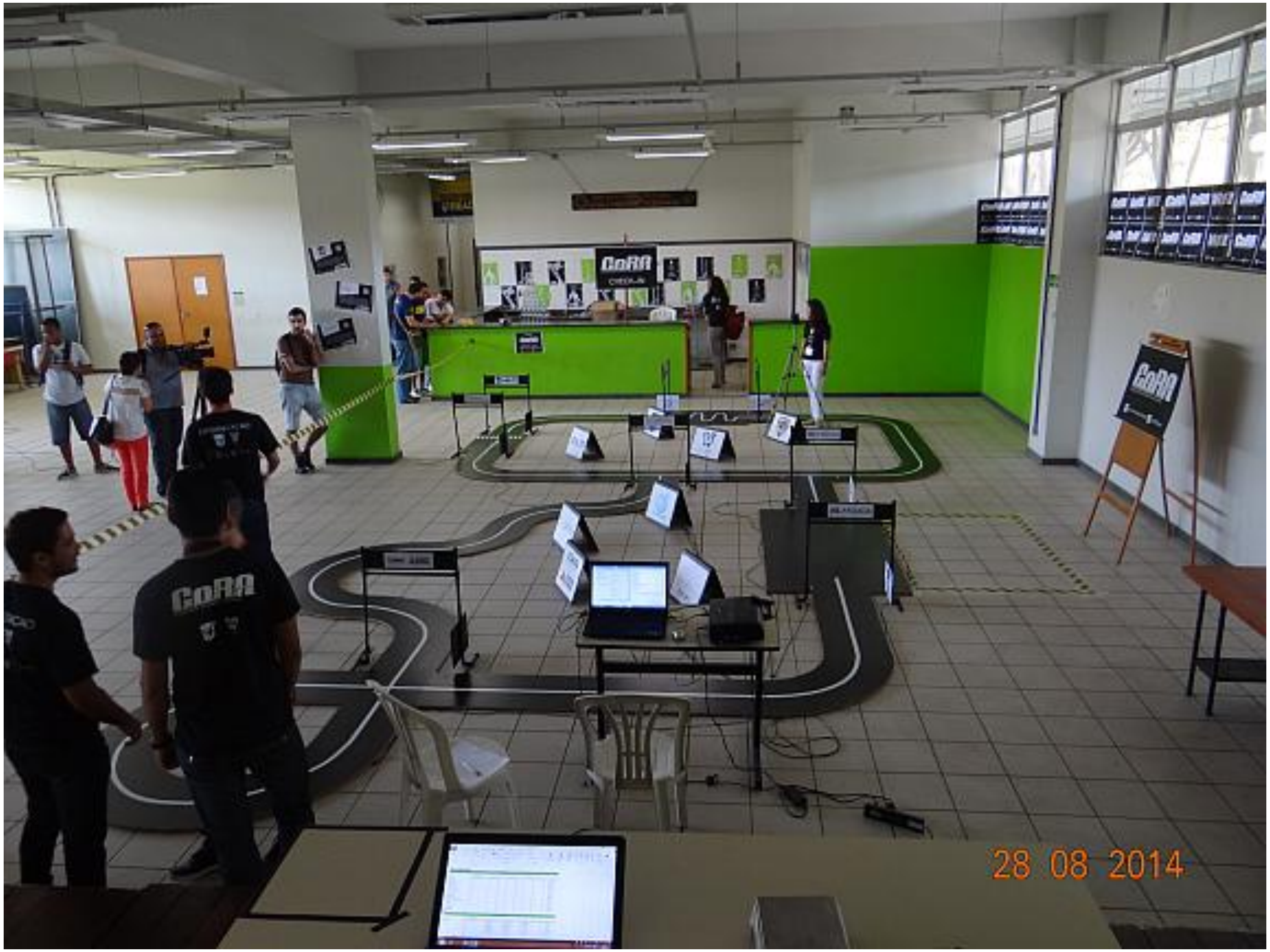
Lack of Education: Pedestrian / Conductors

Intelligent Vehicles

Why to do it ?

Lack of Education: Pedestrian / Conductors

Autonomous Driving: Challenges!



Line follower

CoRA
Autonomous
Robots
Competition
[UFMG]
[FAPEMIG]

Autonomous Driving: Challenges!

COMPETITIONS:

- **DARPA Grand Challenge 2004 (Desert / *No winners*)**
- **DARPA Grand Challenge 2005 (Desert)**
  Winner: Stanley - Stanford Racing Team (S.Thrun)
- **DARPA Urban Challenge 2007 (Urbano)**
  Winner: Boss - CMU (Tartan Racing / Carnegie Mellon University)
- **ELROB – The European Robot Trial**
  M-ELROB: Military (2006, 2008, 2010, 2012)
  C-ELROB: Civilian (2007, 2009, 2011, 2013)
- **AUVSI Competition (IGVC - Intelligent Ground Vehicle Competition)**
- **DARPA Robotics Challenge (DRC) 2013/14 – Humanoid Robot Driving a Car**

Autonomous Driving: Challenges!

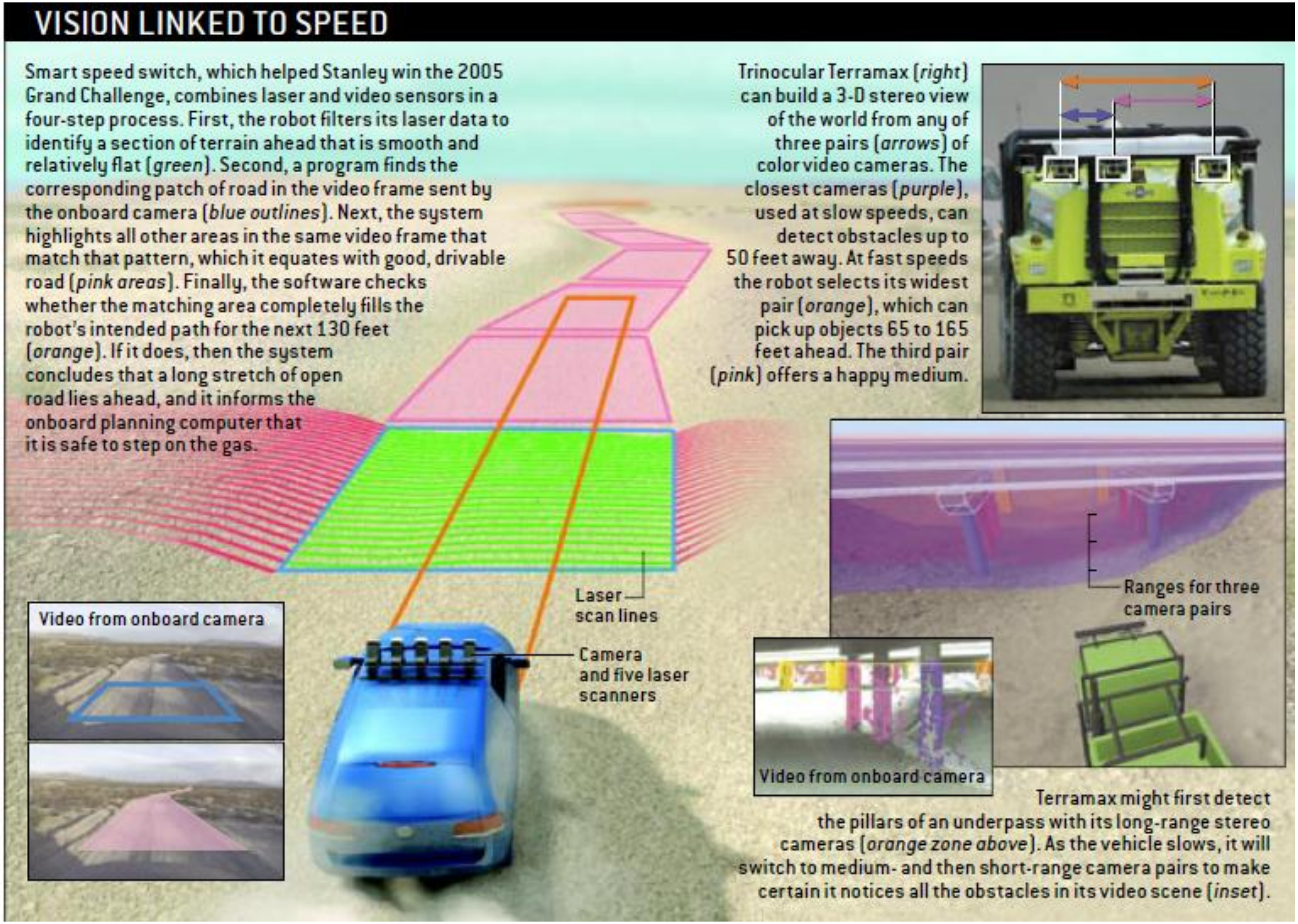
Darpa Grand Challenge

Autonomous Driving: Challenges!

Darpa Grand Challenge
Waypoint – GPS Coordinates

Intelligent Vehicles

DARPA Grand Challenge



Intelligent Vehicles

DARPA Grand Challenge

Winner – Stanley / Stanford University

Sebastian Thrun, Mike Montemerlo, Hendrik Dahlkamp, David Stavens, Andrei Aron, James Diebel, Philip Fong, John Gale, Morgan Halpenny, Gabriel Hoffmann, Kenny Lau, Celia Oakley, Mark Palatucci, Vaughan Pratt, and Pascal Stang, Sven Strohband, Cedric Dupont, **Stanford Artificial Intelligence Laboratory-** Stanford University - Stanford, California 94305, Lars-Erik Jendrossek, Christian Koelen, Charles Markey, Carlo Rummel, Joe van Niekerk, Eric Jensen, and Philippe Alessandrini **Volkswagen of America**, Inc. - Electronics Research Laboratory - Palo Alto, C Gary Bradski, Bob Davies, Scott Ettinger, Adrian Kaehler, and Ara Nefian **Intel Research** - 2200 Mission College Boulevard, Santa Clara, California 95052, Pamela Mahoney ...

Autonomous Vehicles – Urban Spaces

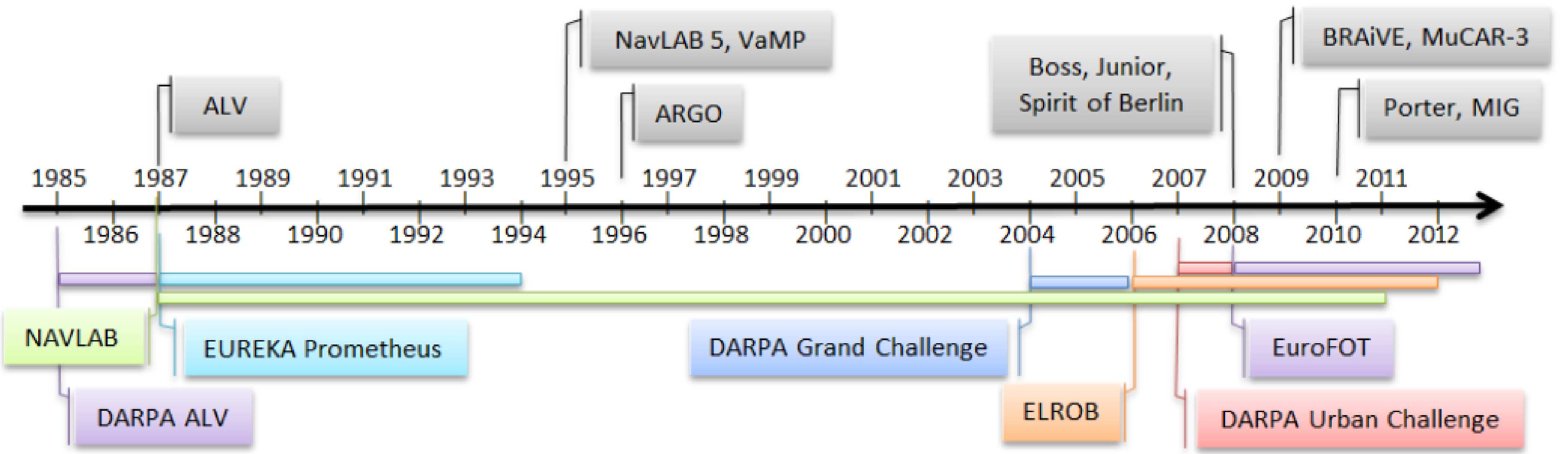
DARPA Urban Challenge

Boss, the autonomous Chevy Tahoe that won the 2007 DARPA Urban Challenge

Tartan Racing – CMU Carnegie Mellon University

Pittsburgh, Pennsylvania

The quest for Autonomous Vehicles



LRM Laboratory :)

2009: INCT-SEC was created and start its activities

2010: April / Acquisition of our 1st vehicle (Electric Car) Club Car CarryAll **CaRINA 1**

2010: October / Autonomous Driving on Campus 2 using CaRINA 1

2011: July / Acquisition of our 2nd vehicle - Fiat Palio Adventure - **CaRINA 2**

2012: September / CaRINA 2 at USP/SC Campus 2 - Fully autonomous!

