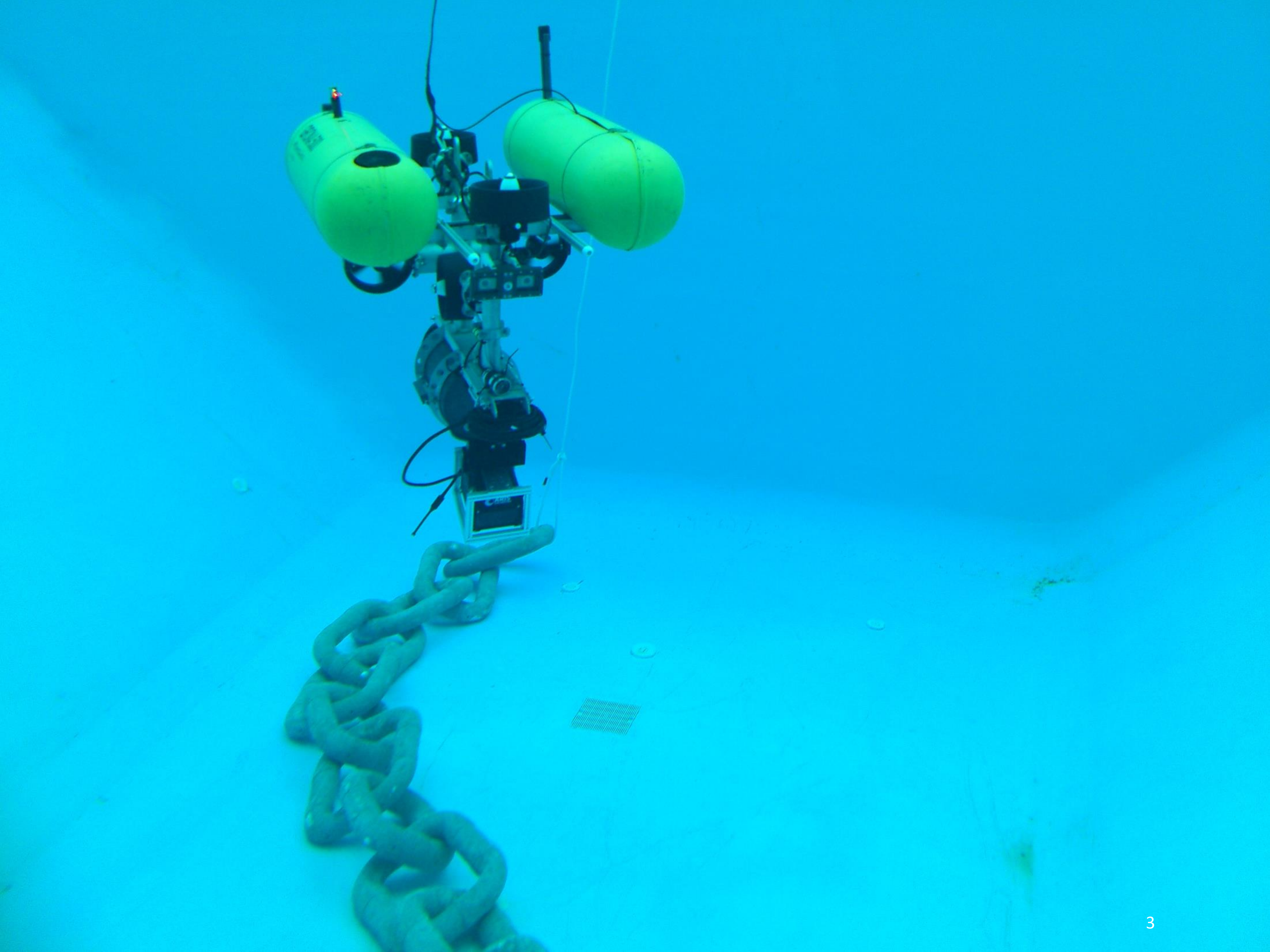
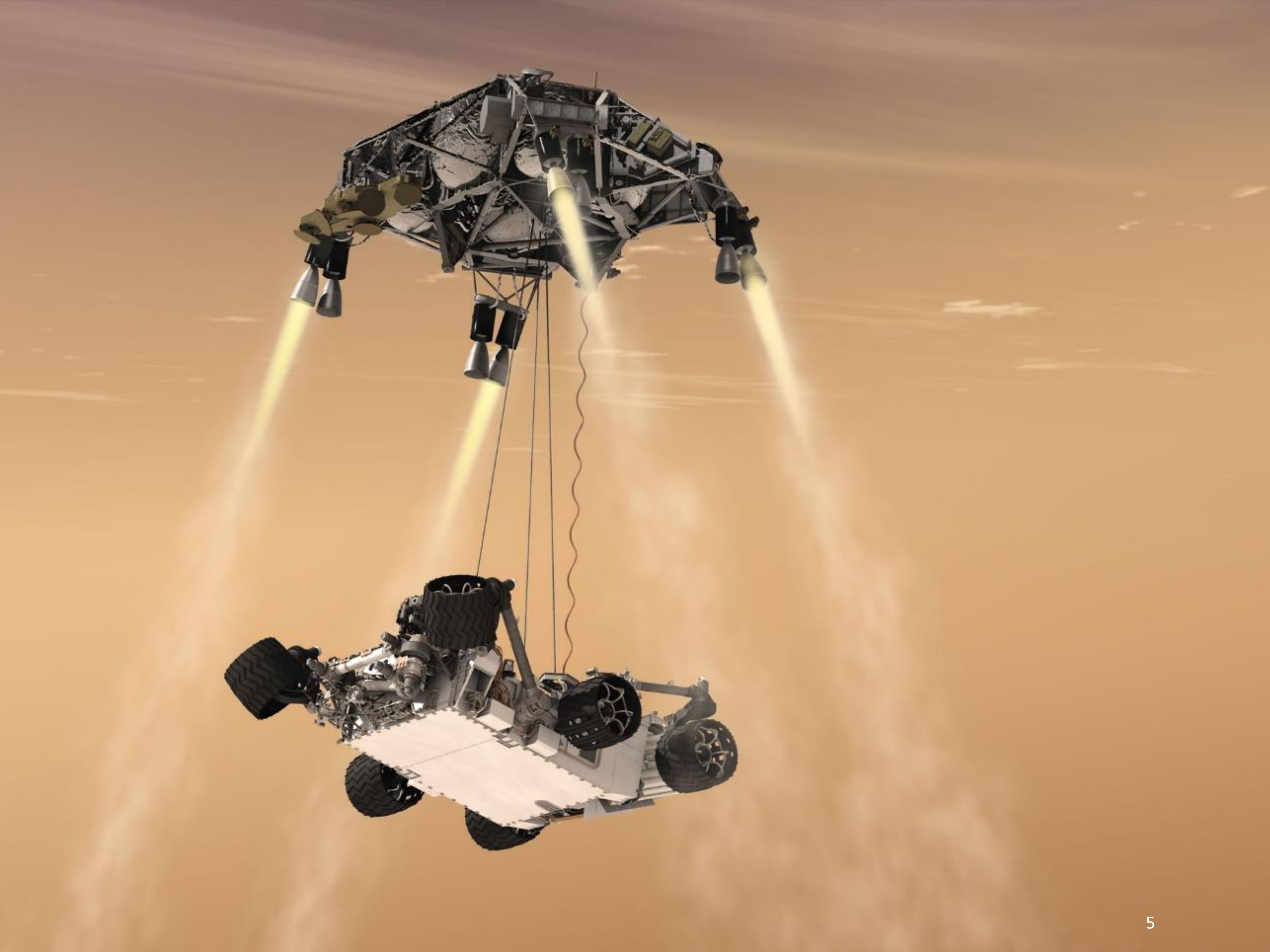
Vision-based systems for autonomous driving and mobile robots navigation

