Automated Driving Applications and Technologies for Intelligent Vehicles

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SLAM technologies for parking applications

(part I: Intro)

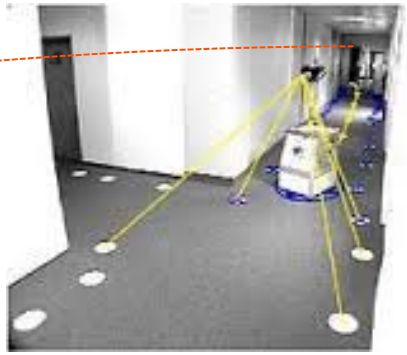
Technical Workshop

Athens, Greece
21-22 APRIL 2016

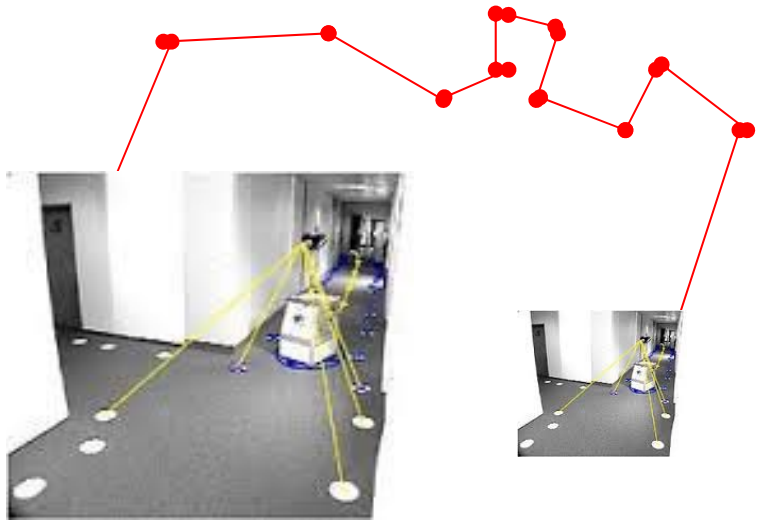
// Content

- Problem history and formulation
- Problem frequent variations w.r.t
  - Sensing
  - Representation
  - Features
- Application (automotive)
- Technological challenges
- Hot topics
- Outlook

// Problem formulation



- Machine speaking:
  - "Where am I?"
  - "How do I move safely?" . . .
  - "Can something show me the way out of this building?" . . .

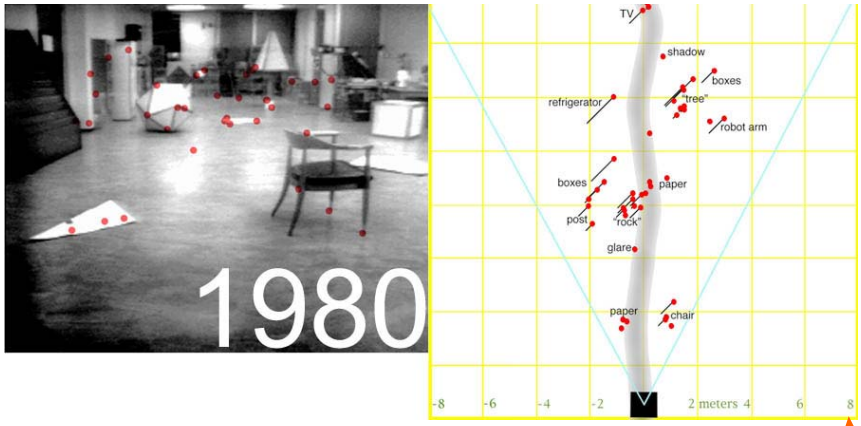


[. . .]

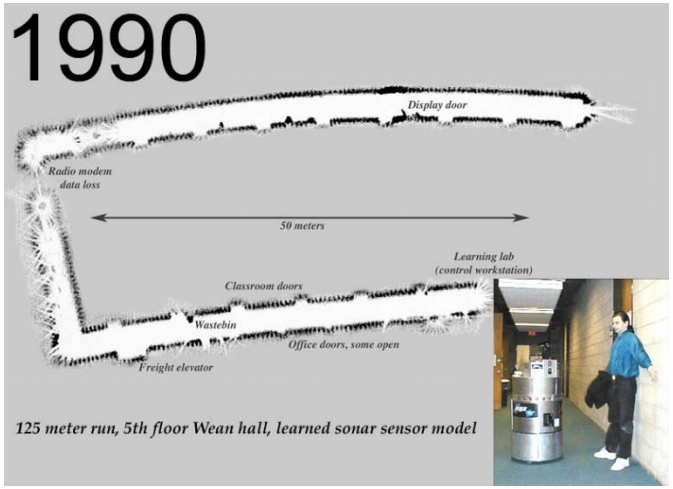
Message: Mobile vehicles which do not use preplaced landmarks or GPS must employ a localization algorithm while (incrementally) mapping an unknown space a.k.a SLAM