State of the Art

- Reference Challenges:
  – DARPA Urban Challenge
  – Elrob
- Projects:
  – Boss, Junior e Spirit of Berlin
  – MIG e MuCAR-3
  – BRAiVE e Porter
  – Google Autonomous Car

State of the Art

State of the Art

State of the Art

Brazilian Initiatives

Automated Vehicles: Assisted conduction, Drive-by-wire

- **GPVA** – Grupo de Pesquisa em Veículos Autônomos / RS
  Automated Baja Buggy, drive-by-wire e sist. de visão - 2002/2008
- **USP SC** – EESC/ICMC - Projeto SENA (Fiat Stilo instrumented w/sensors)
  Sistema Embarcados para Navegação Autônoma 2008/2011
- **UNIFEI /MG** - Grupo de Automação e Tecnologia da Informação / UFJF
  Projeto Driving4u - Chevrolet Zafira 2008/2011

Autonomous Vehicles: Perception e Actuation

- **UFMG DEE** – R&D Group: Veículos Autônomos (PDVA) - GM Astra
  CADU Carro Autônomo Desenvolvido na UFMG – final 2007/2012
- **CTI** CenPRA - DRVC Divisão de Robótica e Visão Computacional - “Freedom”
  Projeto VERO - Veículo Robótico Terrestre de Exterior – 2008/2012
- **USP SC** – ICMC / LRM – Projeto CaRINA I e II - Club Car, Palio Adventure
  Carro Robótico Inteligente para Navegação Autônoma – 2010/2012
- **UFES**: LCAD carro adquirido em Setembro/2012- TorcRobotics Bywire-XGV

Brazilian Initiatives

Autonomous Vehicles:

- **GPVA** –Baja Buggy - 2002/2008
- **USP SC**- SENA – Fiat Stilo - 2008/2011
- **UNIFEI /MG** - Projeto Driving4u
  Chevrolet Zafira 2008/2011

Brazilian Initiatives

Autonomous Vehicles:

- **UFMG DEE** - GM Astra - CADU 2007/2012
- **CTI** CenPRA - DRVC - Freedom Elétrico VERO - 2008/2012
- **USP SC** – ICMC / LRM – Club Car CarryAll CaRINA I - 2010/2012

Brazilian Initiative @ USP São Carlos

Laboratório de Robótica Móvel
ICMC/USP - São Carlos

CARINA
Carro Robótico Inteligente para Navegação Autônoma

Experimental Platforms

CARINA 1

(may 2010)

CARINA 2

(july 2011)

Project CaRINA I : R&D

CaRINA Platform

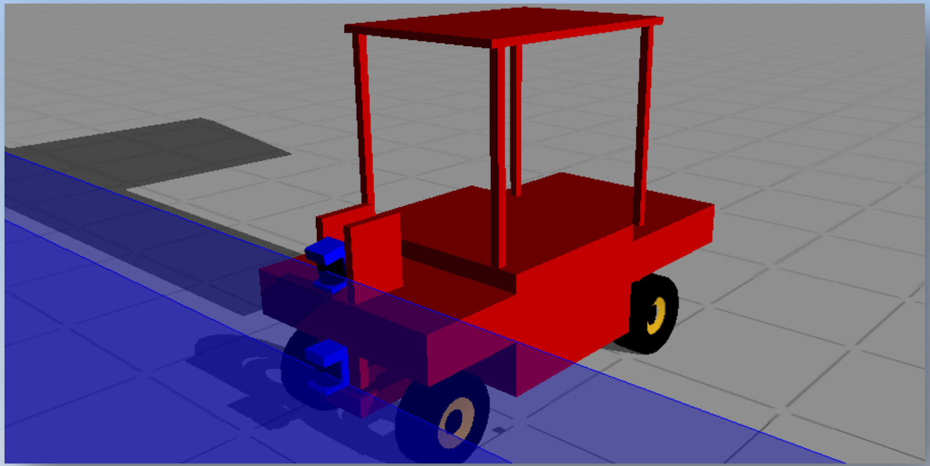
- Carryall 232 (Original Platform from: Clubcar)
  - Electric Powered: 10 HP
  - Battery Source: 48V (8 x 12V)
  - Velocities up to 30 Km/h
  - Transportation utility car (up to 360Kg)
- Perception:
  - Lasers SICK (front), Hokuyo (back)
  - Monocular and Stereo Camera
  - GPS, Compass, IMU and odometry
- Actuators: RoboteQ + Microcontroller
  - Steering Wheel (+ encoders)
  - Speed Control (“gas pedal”) / Breaking System

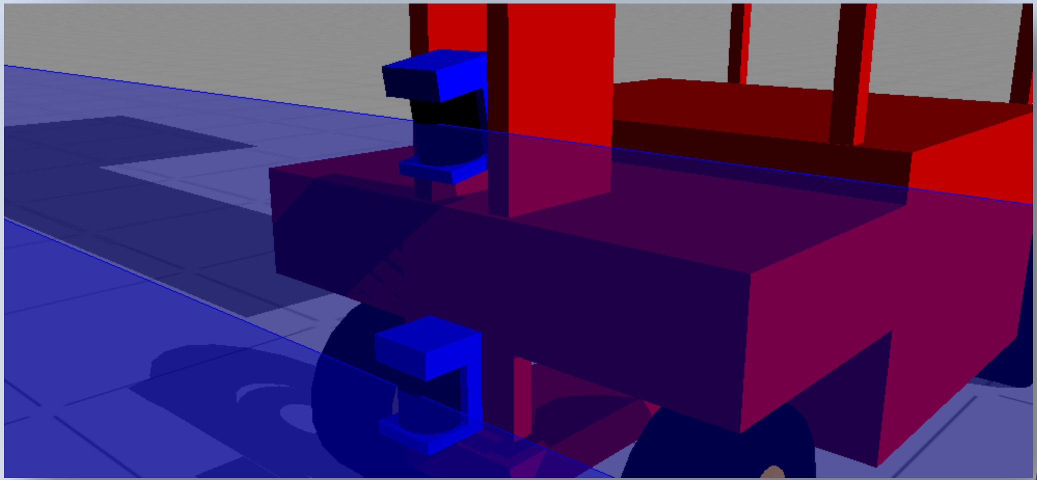
Project CaRINA I : R&D

Perception

Project CaRINA I : R&D

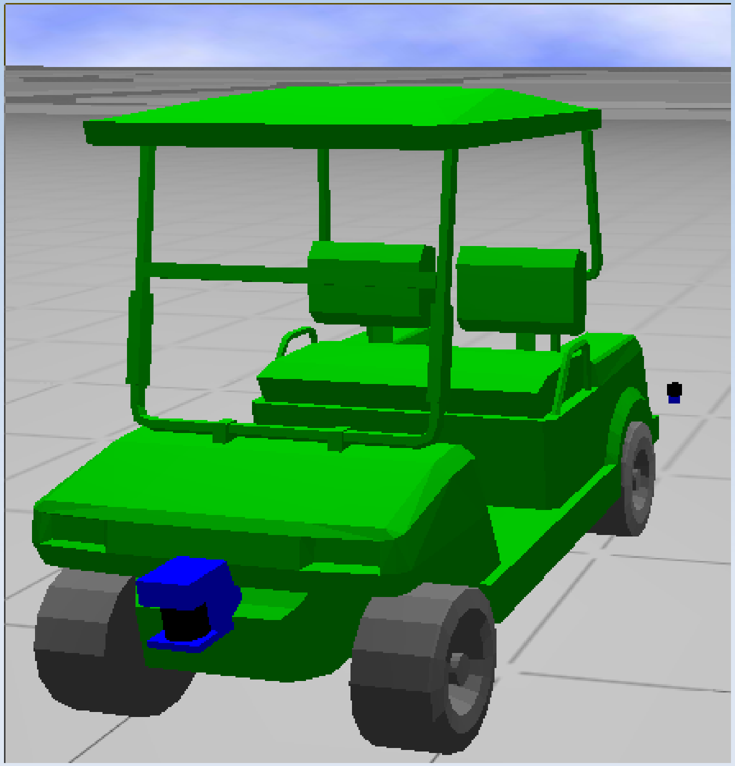
CaRINA 1



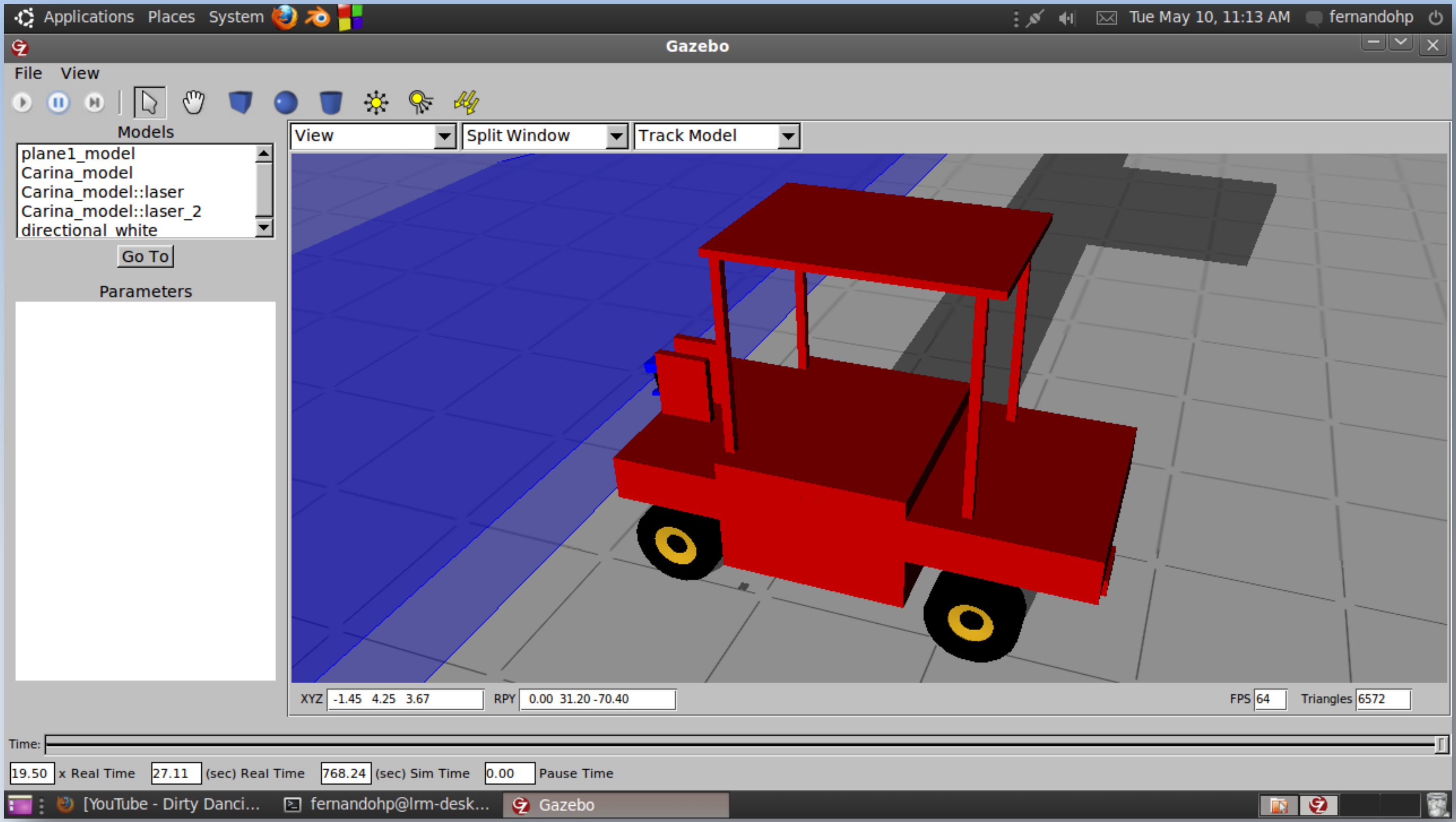


Computational Model

CaRINA I

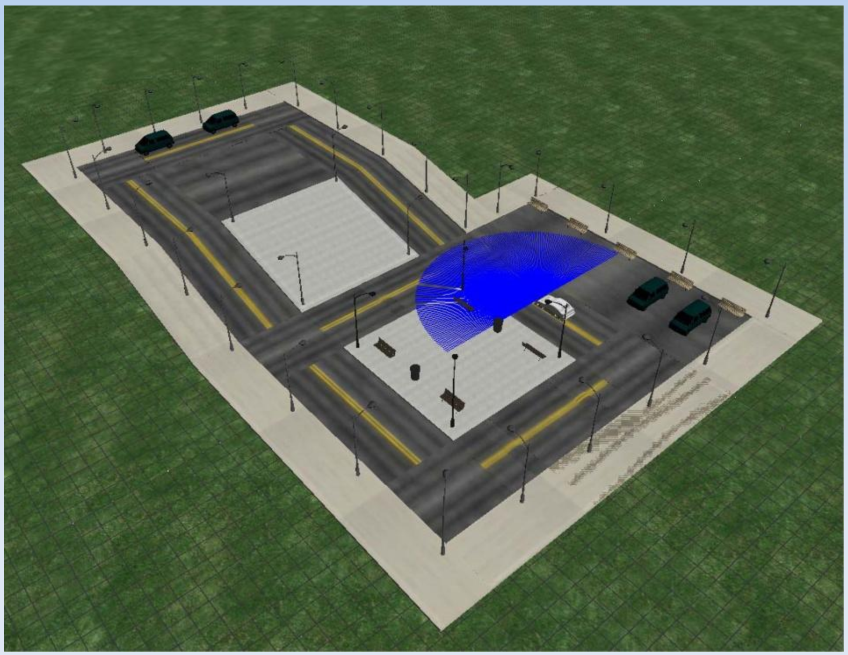


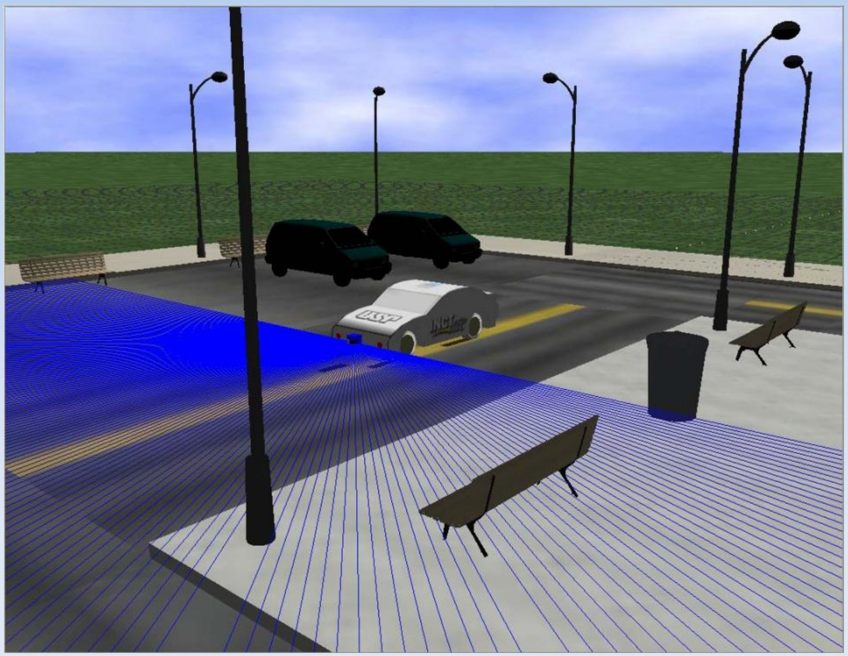
Gazebo


Applications Places System
Tue May 10, 11:13 AM
fernandohp
Gazebo
File View
Models
plane1_model
Carina_model
Carina_model::laser
Carina_model::laser_2
directional_white
Go To
Parameters
View
Split Window
Track Model
XYZ -1.45 4.25 3.67
RPY 0.00 31.20 -70.40
FPS 64
Triangles 6572
Time:
19.50 x Real Time
27.11 (sec) Real Time
768.24 (sec) Sim Time
0.00 Pause Time
[YouTube - Dirty Danci...
fernandohp@lrm-desk...
Gazebo

Autonomous Vehicles Simulation

3D Simulationt Tool: Gazebo





SENSORS

(a) Laser Sick
LMS 2xx

(b) Video Camera

(c) Inertia Unit
IMU - MicroStrain

(d) Laser Hokuyo
URG-04LX

(i) Kinect (Microsoft Xbox)
Indoor only (or at night)