LUKAS HÄFLIGER – SUPERVISED BY MARIAN GEORGE


Push
SAMSUNG
00:21





Google Chauffeur

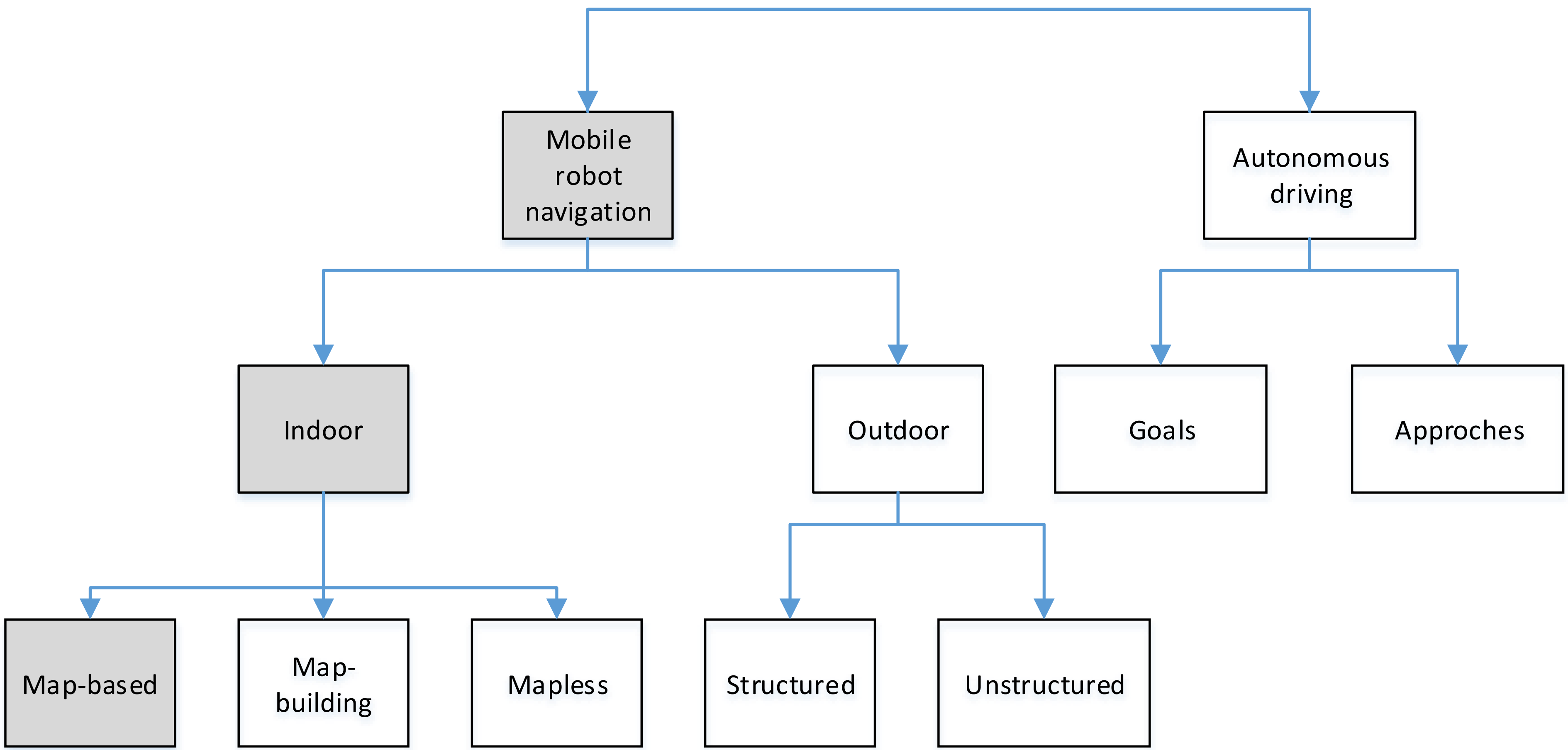
Motivation

- Environments where humans can not operate
- Great distances where manual control is not feasible
- Regular tasks
- Time saving
- Improving safety
- …

Introduction

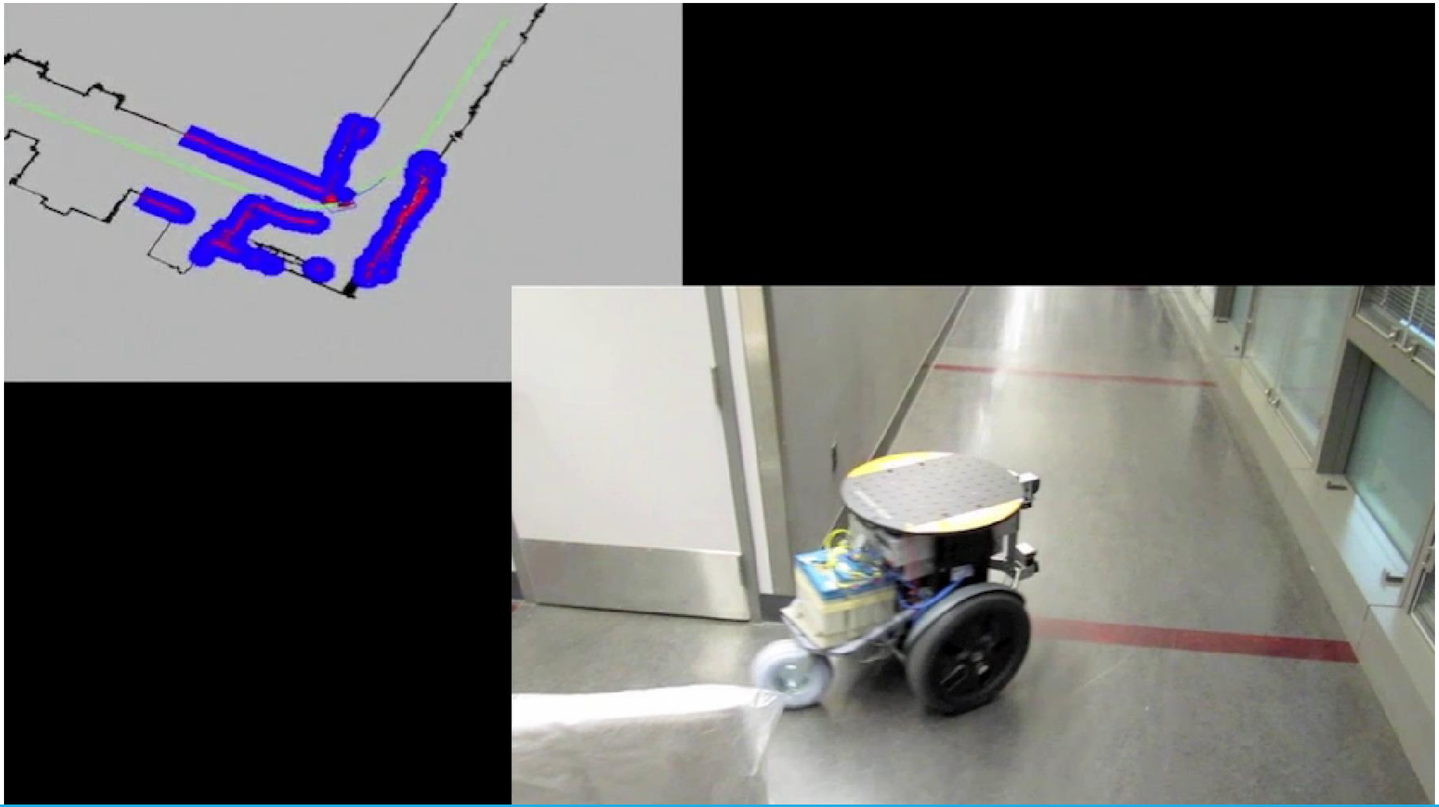
- AGV – Autonomous Ground Vehicle
- AUV – Autonomous Underwater Vehicle
- UAV – Unmanned Aerial Vehicle