//SLAM history

Slow, risky 3D navigation (1 MIPS)



Fast, good 2D navigation (20 MIPS)



Dense 3D Grid Maps (500 MIPS)

Source: H. Moravec, SEEGRID slides

Industrial Transport by 3D Map (2,000 MIPS)

Indoor multi-floor navigation and dense 3D Map rec.(20,000 MIPS)

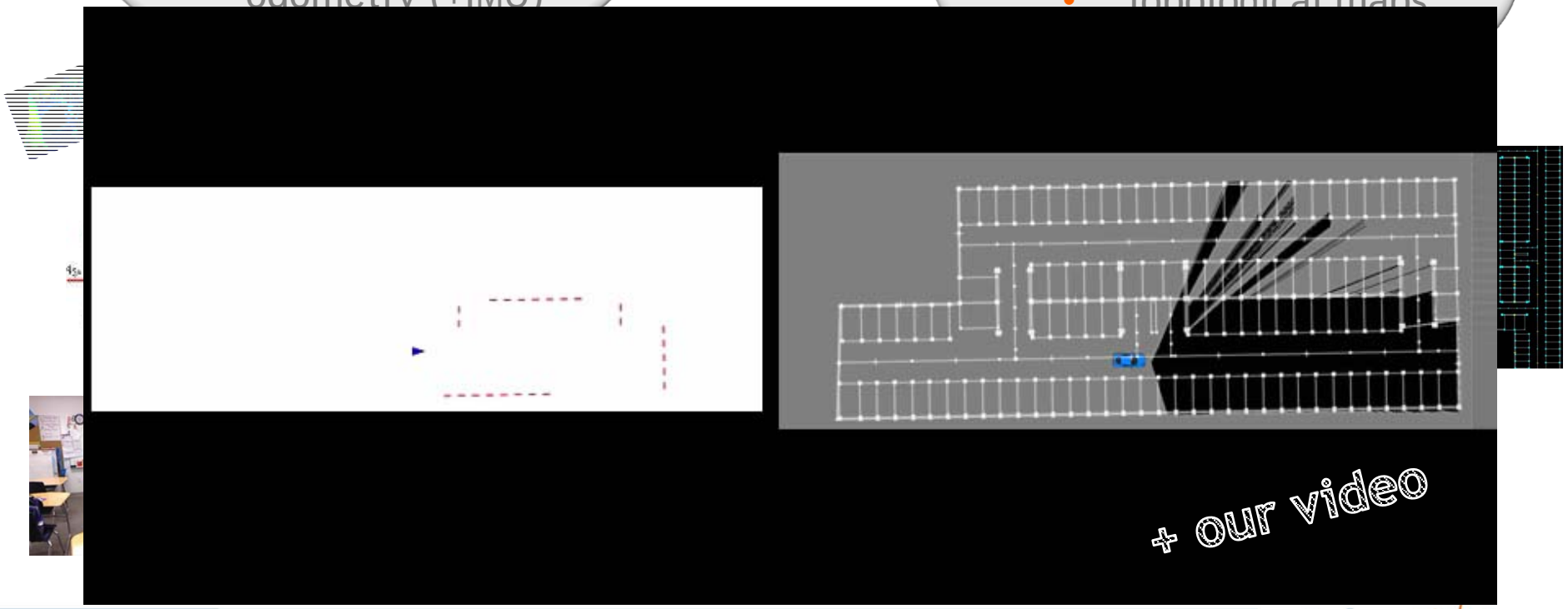
Source: Kaess et al. Kintinuous

//SLAM frequent variations

- Odometry
- Lidar-based odometry (+IMU)
- Camera-based odometry (+IMU)

- Feature-based
- View-based (scan matching)

- Occupancy grids
- Feature maps
- Topological maps



// Applications (automotive field)

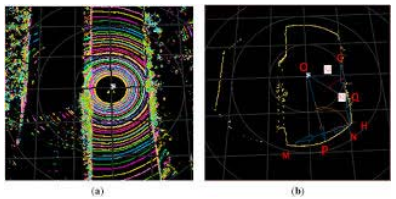
- Indoor parking + rendezvous [source AUTOPLES project]

// Ideally….(vision based)SLAM will…

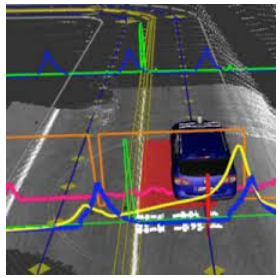
- Robustly estimates camera pose
  - Geometry + photometry
- Reliably estimates the surface
  - Fused representation to remove noise
- Scales well
  - Room, house scale
- Is completely closed loop (updating)
  - Update revisited areas
- Realtime
  - Globally consistent map available at any point in time
- Non-restrictive of motion
  - Happy to deal with extremely loopy motion and many such loop closures

// Technological challenges

- Lidar/radar: problems in roads with potholes/snow
- Lidar/camera: occlusions
- Cameras: direct sunlight
- Calibration is always an issue



- Data association algorithms for finding rich correspondences between consecutive frames are really time/memory consuming
- Online loop closure still difficult!