(e) STOC Video Camera
Stereo-on-a-Chip

(f) Thermal Camera
FLIR PathFindIR

(g) Compass Module
HMC6352

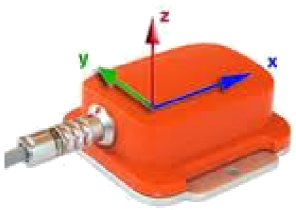
(h) Sonar Module
Maxbotix LV-EZ0

(j) GPS Garmin
(Outdoor only)

Velodyne HDL-32E

PointGray LadyBug 2

PointGray Bumblebee 2

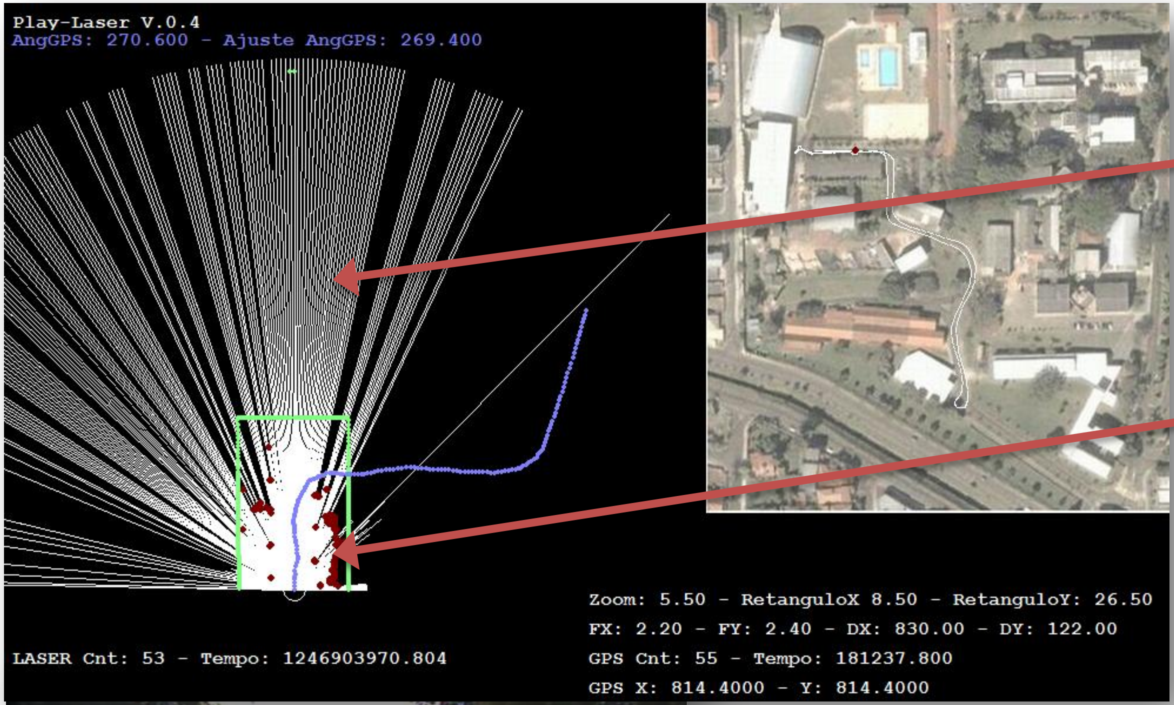


Xsens Mti-G

Laser Hokuyo URG-30LX

http://lrm.icmc.usp.br/wiki/index.php/Velodyne_HDL-32E

SENSORS



Laser Beans

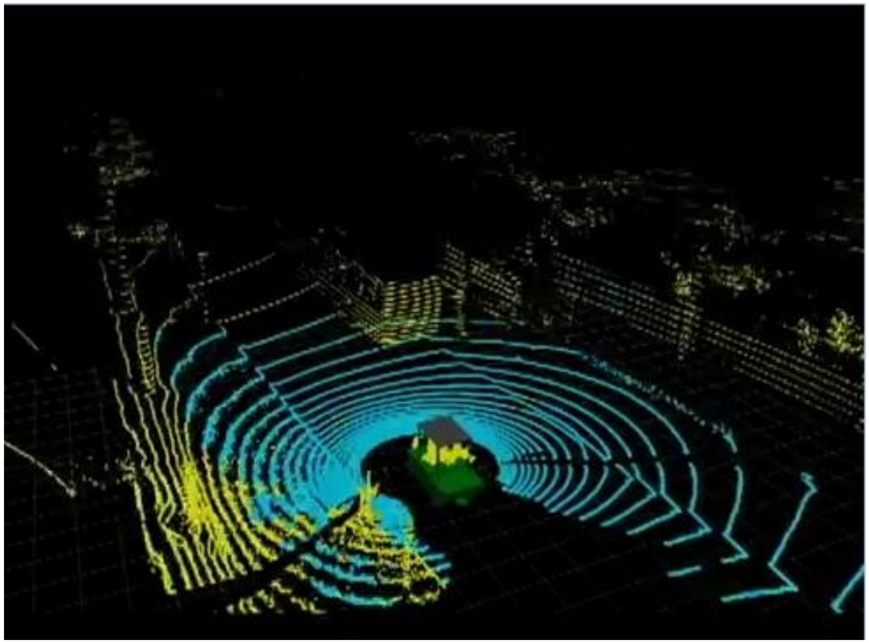
Laser: Real Data

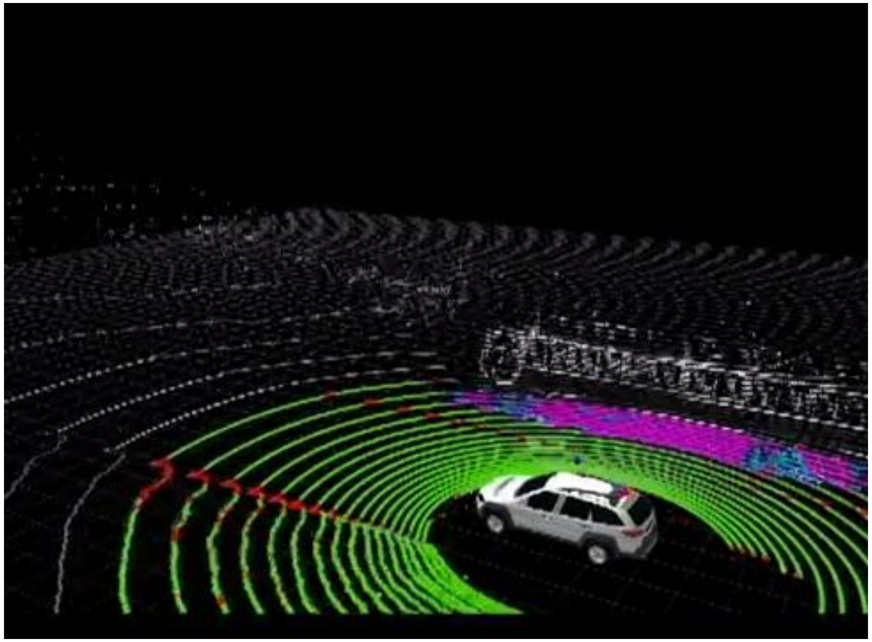
Obstacles

http://en.wikipedia.org/wiki/Lidar

SENSORS

Laser Velodyne HDL 32
32 Laser beans – Max distance.: 100 mts – Max speed: 10 Hz
Wide view of 360º degrees – Precision > 0.5 cm
3D Cloud of Points - 70.000 xyz points x 10 Hz = 700.000 points / sec





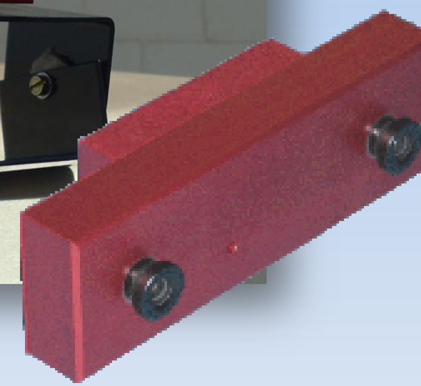
Sensores que permitem obter "Nuvens de Pontos 3D" (Cloud of Points):
Velodyne, Câmera de Vídeo Estéreo (PointGray Bumblebee), Kinect XBox
Sensor laser tipo Sick de feixe único + Deslocamento (composição)