Mobile robot navigation



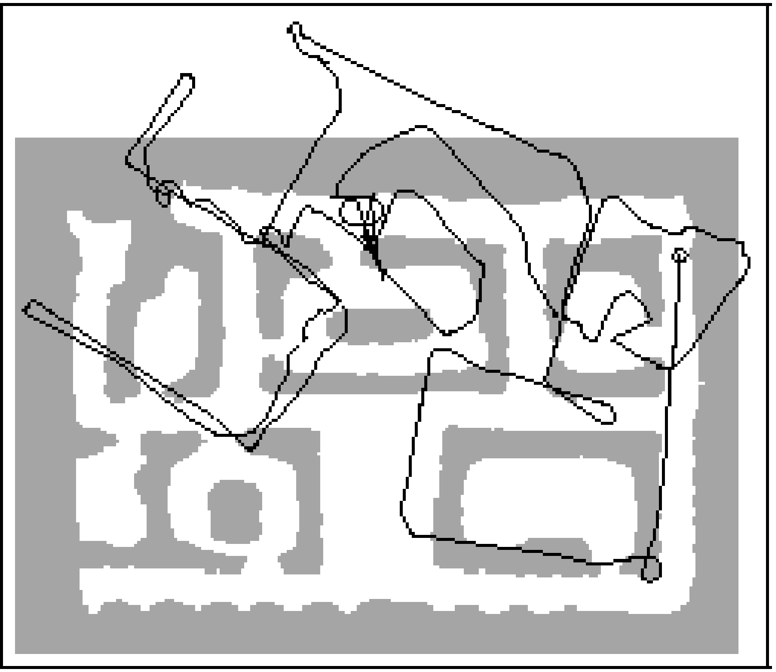
Indoor – Map-based systems

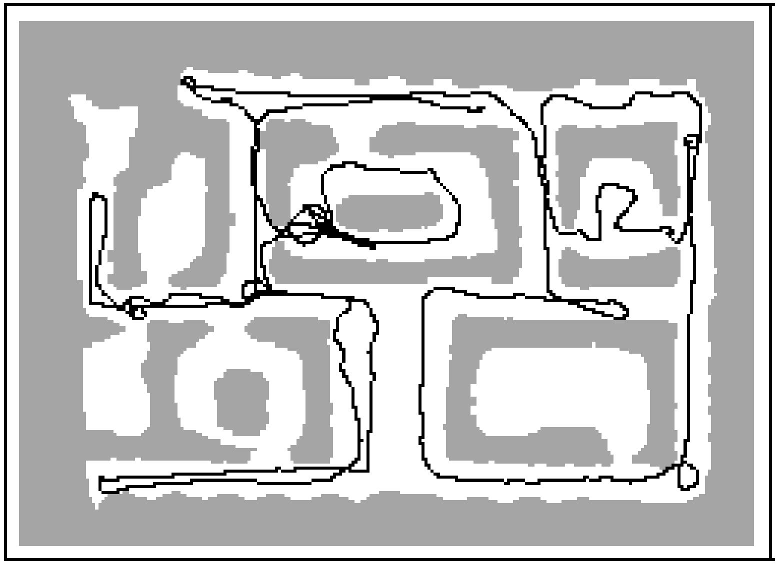
- The robot is provided with a map
- Needs to localize itself within the map



Indoor – Map-based systems

- Robot needs to correct its trajectory if it does not match the calculated trajectory


(a)


(b)

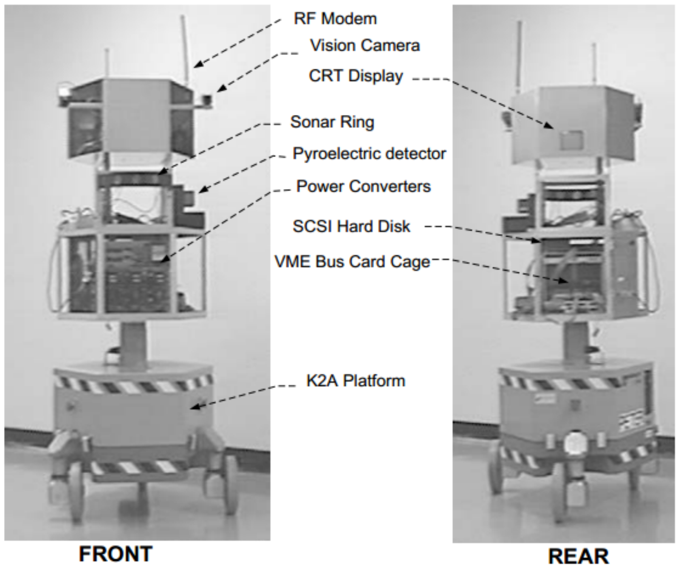
http://www.cs.cmu.edu/

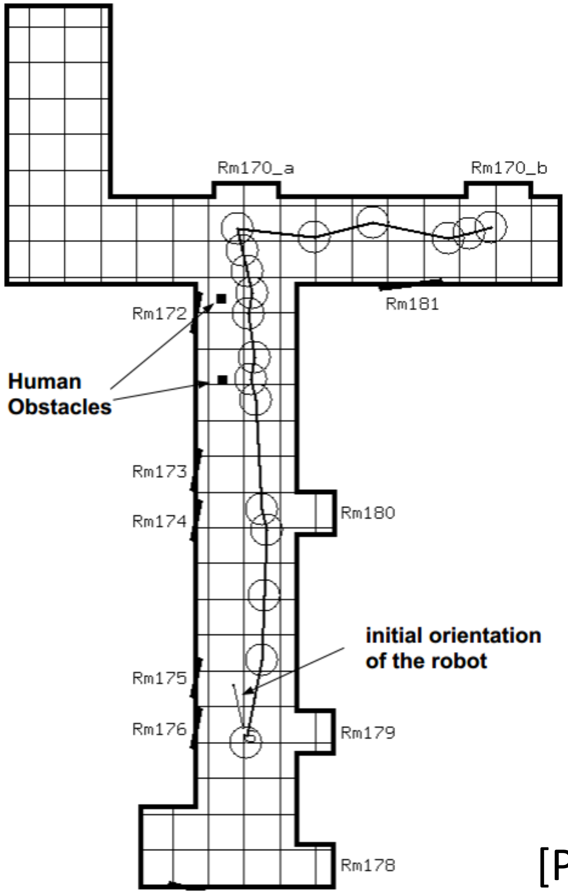
Indoor – Map-based systems

- The robot is provided with a map
- Needs to localize itself within the map
- Robot needs to correct its trajectory if it does not match the calculated trajectory

- Different approaches
  - Force fields
  - Occupancy grids
  - Landmark tracking