- Detailed prior maps are rarely available and generating them is laborious and needs manual intervention. Also, road cartography is subject to changes (lanes can be re-painted).
- Big scale problem still unsolvable (e.g. 100's meters)

// Hot topics

- ICP algorithm: techniques borrowed from graphics to accelerate creation/ rendering of the 3d map (+GPU based parallelized computations)
- Beyond EKF: Random Finite sets (feature based maps, clutter data)
- 3D ego-vehicle kinematics (*6DOF* or 9DOF IMU sensors to filter out vehicle pitch/tilt)
- Object detection and categorization using machine learning (important for non-free space detection and scene understanding)

// Outlook

- SLAM performance expected to improve with better hardware (sensing + embeded computation)
  - While monocular SLAM is very exciting from an academic point of view, if your robot is a 30,000$ car or 10,000$ drone prototype, you should have a good reason to use a two+ camera setup
- Accurate GNSS is not always available: gps-denied environments will proliferate from SLAM techniques
- SLAM gets harder in unstructured or(and) dynamic environments

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Thank you.

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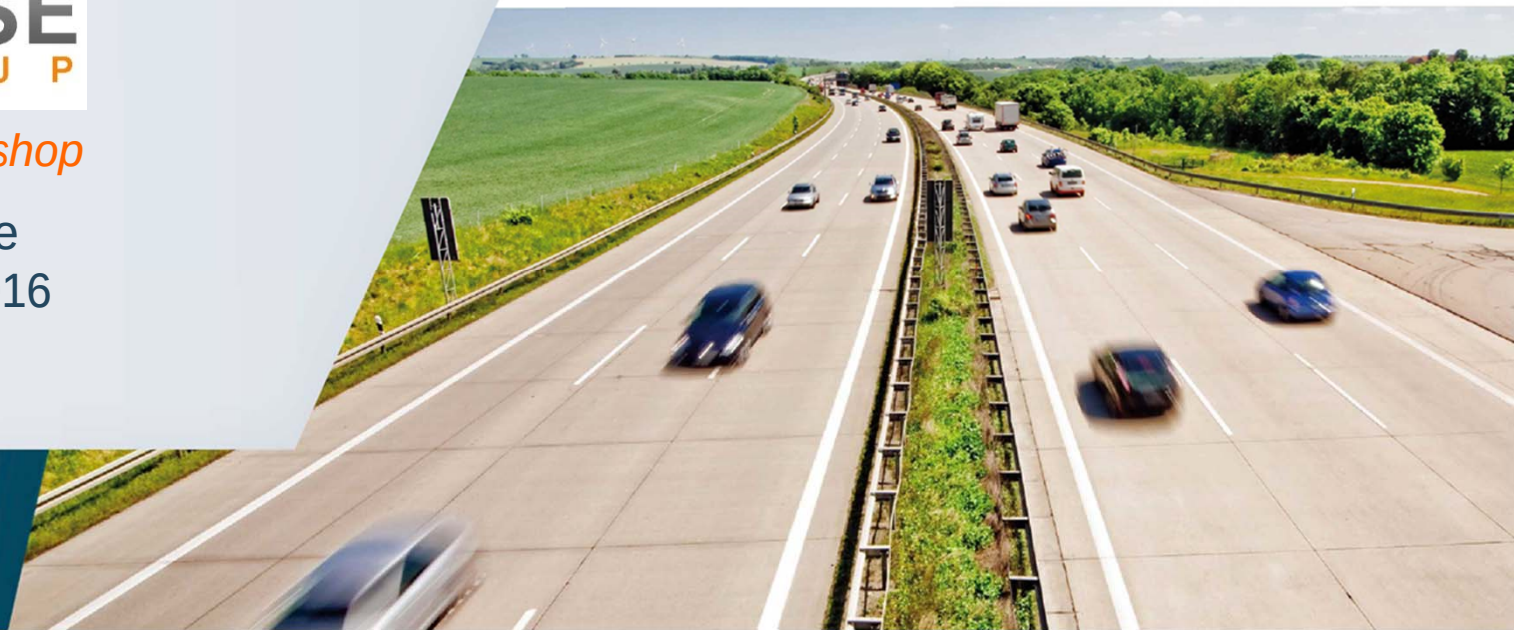

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(part II: A showcase (AdaptIVe))

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