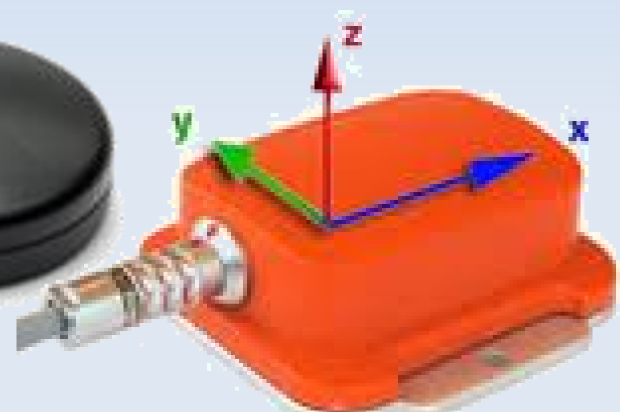
Project CaRINA I : R&D

Perception Systems

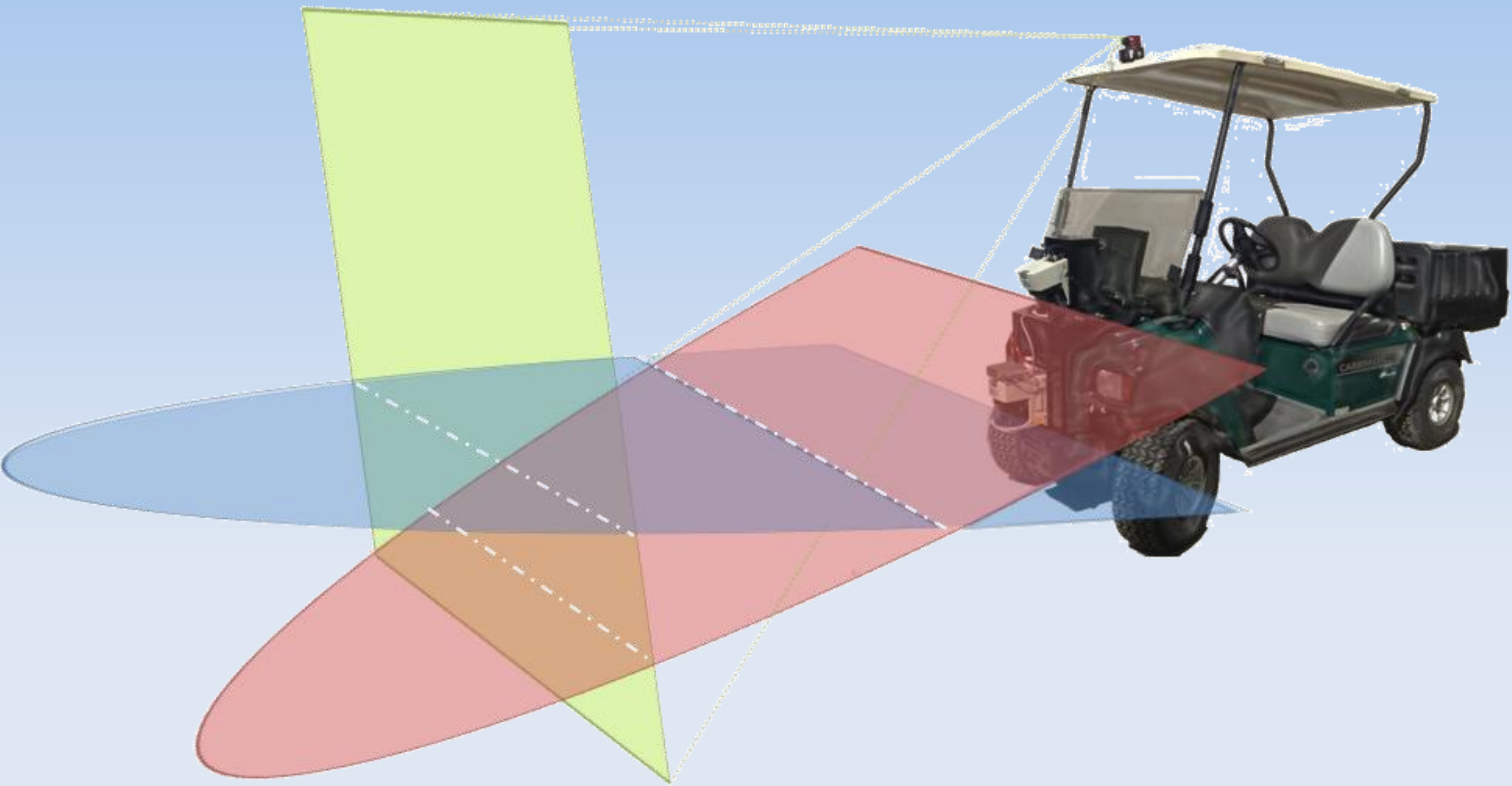
Project CaRINA I : R&D

Perception Systems



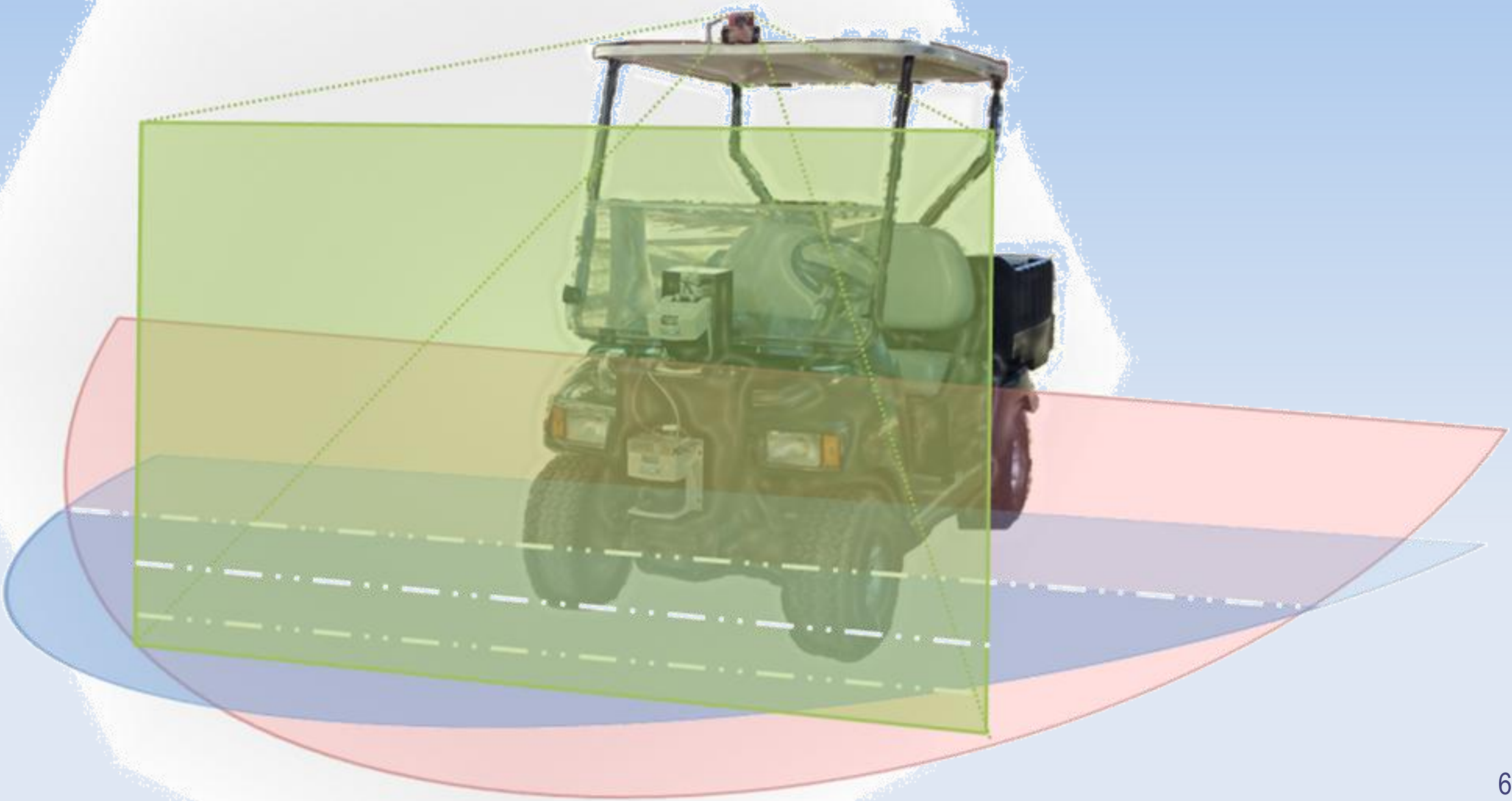


CaRINA I – Perception



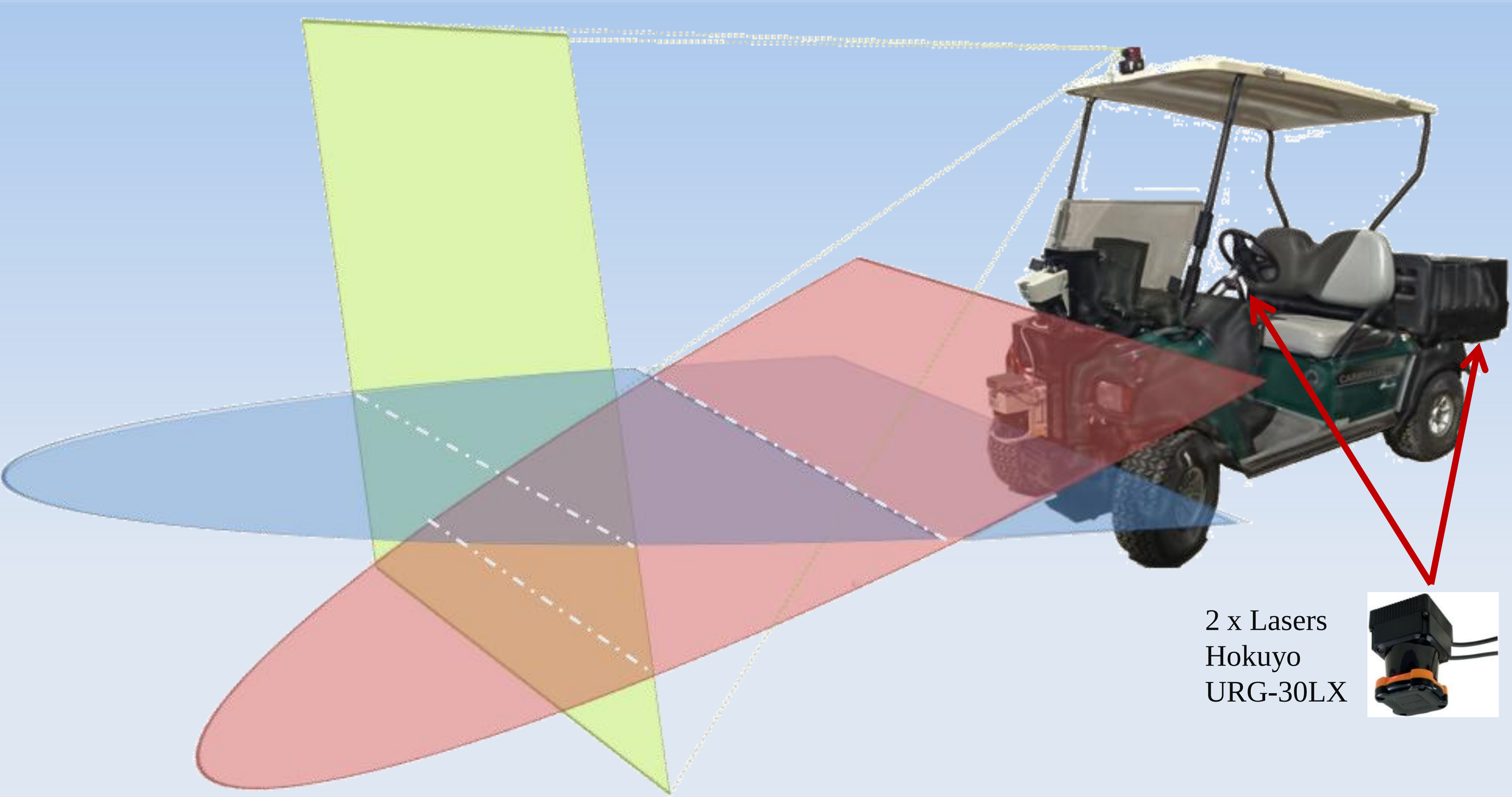
Project CaRINA I : R&D

CaRINA I – Perception



Project CaRINA I : R&D

CaRINA I – Perception



2 x Lasers
Hokuyo
URG-30LX

Project CaRINA I : R&D

Main Results

http://www.lrm.icmc.usp.br/wiki/index.php/Publications

- **Motor Control: Steering Control, Speed Control, Breaking System**
- **Software Integration into CaRINA I: Player, Stage e Gazebo + ROS (more recently)**
- **Computer Assisted Driving**
  - **Intelligent obstacle detection (remove false positives)**
- **Navigable and Safe Region Classification and Detection**
  - **Image processing using single (monocular) cameras and stereo cameras**
  - **Laser: lane detection, borders of sidewalk, turns, crossings**
- **Navigation and Obstacle Detection**
  - **Using vision to navigate and to avoid obstacles (navigable region, templates)**
- **Mapping and Representation of Environment Models**
  - **Mapping the environment using laser and vision systems**
- **Finite State Machine (FSM) based Navigation**
  - **Detecting situations (context) and taking actions**
- **Application into Agricultural Environments**
  - **Autonomous pesticide spraying machines**
- **Tele-operation (i-CaRINA)**

Project CaRINA I : R&D

Fusion of Sensors: Laser + GPS + Compass

Vehicle localization

Actual Laser Data

Planned Path

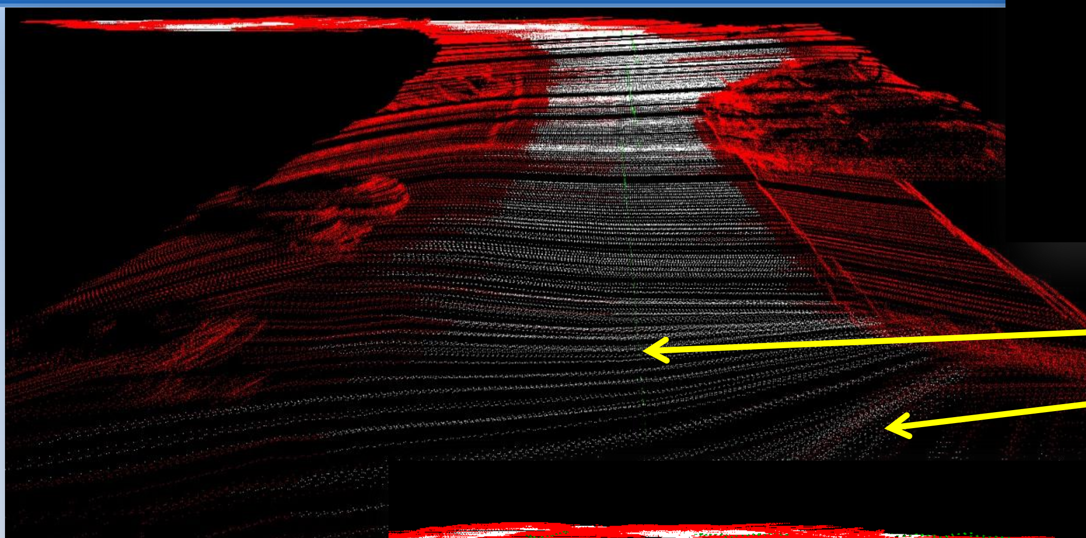
Detected Obstacles

Camera Image

[Leandro Fernandes]

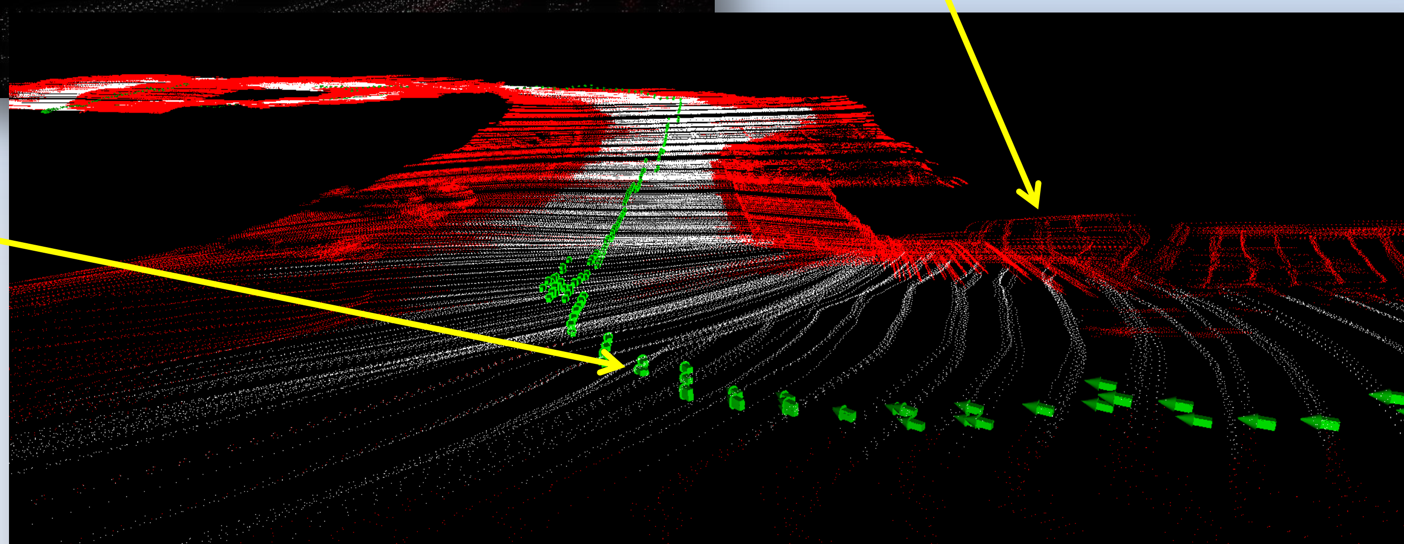
Project CaRINA I : R&D

3D Reconstruction



Vehicle Position

Laser Data



3D Pose
(Position and Orientation)

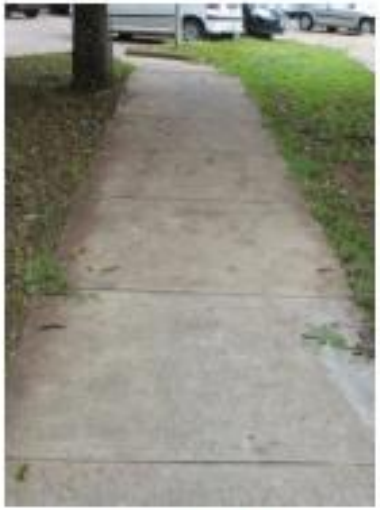
Integration:
Laser_2D +
GPS + IMU + KF

Terrain Mapping and Reconstruction (laser)

[Alberto Hata]

(a) Cenário I

(b) Cenário II



(c) Cenário III

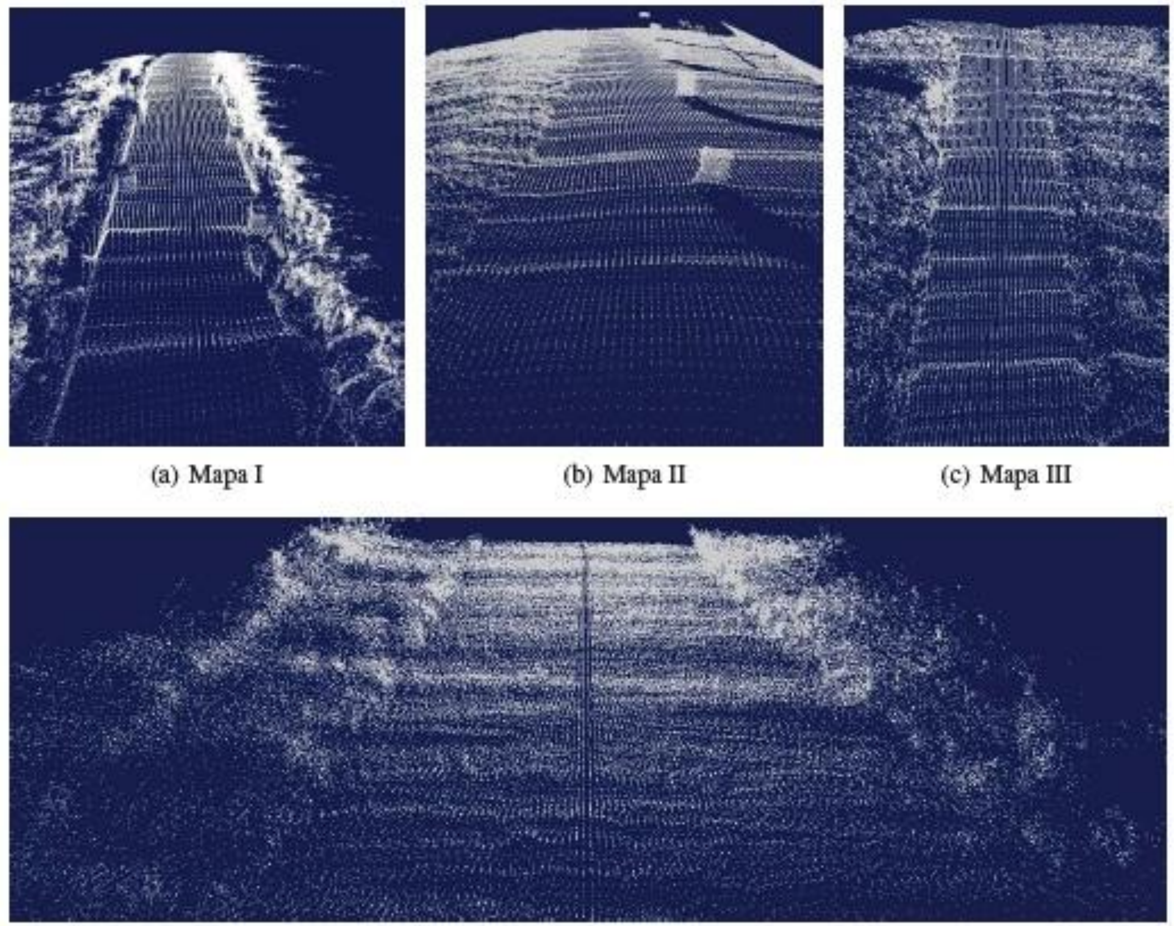
(d) Cenário IV

Terrain Mapping and Reconstruction (laser)