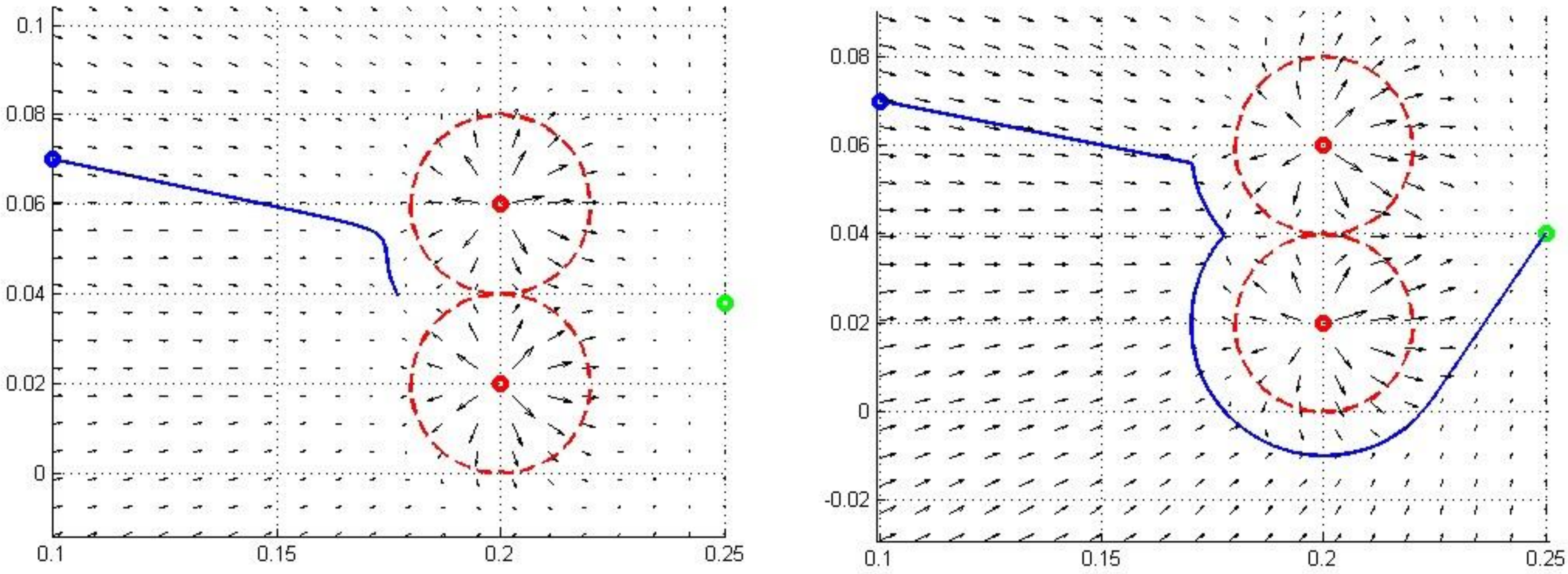
Prominent robot: FUZZY-NAV



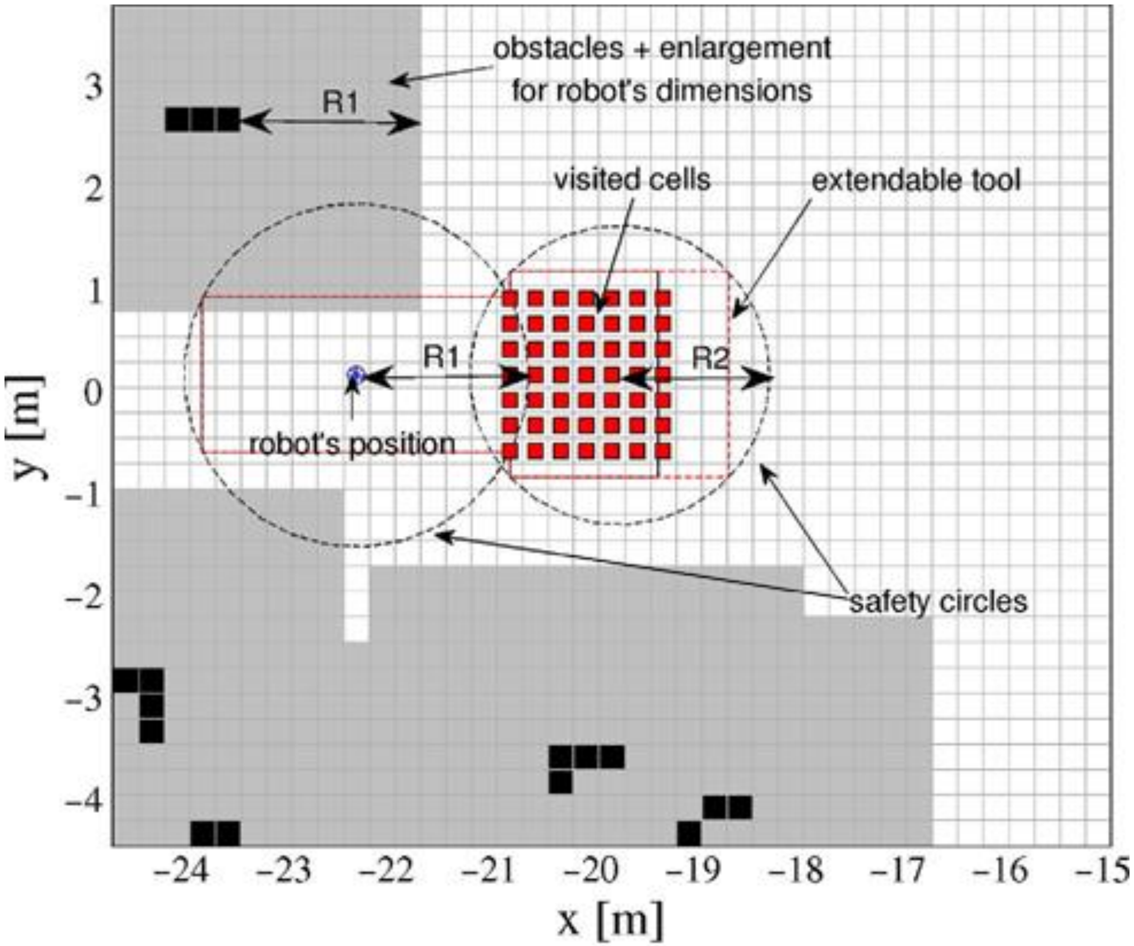


[PAN1995]

Force field


0.1
0.08
0.06
0.04
0.02
0
0.1
0.15
0.2
0.25
0.08
0.06
0.04
0.02
0
-0.02
0.1
0.15
0.2
0.25

Occupancy grid

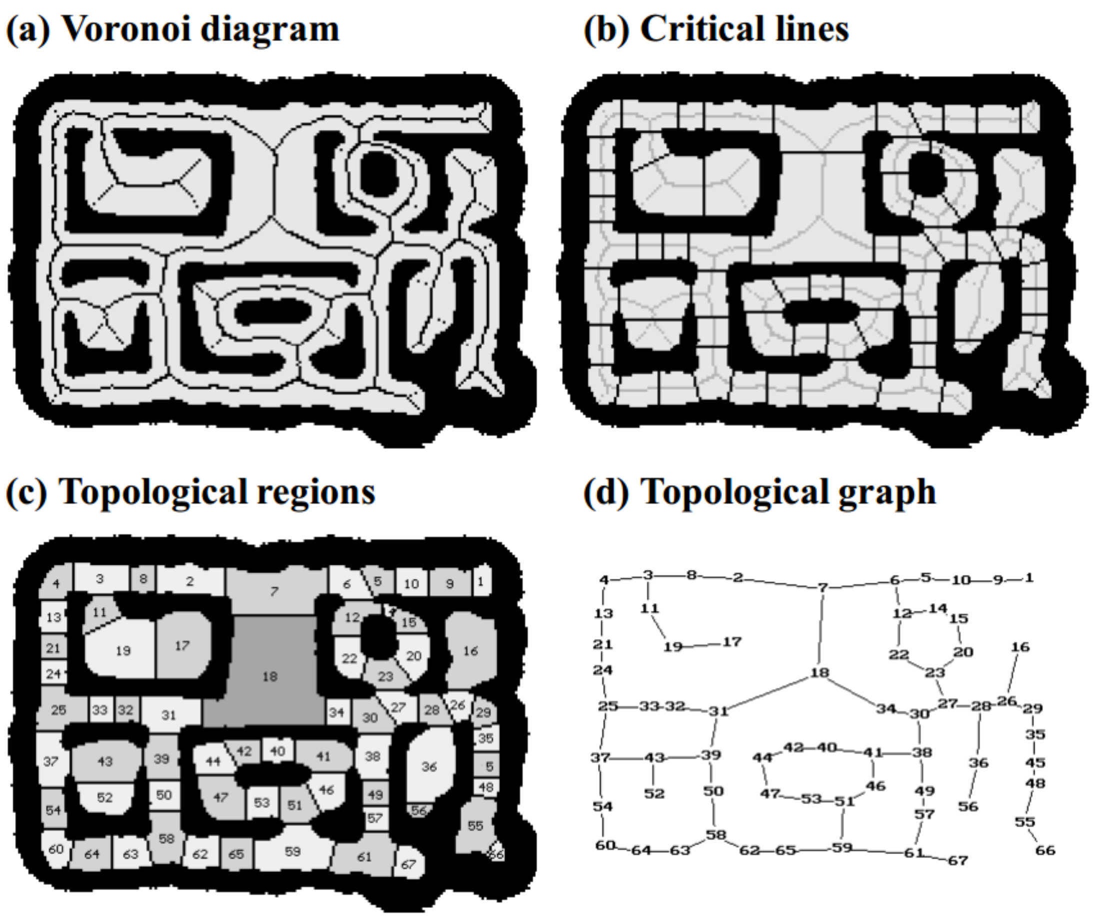


Indoor – Map-building systems

- In a first step the robot explores the map until enough information is gathered
- In a second step the navigation is started using the autonomously generated map
- Different approaches:
  - Stereo 3D reconstruction
  - Occupancy grid
  - Topological representation (feasible alternative to occupancy grids)

Stereo 3D reconstruction

Topological representation



[THRUN1996]

Indoor – Mapless systems

- The robot is not provided with a map
- Needs to detect and drive around obstacles
- Needs to localize itself within the envirnonment
- Different approaches:
  - Optical Flow
  - Appearance-based

