3D Sensing and Sensor Fusion

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3DSSF Teachers

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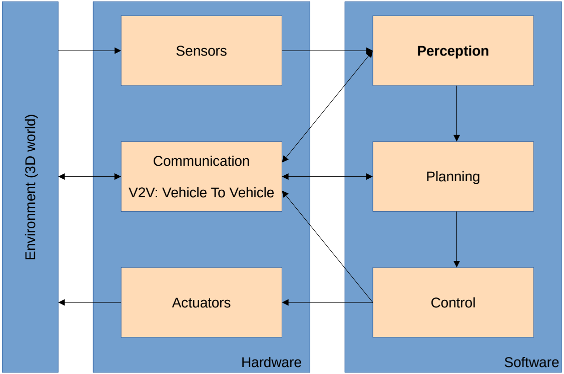
Motivation 1/2

- 3D vision is a very important domain within computer engineering/science
  - Tasks are usually very challenging
  - Results are very spectacular
  - Needs both high theoretical and practical skills
- Several sensors can be connected to computers
- Different modalities have different benefits/disadvantages
  - Measured data can be fused to exploit the advantages

Motivation 2/2

System Overview of an Autonomous Vehicle

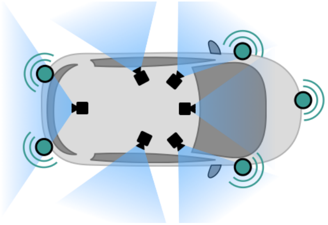


Subject Overview (1/2)

- Goal: overview of (i) (advanced) 3D vision and (ii) sensor fusion methods
- In modern sensor setups, several devices applied
  - Digital cameras
  - Depth sensors (structured light, ToF, ...)
  - Light Detection and Ranging (LiDAR): 3D and 2D
  - Global positioning system (GPS – GPSS)
  - Acoustic sensors (ultrasonic)
  - Thermal cameras
  - Radars
  - Inertial Measurement Unit (IMU) – accelerometer, magnetometer, gyroscope
  - High-density (HD) Semantic Maps
- In this course, we principally concentrate on multi-view images, 2D and 3D LiDAR scans, radars, GNSS/GPS, IMU, ...

Subject Overview (2/2)

- Two sensors can be used together if they are
  - synchronized in time (usually via timestamps) and
  - their 3D pose are know w.r.t. each other
- This course principally focuses on 3D pose estimation
  - → Pose: rigid transformation
  - → 3D rotation and translation, aka. extrinsic parameters, aka. pose
- In human-made environments, bird-eye view is preferred for the data.



Key Problem

- Pose can be estimated by calibration
- There are two ways for calibration
  - Offline
    - $\rightarrow$ Calibration object is applied
  - Online
    - $\rightarrow$ Environment reconstruction carried out
- Target object have usually well define surfaces/shapes
  - 2D: lines, circles, ellipses,...
  - 3D: planes, spheres, cylinders, ...

3DSSF Content

- Introduction to estimation theory
  - Focus: surface/curve fitting
- Robust estimation and the L_1 norm
- Transformations, projections
- Lie algebra
- Optimal point set registration
- LiDAR-camera calibration
  - using planar or spherical objects
- Many surprises by Péter Kozma

3DSSF Requirements

- Lecture
  - Oral exam in examination period
  - Topics will be published before exam-period
- Practice
  - Two assignment in termtime
- Combined mark is given: 50-50% from oral exam and assignment
  - Satisfactory should be reached for noth assignment and oral exam
- Final grade
  - 5 (excellent): $\geq 85\%$
  - 4 (good): $70 \ldots 84$ %
  - 3 (satisfactory): $55 \ldots 69$ %
  - 2 (pass): $40 \ldots 54$ %
  - 1 (fail): $< 40\%$

Our forums

- Canvas `https://canvas.elte.hu`
  - Materials
  - Assignments
- Webpage `https://cg.elte.hu`
  - Under construction
- Teams
  - It will be created next week.

Practice

- On Wednesdays,
  - 16.00-17.300
  - North Building, lab. 0.99
- Teacher: Péter Kozma

Extra Practice

- Demonstation of our vehicles and sensor-kit
- We gather at the 'Danube entrance' of South Building
  - together with '3D Comp. Vision' students
  - Wednesday, 11th September, 17:45