[Alberto Hata]

(a) Cenário I (b) Cenário II (c) Cenário III

(d) Cenário IV



(a) Mapa I (b) Mapa II (c) Mapa III

(d) Mapa IV

Terrain Classification – Safe/Unsafe (laser)

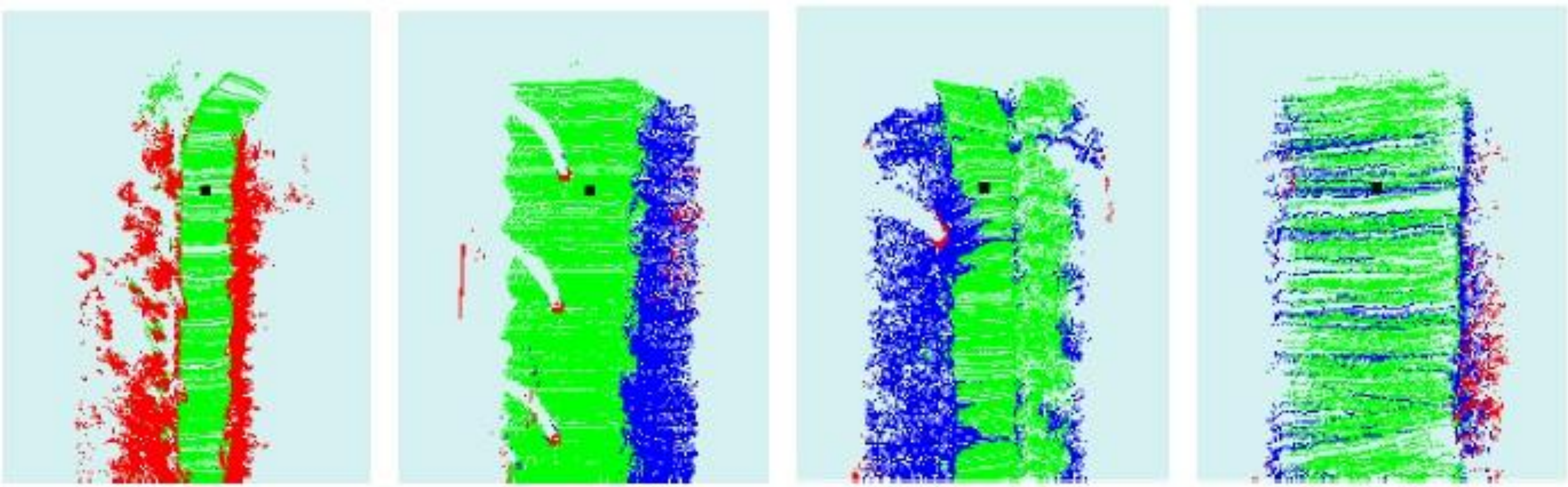
[Alberto Hata]

(a) Cenário I

(b) Cenário II

(c) Cenário III

(d) Cenário IV



(a) Cenário I (b) Cenário II (c) Cenário III (d) Cenário IV

Classification: Navigable x Non Navigable

Project CaRINA I : R&D

Where is safe?

Computational Vision

Project CaRINA I : R&D

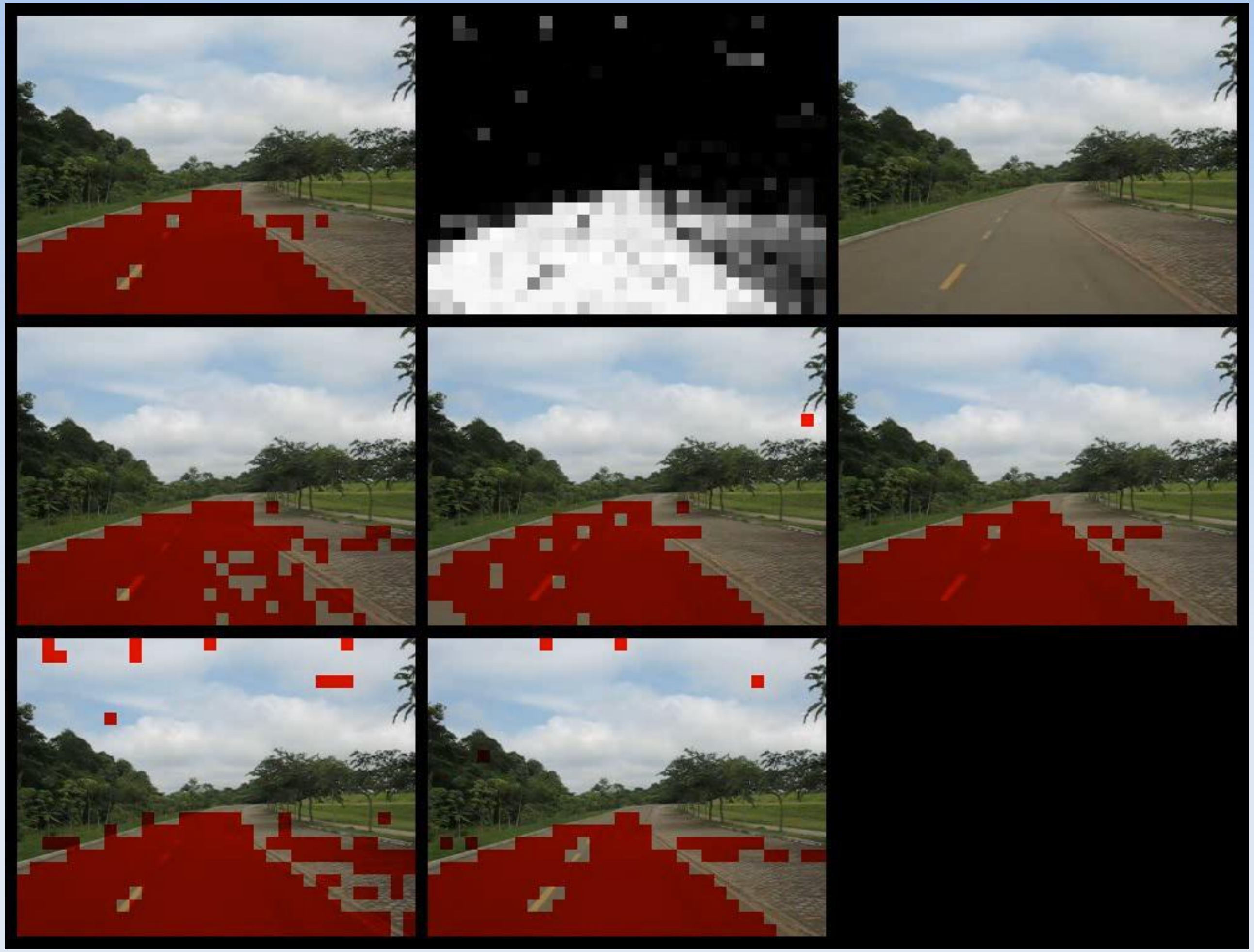
Where is safe?

Computational Vision

Project CaRINA I : R&D

Vision based Navigation

[Patrick Shinzato]

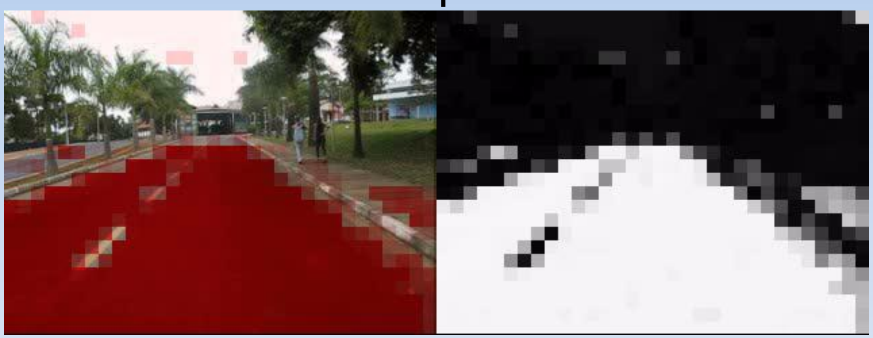


Project CaRINA I : R&D

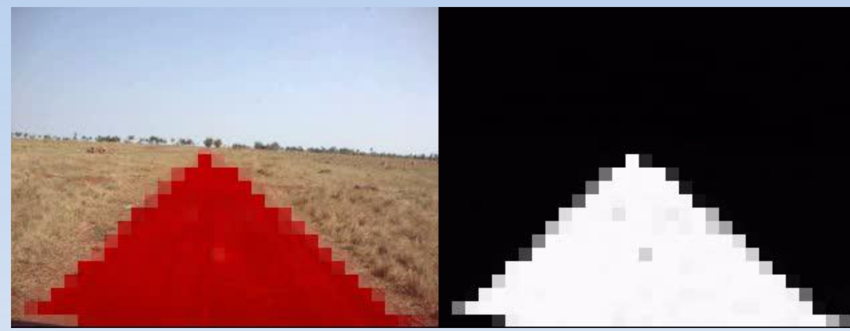
[Patrick Shinzato]