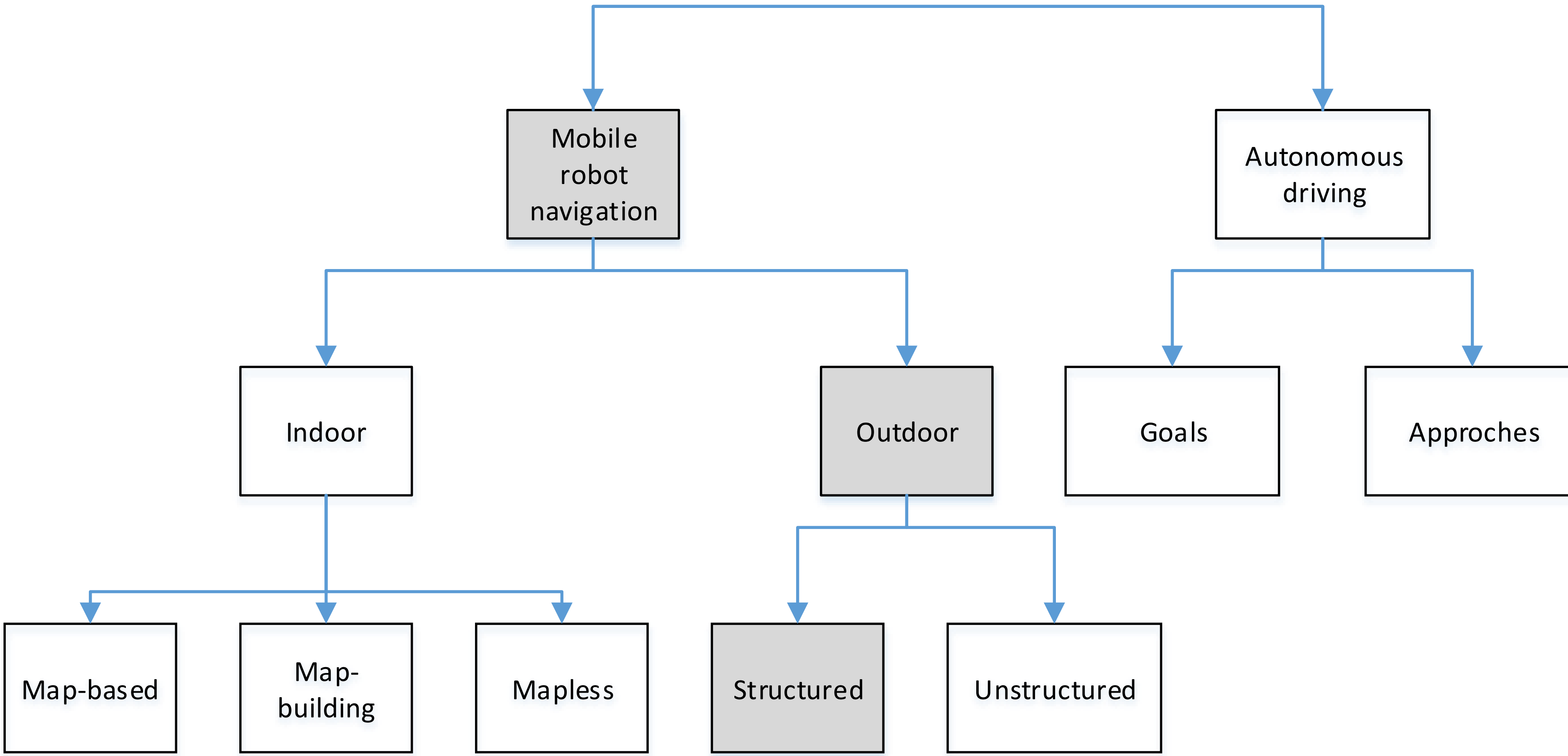
Optical Flow

[GUZEL2010]

Appearance based

- Based on stored image templates of a previous recording phase
- Robot selflocates and navigates using these templates