Computational Vision

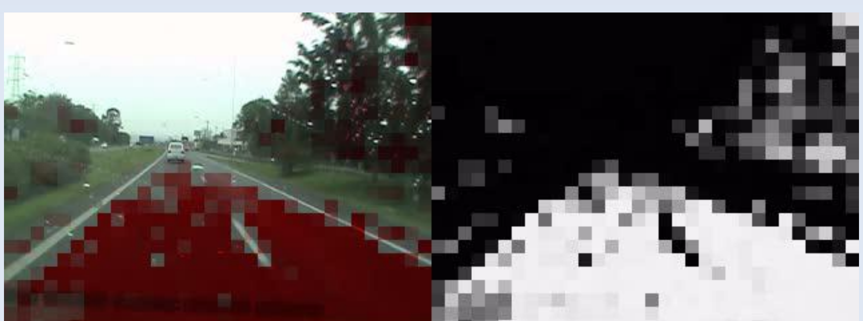
Urban Space



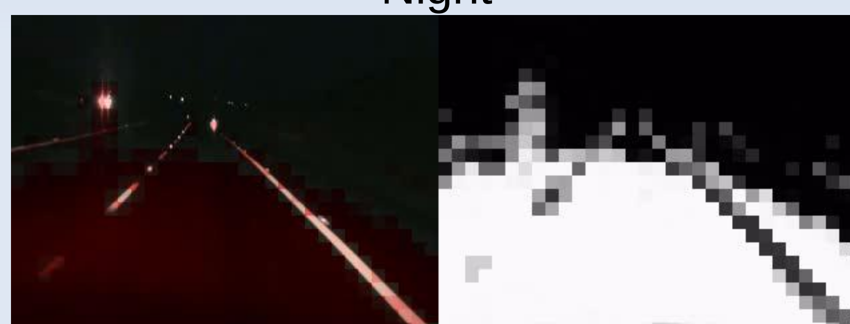
Country Space



Rain

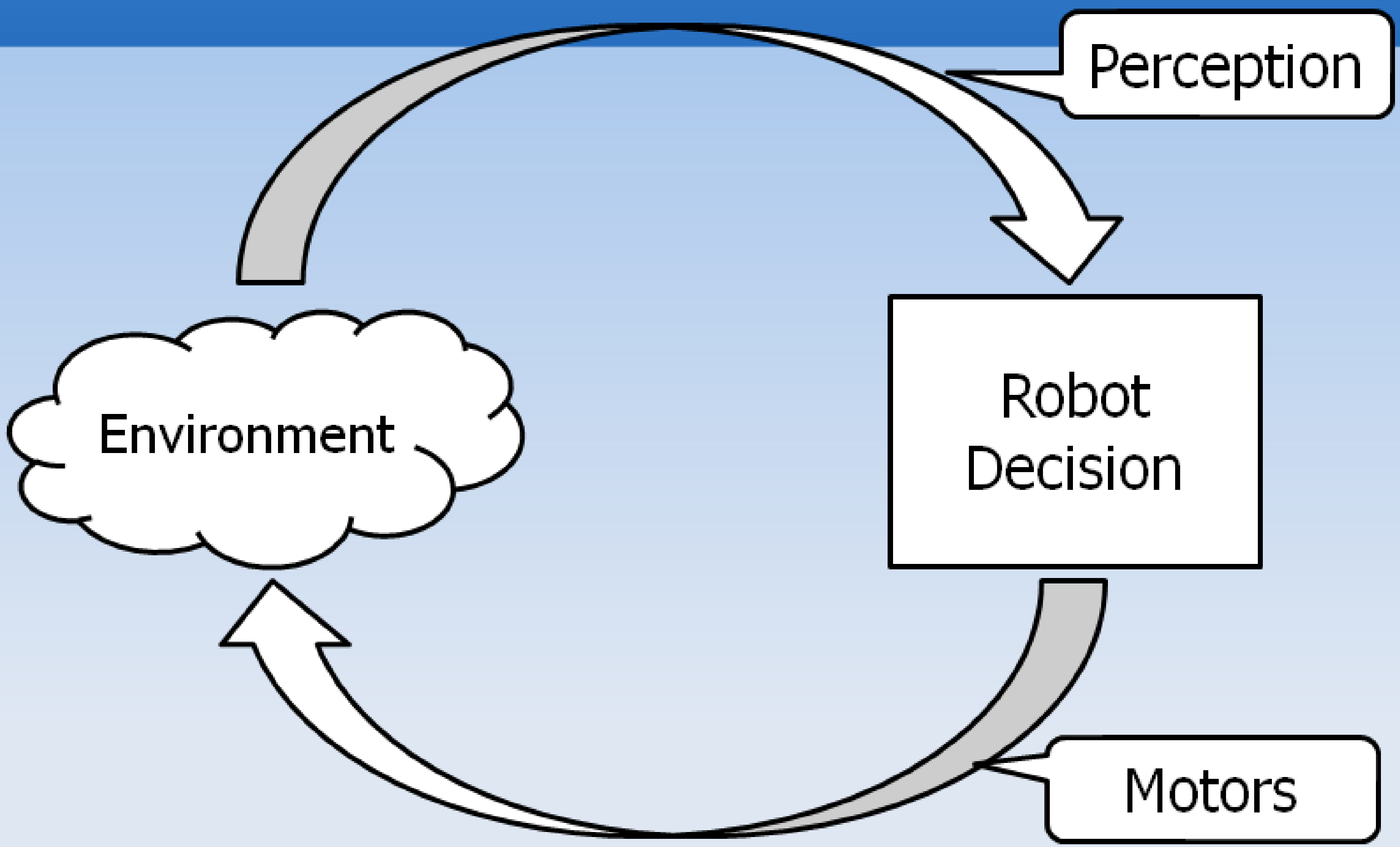


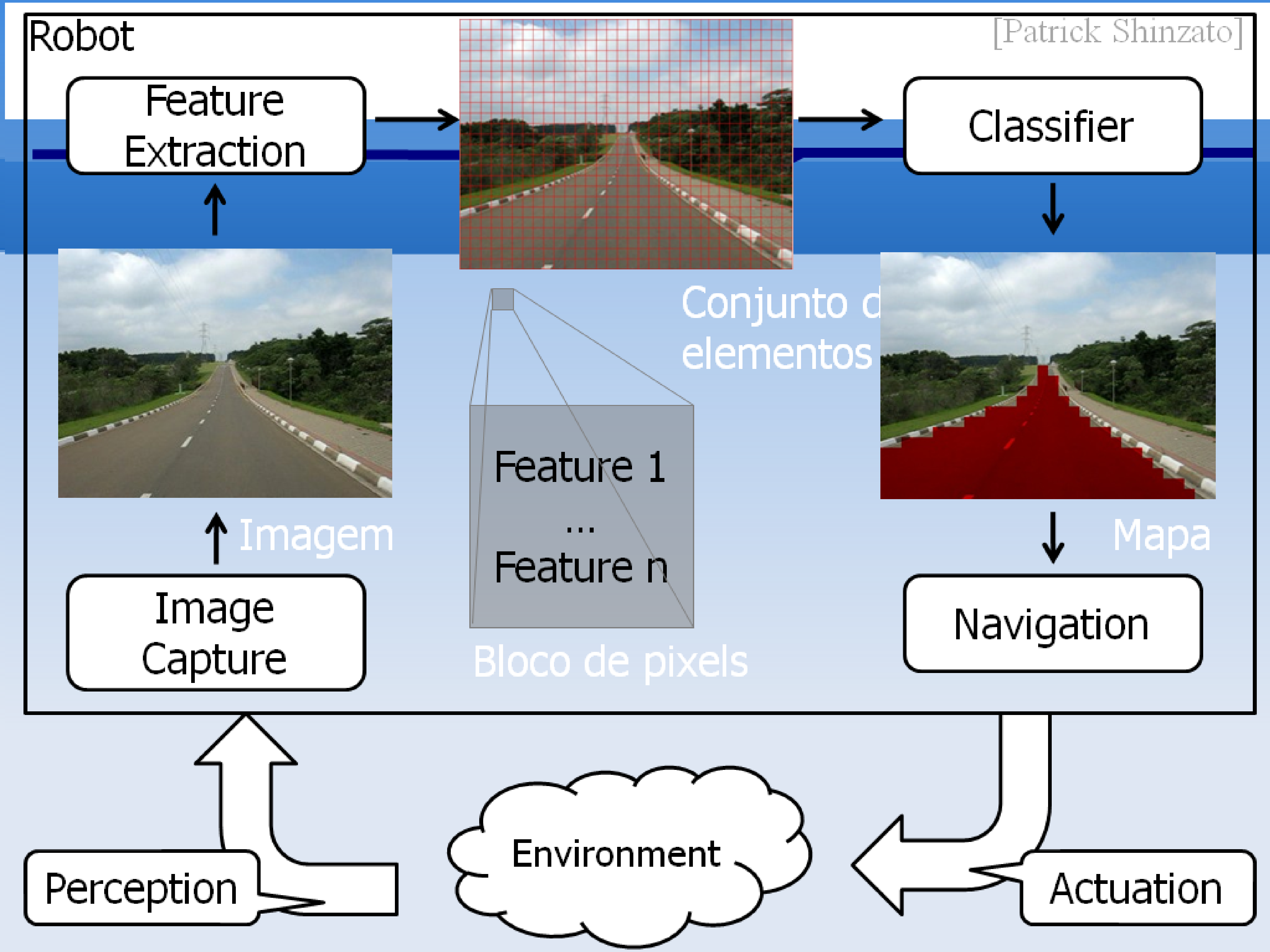
Night



[Patrick Shinzato]

Methodology




Robot
[Patrick Shinzato]
Feature Extraction
Classifier
Conjunto d
elementos
Imagem
Feature 1
...
Feature n
Mapa
Image Capture
Bloco de pixels
Navigation
Environment
Perception
Actuation

Project CaRINA I : R&D

Autonomous Navigation

Autonomous Navigation based on Computational Vision

October 2010

November 2010

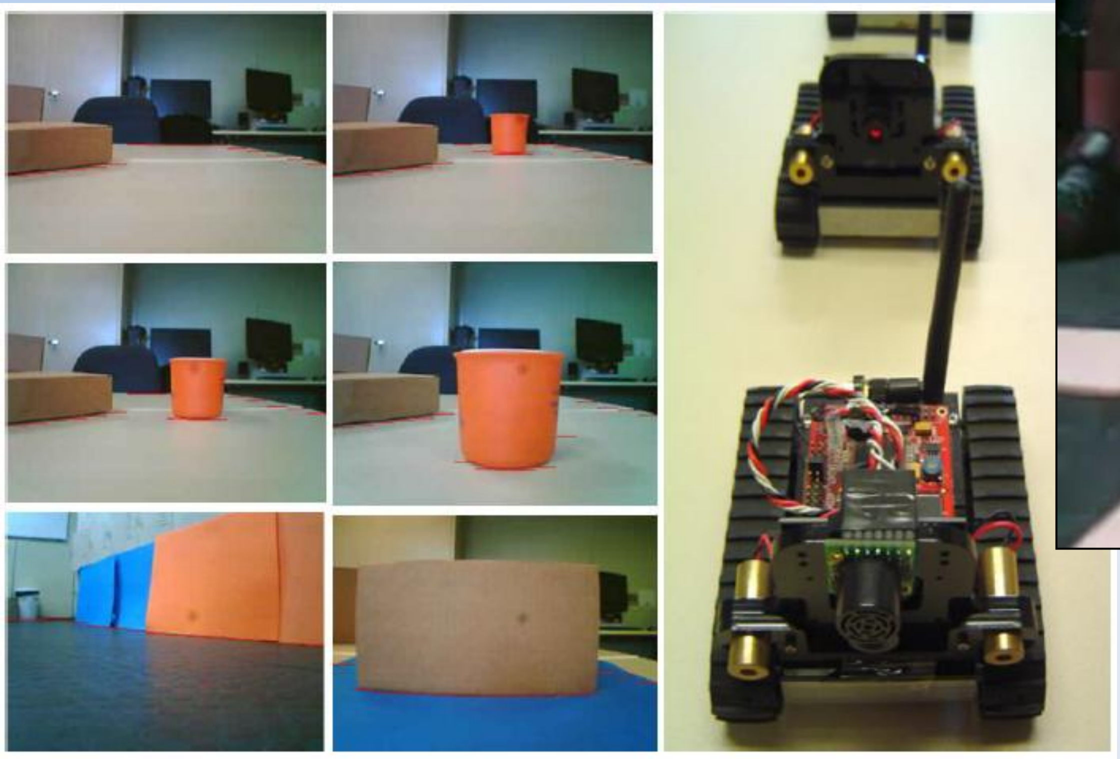
http://youtube.com/lrmicmc

[Jefferson Souza, Daniel Sales, Gustavo Pessin, Patrick Shinzato]

Project CaRINA I : R&D

Autonomous Navigation

Using also small INDOOR robots…



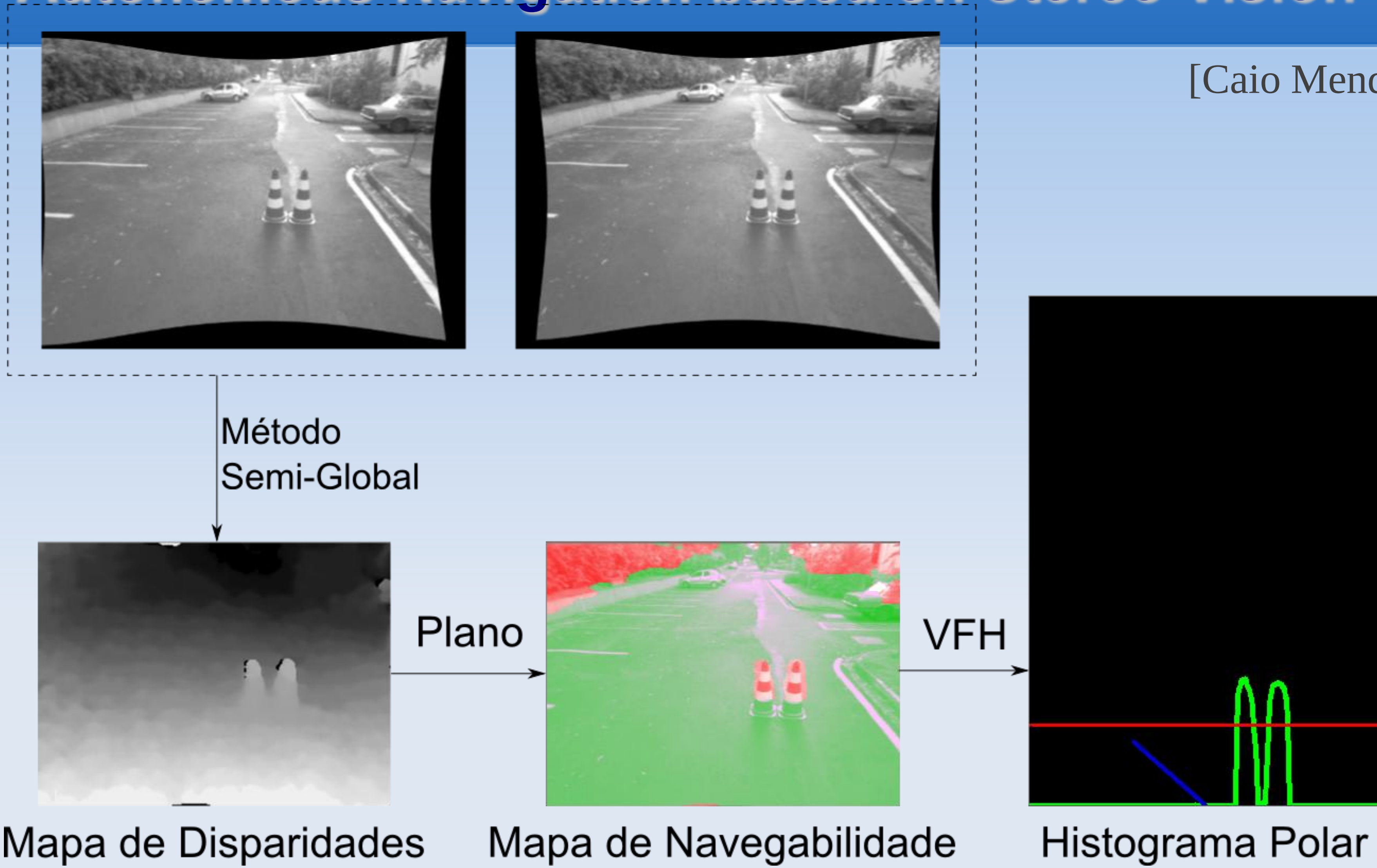
[Daniel Sales]

http://youtube.com/lrmicmc

Project CaRINA I : R&D

Autonomous Navigation based on Stereo Vision

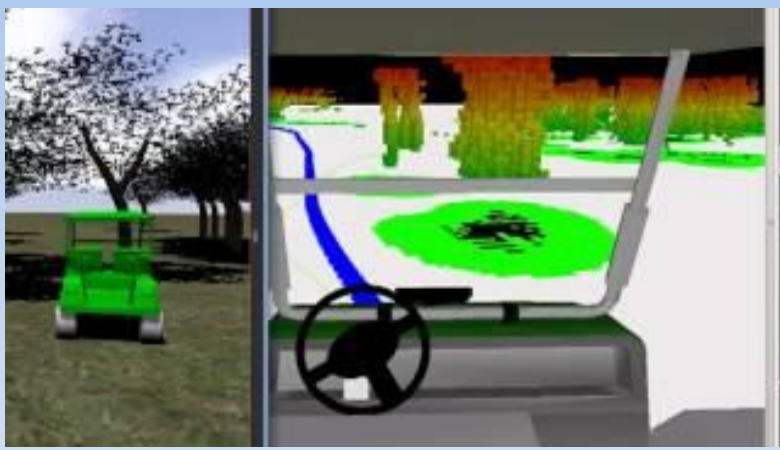
[Caio Mendes]

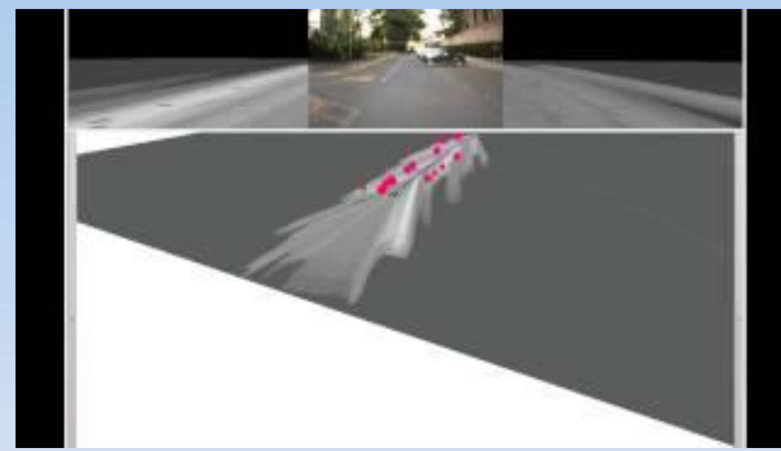


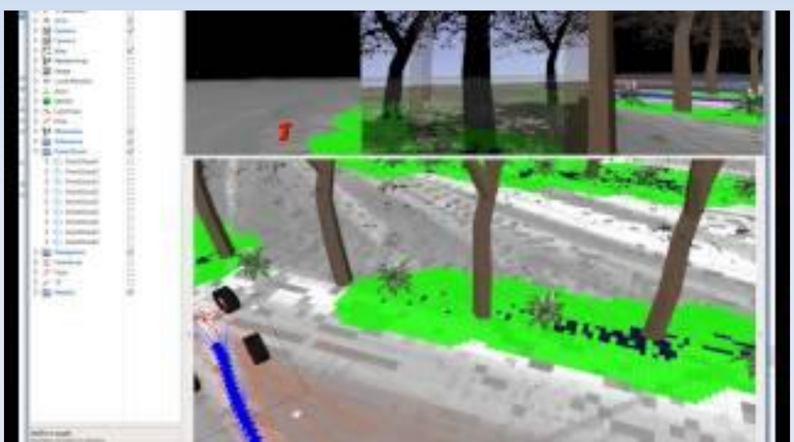
Project CaRINA I : R&D

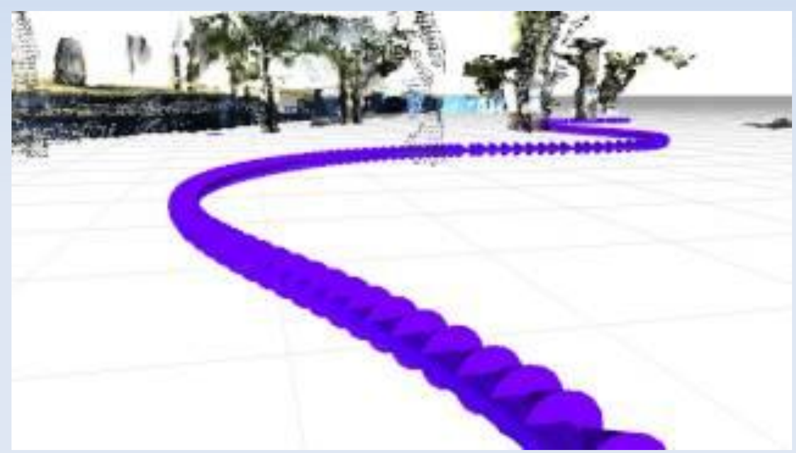
Autonomous Navigation based on Stereo Vision

[Rafael Klaser]





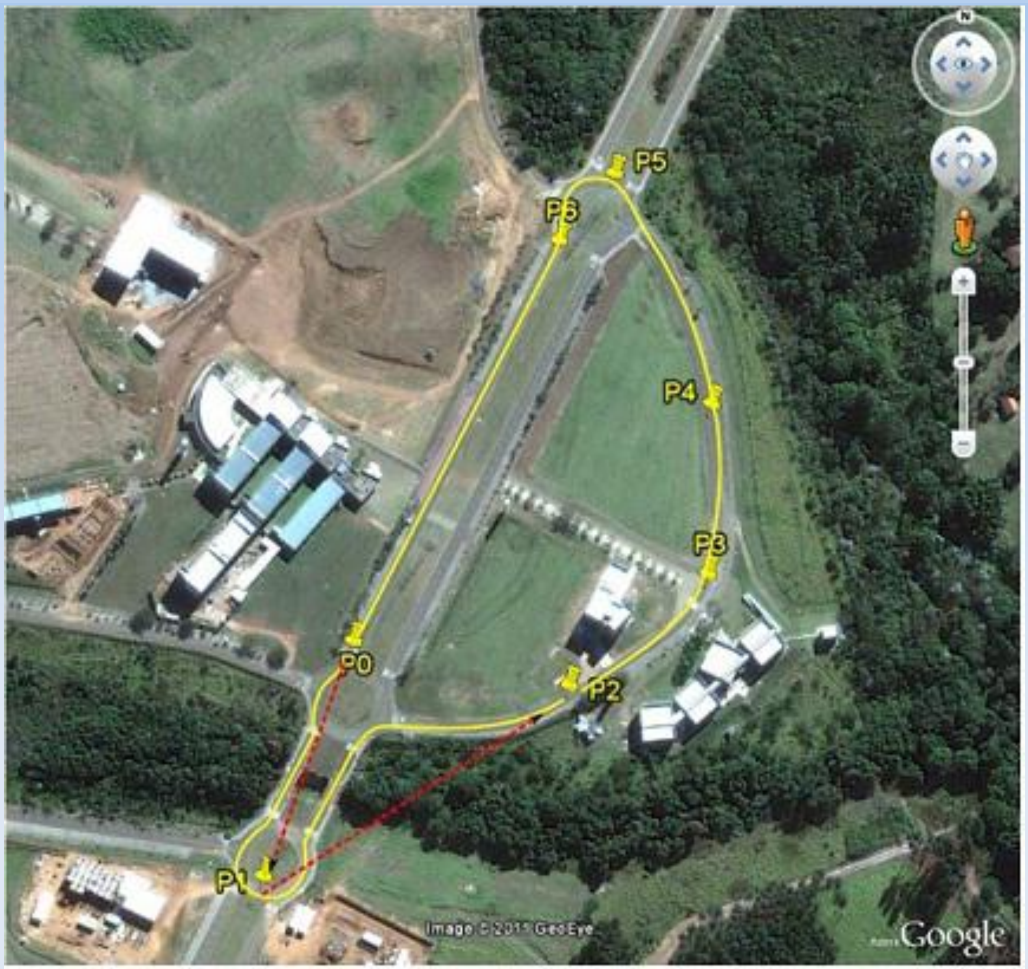




https://www.youtube.com/user/rlklaser http://www.lrm.icmc.usp.br/wiki/index.php/Publications

Project CaRINA I : R&D

Autonomous Navigation



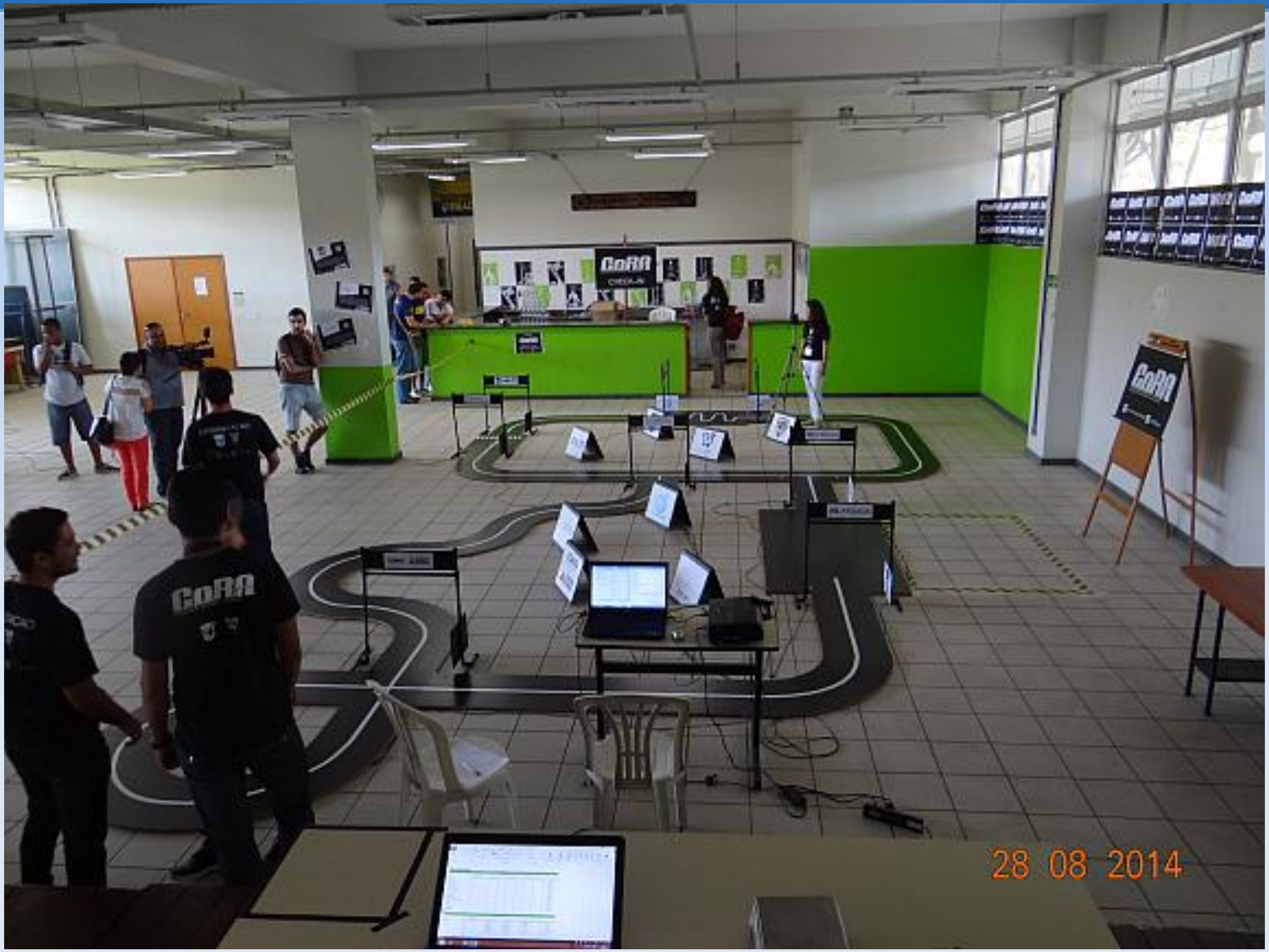
October 2011:

Total path: 1,08 km

Autonomous Control Mode

[G.Pessin, J.Souza]

Autonomous Driving: Challenges!



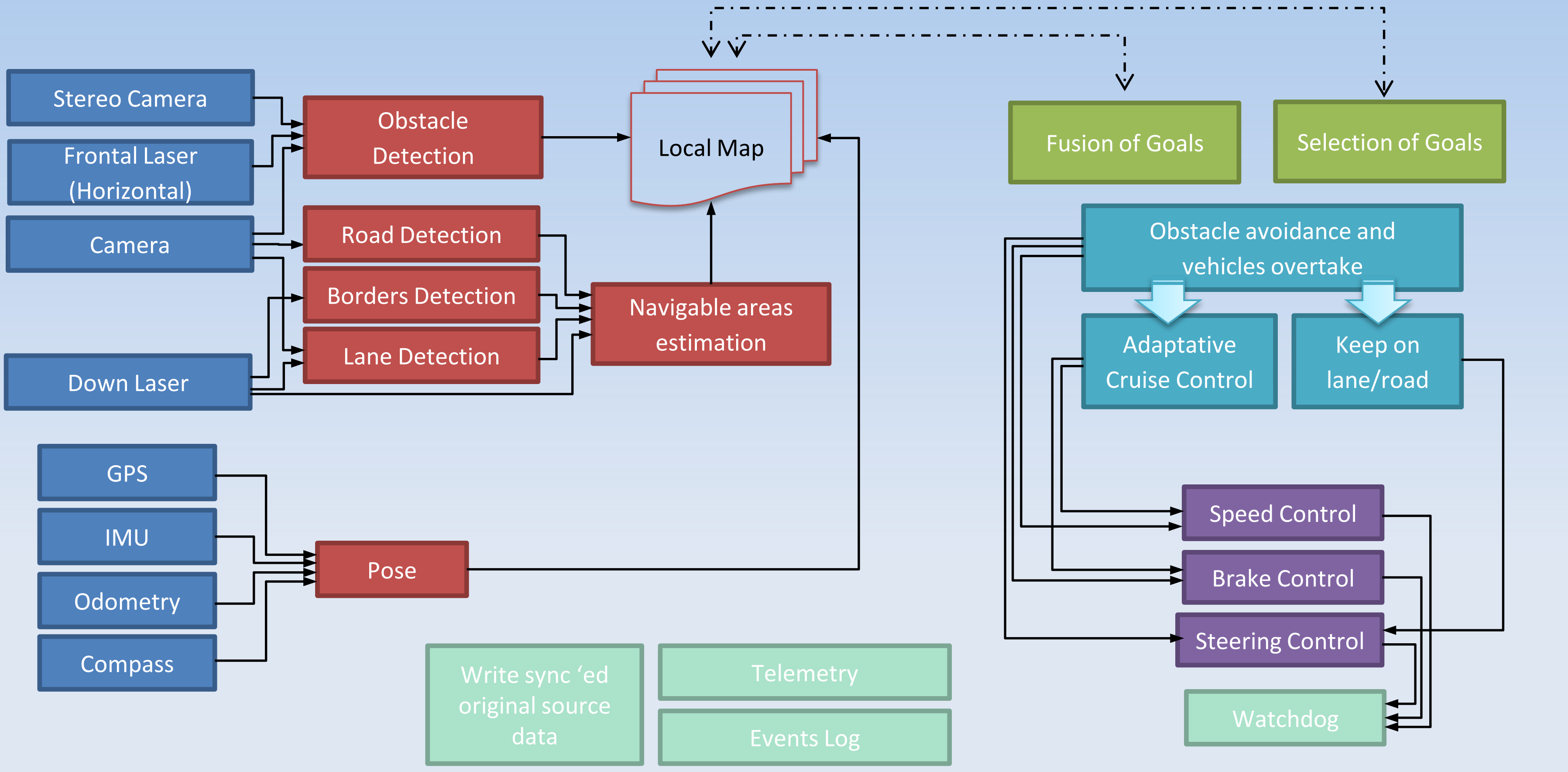
Line follower

CoRA
Autonomous
Robots
Competition
[UFMG]
[FAPEMIG]

+ ADD +
Perception!!!
(obstacle detection,
obstacle avoidance)

Project CaRINA I : R&D

Control Architecture Design



[L.Fernandes]

Project CaRINA **I** and **II** : R&D

Software

TOOLS:

Player-Stage (Old)

Gazebo – Gazebosim Robot Simulator

ROS – Robot Operating System

OpenCV – Open Source Computer Vision Library

PCL – Point Cloud Library

Morse - Modular OpenRobots Simulation Engine

Matlab, Weka, SNNS/JavaNNS, FANN, GALib, Python, ...