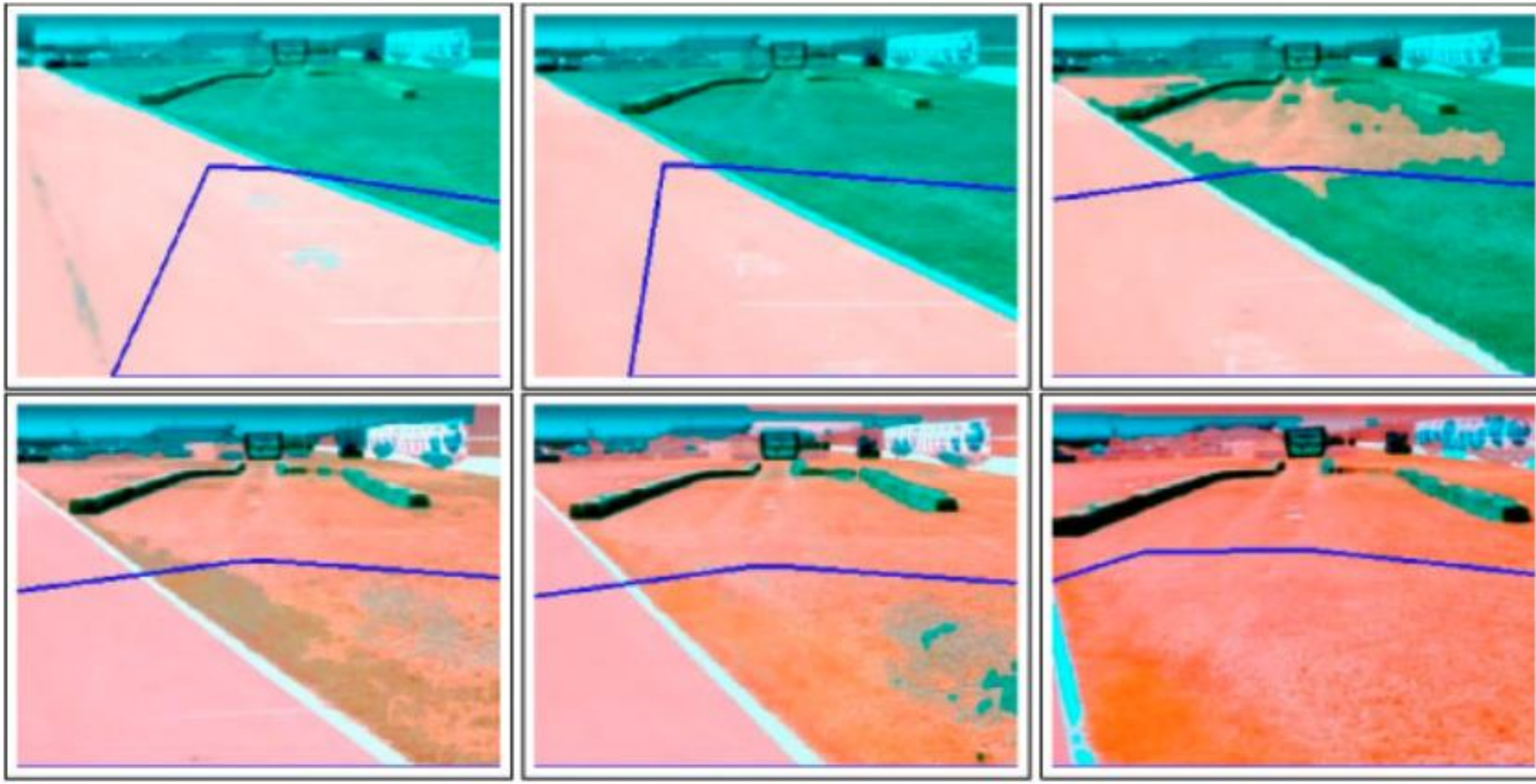
Mobile robot navigation



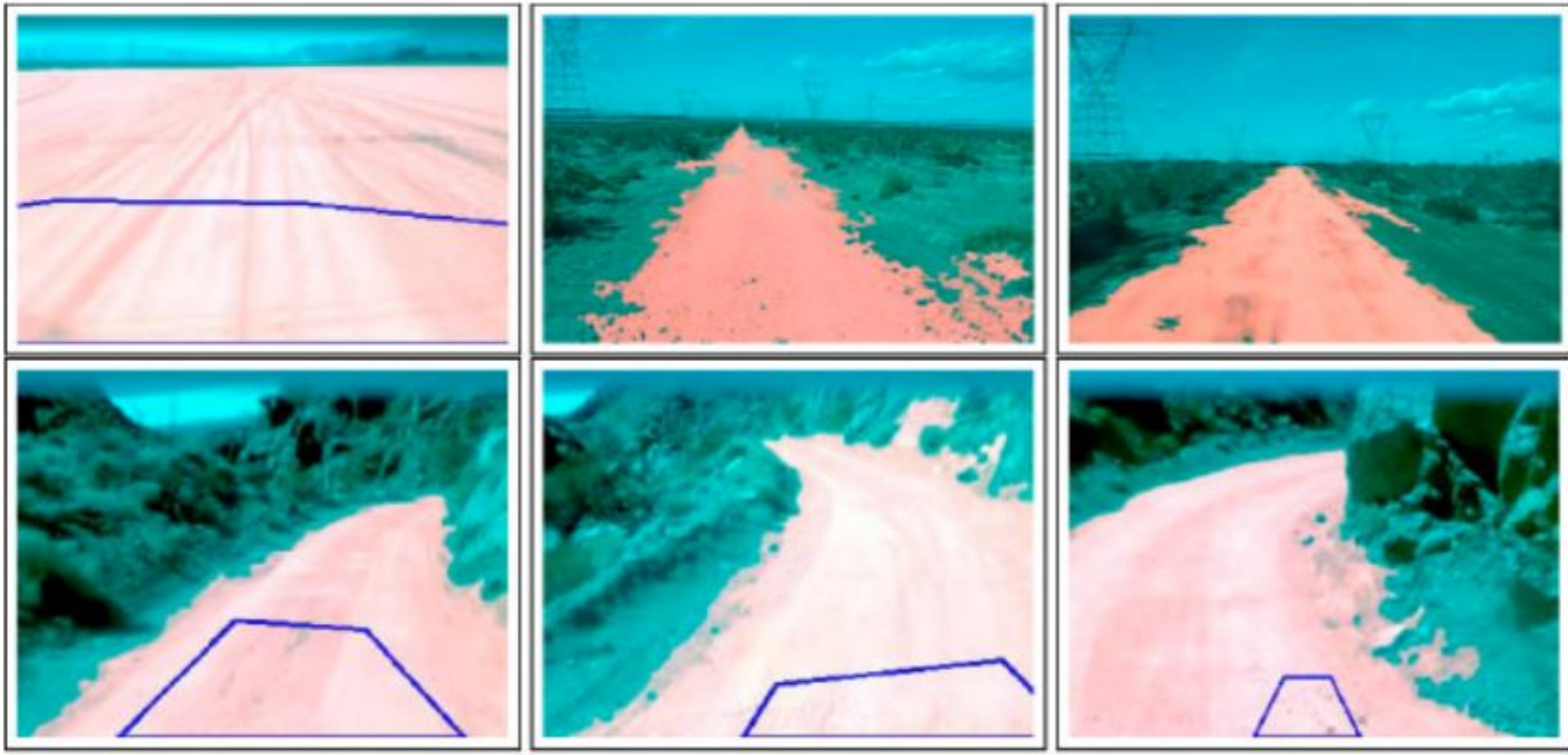
Outdoor – structured environments

- Represents road following
  - Detect lines of the road and navigate robot accordingly
- Different approaches
  - Laser range finders
  - Machine learning
  - GPS
  - Obstacle maps

Meet STANLEY



[THRUN2006]



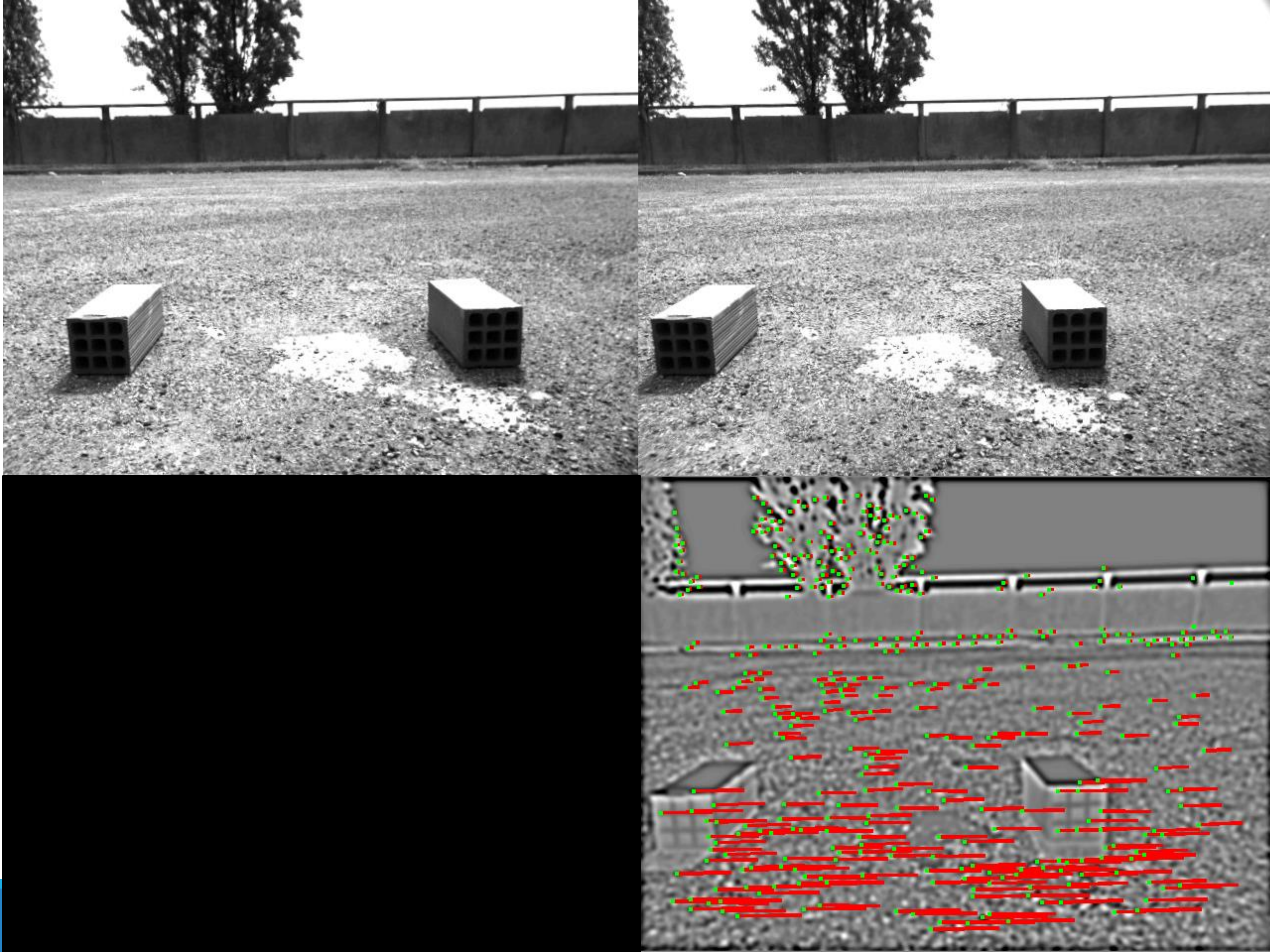
[THRUN2006]