Player Stage

GAZEBO

ROS

OpenCV

pcl

Morse

CARINA II

CARINA

Carro Robótico Inteligente para Navegação Autônoma

Autonomous Vehicle No. 2

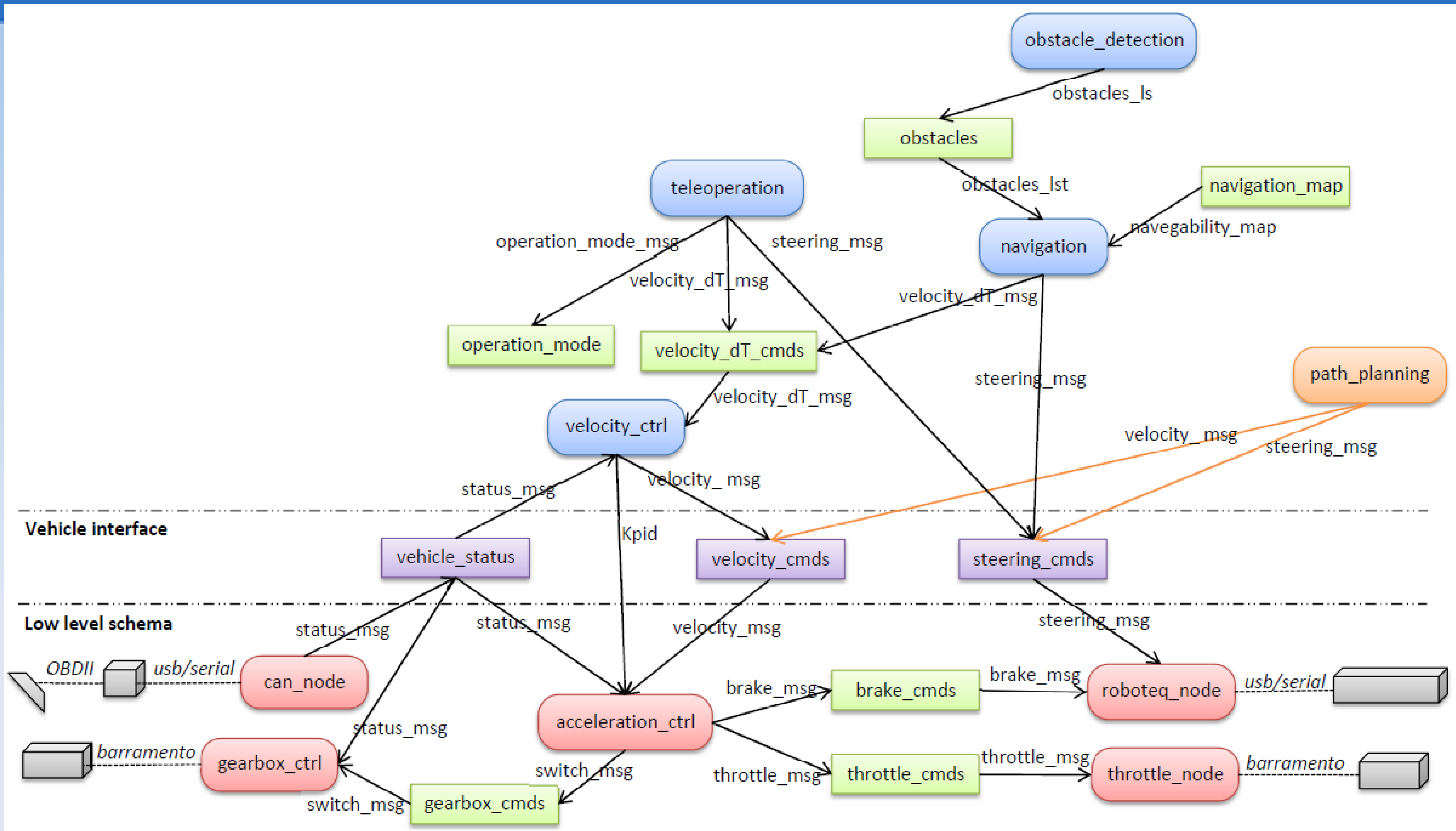
CARINA II

Laser SICK
Laser Velodyne
LadyBug 360º Camera (Pointgray)
Stereo Camera BumbleBee (Pointgray)

GPS + IMU
Inerial Unit

CaRINA II: Sensors

CaRINA: Software Architecture



Project CaRINA II : R&D

Computational Model

CARINA II

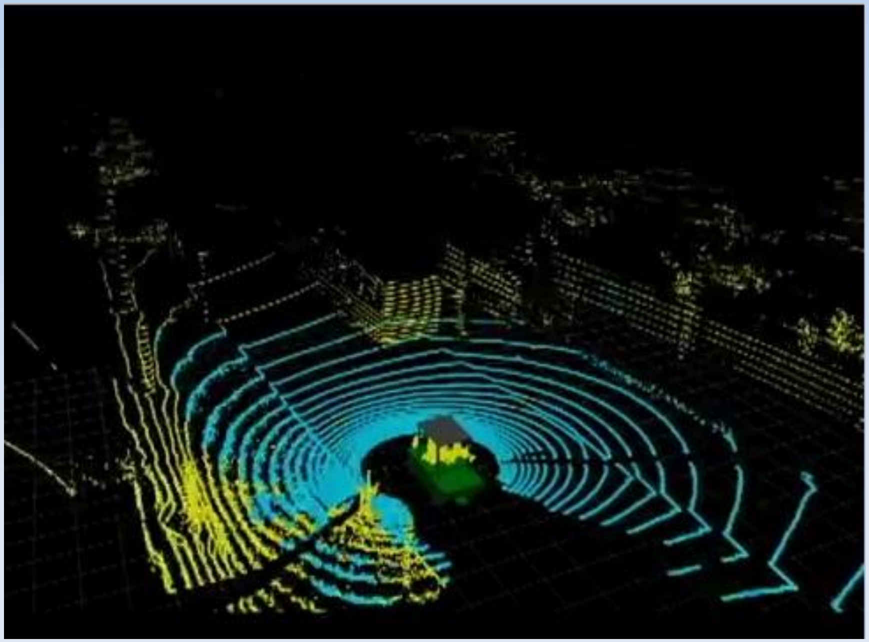
Project CaRINA II : R&D

CARINA II - Automation

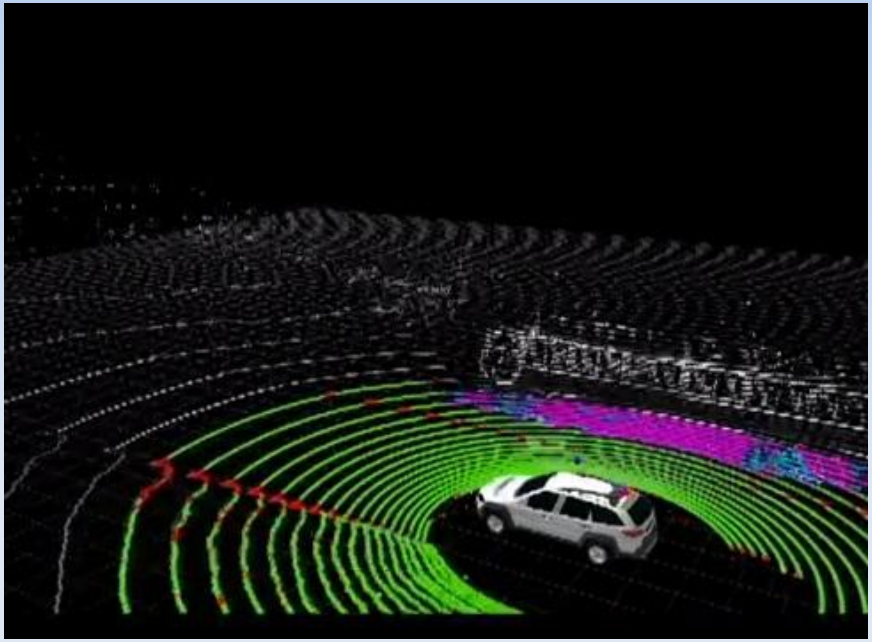
Sept. 2012

Using LIDAR 3D

Actual data obtained with Velodyne HDL-32E



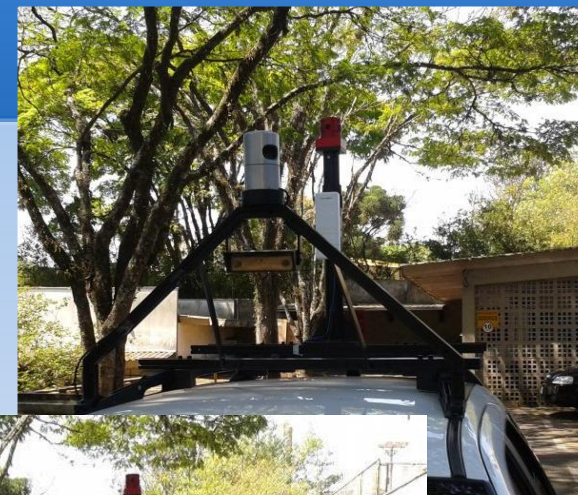
CaRINA I
April 2012



CaRINA II
May 2012

http://youtube.com/lrmicmc

CARINA II: Present Configuration



Project CARINA: news coverage

EPTV – April 2012

TV Record – October 2010

Portal G1 – April 2012

Revista Quatro Rodas – July 2012

Jornal Nacional – September 2012

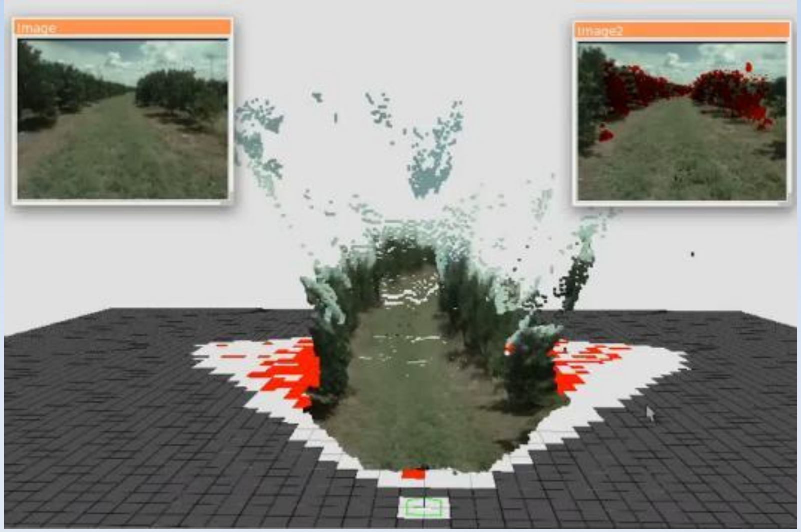
Diário Oficial– May 2012

NAV-AG Autonomous Navigation for Agribusiness Applications

Research project in collaboration with JACTO company

Development of Agricultural Applications

JAV – Jacto Autonomous Vehicle (agricultural pesticides)



Started in January 2012

NAV-AG Autonomous Navigation for Agribusiness Applications

Research project in collaboration with JACTO company

Início em janeiro 2012

NAV-AG Autonomous Navigation for Agribusiness Applications

Research project in collaboration with JACTO company

Início em janeiro 2012

Project NAV-AG

JAV II - Agrishow 2013

Project NAV-AG

Jacto JAV II

https://www.youtube.com/watch?v=kUVP9HsywDU JAV 2

Prof. Fernando Osório
http://www.icmc.usp.br/~fosorio
E-mail: fosorio@icmc.usp.br

Laboratório de Robótica Móvel – ICMC/USP

http://www.lrm.icmc.usp.br/
http://www.lrm.icmc.usp.br/wiki/index.php/Publications

LRM Group – Mobile Robotics Lab @ ICMC USP

Main Professors: **Prof. Dr. Denis Wolf, Prof. Dr. Fernando Osório**
External Profs: Prof. Dr. Valdir Grassi Jr. e Profa. Dra. Kalinka Castelo Branco

Graduate and Undergraduate Students (2012): ~ 30 people

- PhD Students: G. Pessin, L. Fernandes, M.Dias, D.Habermann, D.Sales J.Souza, P.Shinzato, A.Hata, C.Mendes, F. de Alencar
- MSc Students: D.Correa, R.Klaser, V.Utino, D.Sciotti, M.Gomes, A.Toshio
- Post-Doc: Edimilson Santos
- UnderGrad Studies: Iniciação Científica, Iniciação Tecnológica, Pré-Iniciação Científica, TCCs, Programas de Bolsas USP (Tutoria, PRG, PREx)

http://youtube.com/lrmicmc

Prof. Fernando Osório
http://www.icmc.usp.br/~fosorio
E-mail: fosorio@icmc.usp.br

Laboratório de Robótica Móvel – ICMC/USP

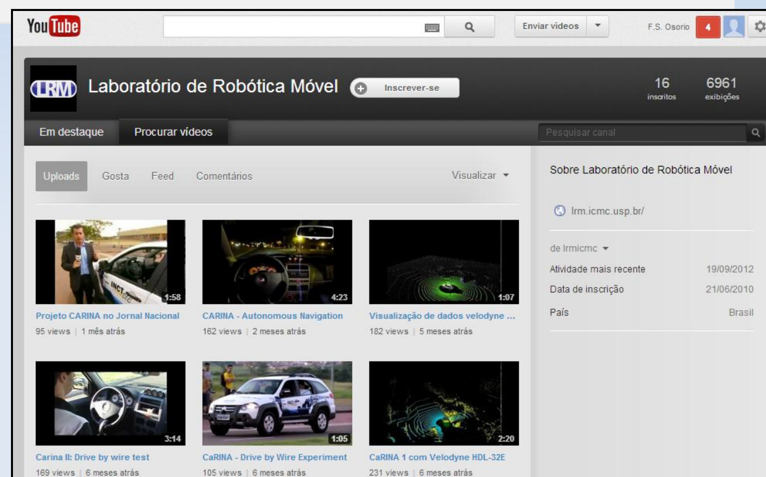
http://www.lrm.icmc.usp.br/

LRM Group – Mobile Robotics Lab @ ICMC USP

Google: LRM Carina

Main Professors: **Prof. Dr. Denis Wolf, Prof. Dr. Fernando Osório**

Google: LRM Robotica



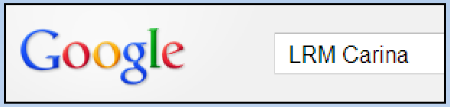
http://www.youtube.com/user/lrmicmc/videos

Prof. Fernando Osório
http://www.icmc.usp.br/~fosorio
E-mail: fosorio@icmc.usp.br

Laboratório de Robótica Móvel – ICMC/USP

http://www.lrm.icmc.usp.br/

LRM Group – Mobile Robotics Lab @ ICMC USP



Main Professors: **Prof. Dr. Denis Wolf, Prof. Dr. Fernando Osório**

OBRIGADO
PELA SUA ATENÇÃO!

http://jcris2014.icmc.usp.br/

JCRIS2014

Joint Conference on Robotics and Intelligent Systems 2014

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Joint conference 2014 18-23 October 2014 / São Carlos, SP

You are here: Home

CONFERENCES

JOINT CONFERENCE ON ROBOTICS AND INTELLIGENT SYSTEMS 2014

LARS/SBR

Joint Conference on Robotics and Intelligent Systems 2014

Introduction

Events: LARS, SBR, RoboControl, LARC, CBR, OBR, MNR, WRE, BRACIS, …

Robótica Móvel – Editora LTC

Robótica Móvel – Editora LTC