Stanford Racing Team
Stanley's Final Desert Test

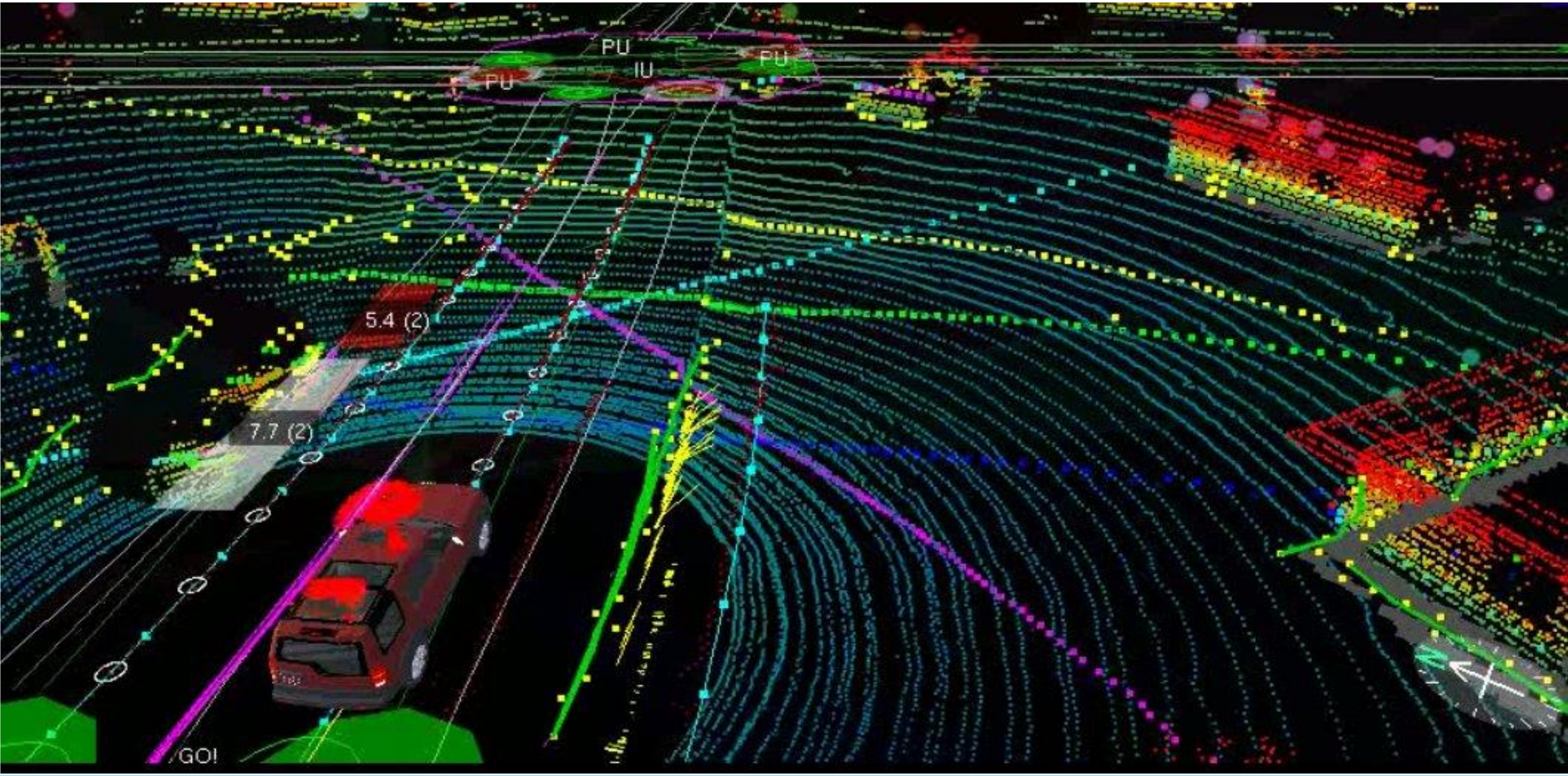
Outdoor – unstructured environments

- Random exploration
  - Only needs reactive obstacle detection
- Mission-based exploration
  - The robot has a goal position
  - Robot needs to map the environment
  - Robot needs to localize itself in the map
- Different approaches
  - Stereo vision
  - Ladar
  - Visual odometry

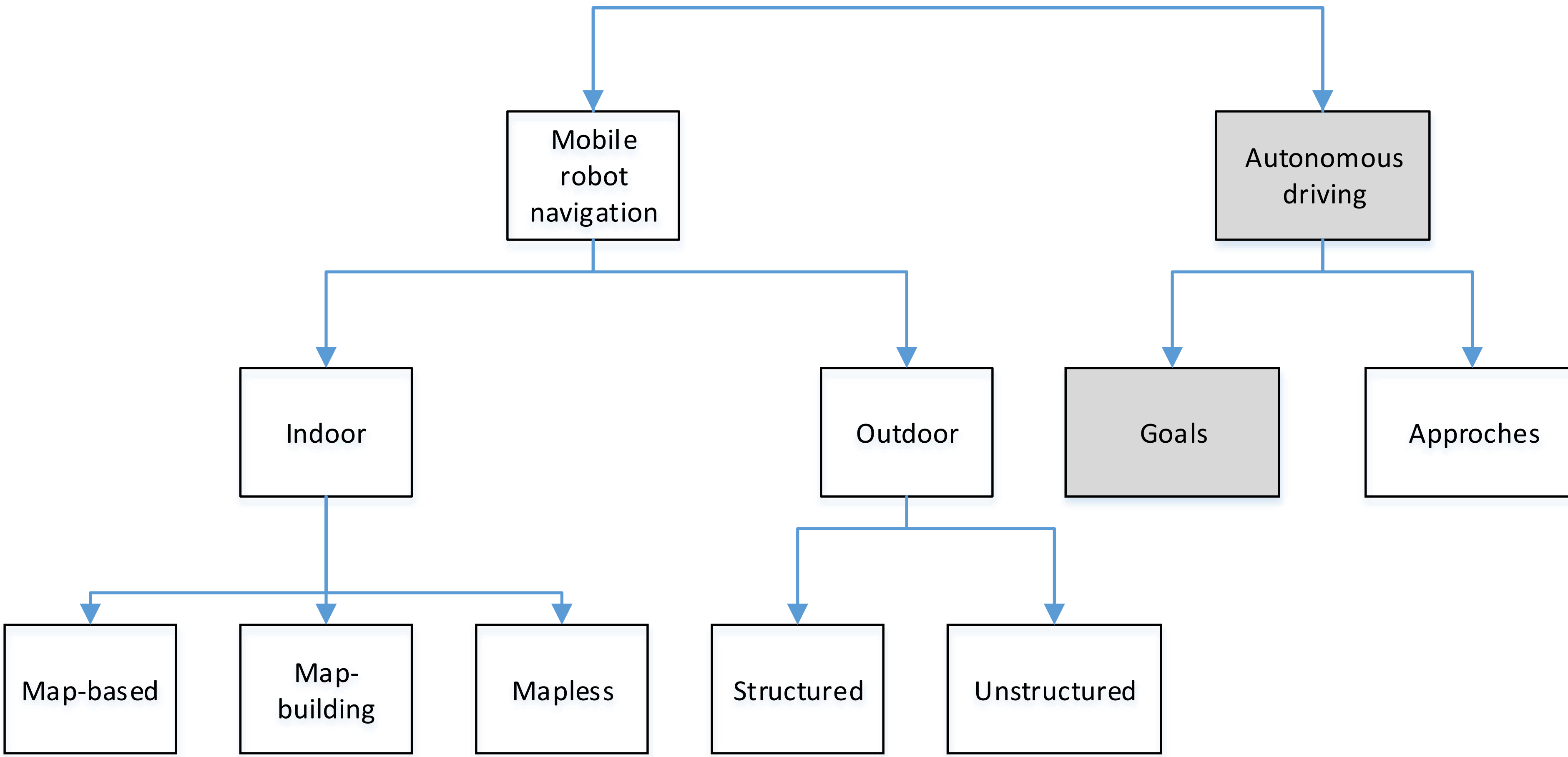
Prominent example: Curiosity



Ladar – Laser detection and ranging



Autonomous driving



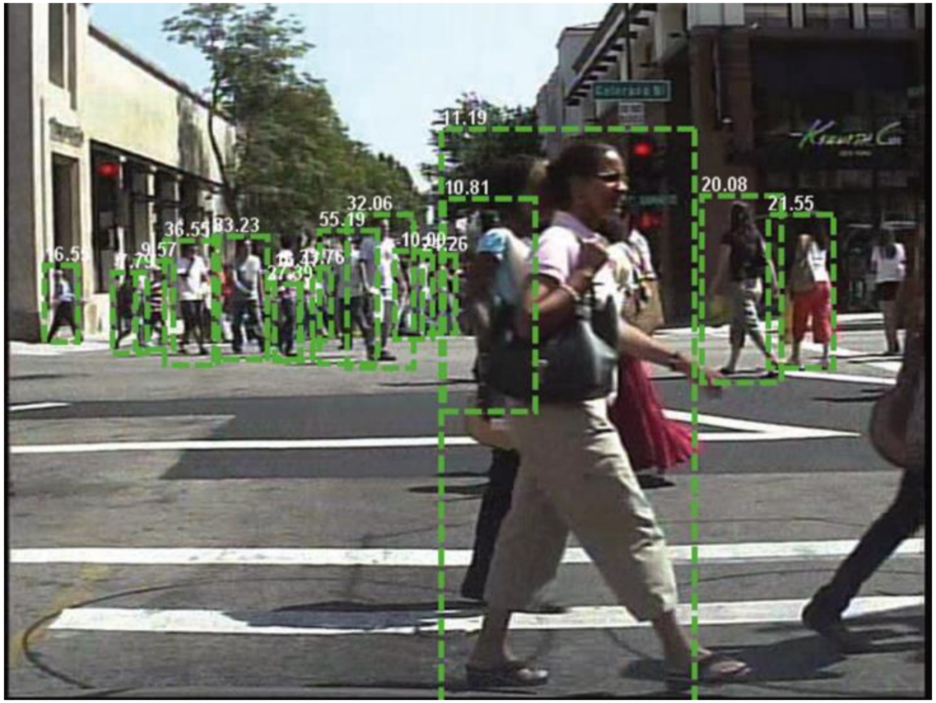

BOSCH

Autonomous driving - goals

- Reliable pedestrian detection
- Detect and interpret road signs
- Detect obstacles (other cars, trees on the street,…)
- Follow the road in given borders
- React to street signals like red lights
- …

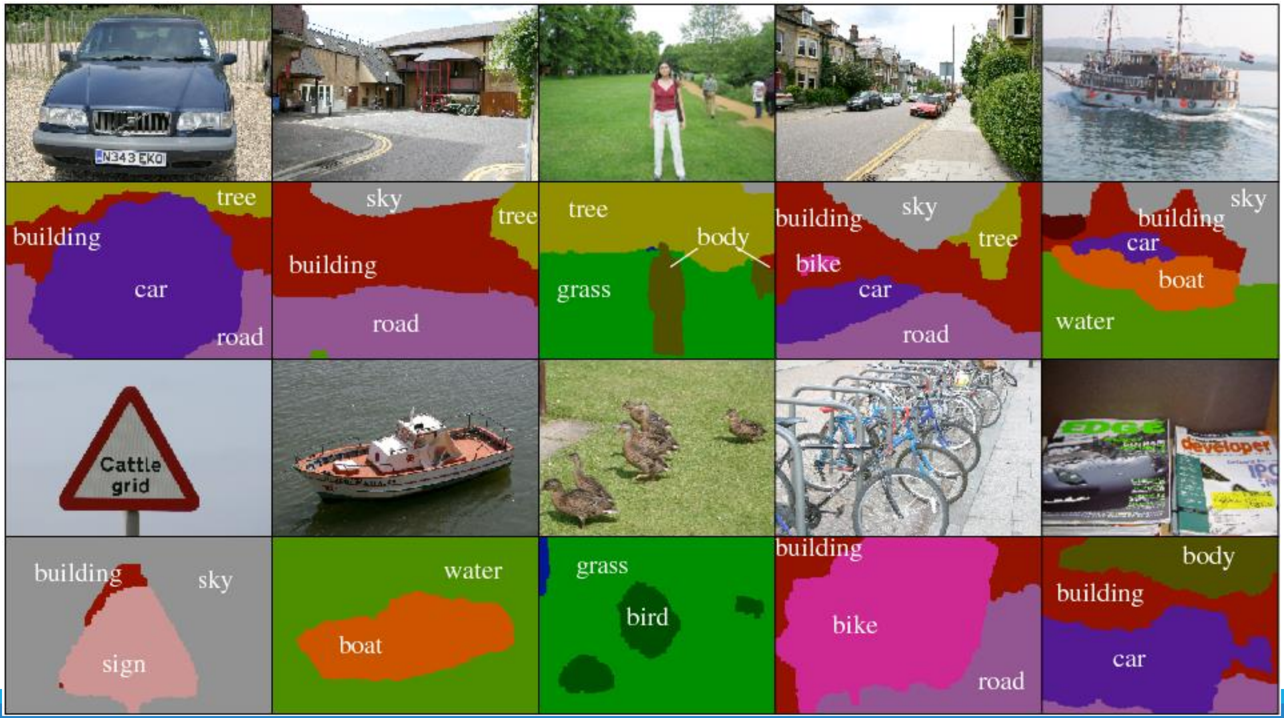
Approaches – Reliable pedestrian detection

- Stereo vision [CHOI2012]
- Predict pedestrian motions [BERGER2012]
- Shape recognition [FRANKE1998]



Approaches – Detect road signs

- Stereo vision [FRANKE1998]
- Detection based on shape, color and motion [FRANKE1998]
- MSRC [GALLEGUILLOS2010]



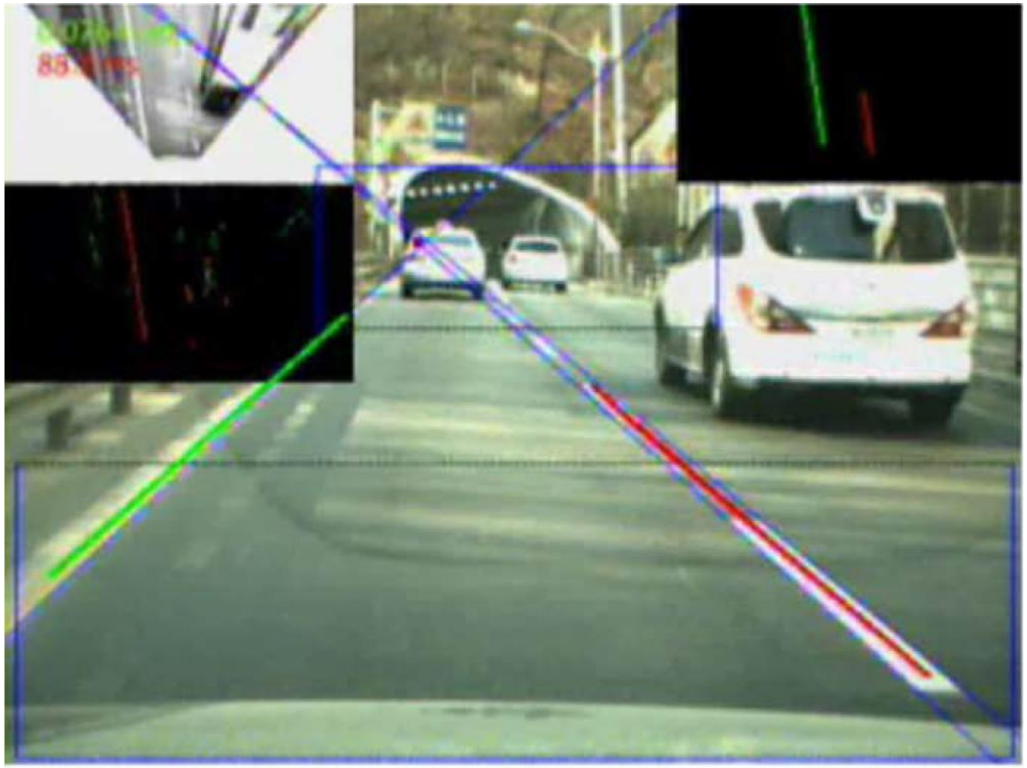
Approaches – Obstacle detection

- Obstacle maps [CHOI2012]

[CHOI2012]

Approaches – Road following

- Follow the road in given borders
  - Dark-light-dark transitions [CHOI2012]



[CHOI2012]

Approaches – Street signals

- React to street signals like red lights
  - Camera-based [LEVINSON2011]

Thank you for your attention

Image Reference

Slide 2: http://farm7.staticflickr.com/6087/6145774669_b855d4a0fa_o.jpg

Slide 3: http://persistentautonomy.com/wp-content/uploads/2013/12/DSC_1053.jpg

Slide 4: http://25.media.tumblr.com/0c2b1a9479dc09971df4d15f05cc77d5/tumblr_mpqtp1BtTa1rdiu71o2_1280.jpg

Slide 5: http://electronicdesign.com/site-files/electronicdesign.com/files/archive/electronicdesign.com/content/content/74282/74282_fig1-nasa-curiosity-landing.jpg

Slide 10: http://www.cs.cmu.edu/~maxim/img/mobplatforminautonav_2.PNG

Slide 11: http://www.cs.cmu.edu/

Slide 14: https://eris.liralab.it/wiki/D4C_Framework

Slide 15: http://www.emeraldinsight.com/content_images/fig/0490390507007.png

Slide 17: http://www.vis.uni-stuttgart.de/uploads/tx_visteaching/cv_teaser3_01.png

Slide 21: http://www.extremetech.com/extreme/115131-learn-how-to-program-a-self-driving-car-stanfords-ai-guru-says-he-can-teach-you-in-seven-weeks

Slide 29: http://f.blick.ch/img/incoming/origs2243351/4650486351-w980-h640/Curiosity.jpg

Slide 30: http://www.inrim.it/ar2006/ar/va_quattro1581.png

Slide 31: http://www.hizook.com/files/users/3/Velodyne_LaserRangeFinder_Lidar_Visualization.jpg

Slide 33: http://mindcater.com/wp-content/uploads/2013/08/bosch-dubai-Autonomous-Driving.jpg

Slide 35: http://opticalengineering.spiedigitallibrary.org/article.aspx?articleid=1158526

Slide 36: http://www.cse.buffalo.edu/~jcorso/r/semlabel/files/msrc-montage.png

STANLEY details

- VW Tuareg
- Drive-by-wire system by VW
- 7 Pentium M processors
- 4 Ladars
- Radar system
- Stereo vision camera pair
- Monocular vision system
- Data rates between 10Hz and 100Hz

Curiosity details

- 900kg
- 2.90m x 2.70m x 2.20m
- Plutonium battery
- RAD750 CPU up to 400MIPS
- Multiple scientific instruments
- Stereo 3D navigation with 8 cameras (4 as backup)
- $2.5 billion

Google Chauffeur details

- 150’000$ Equipment
- LIDAR