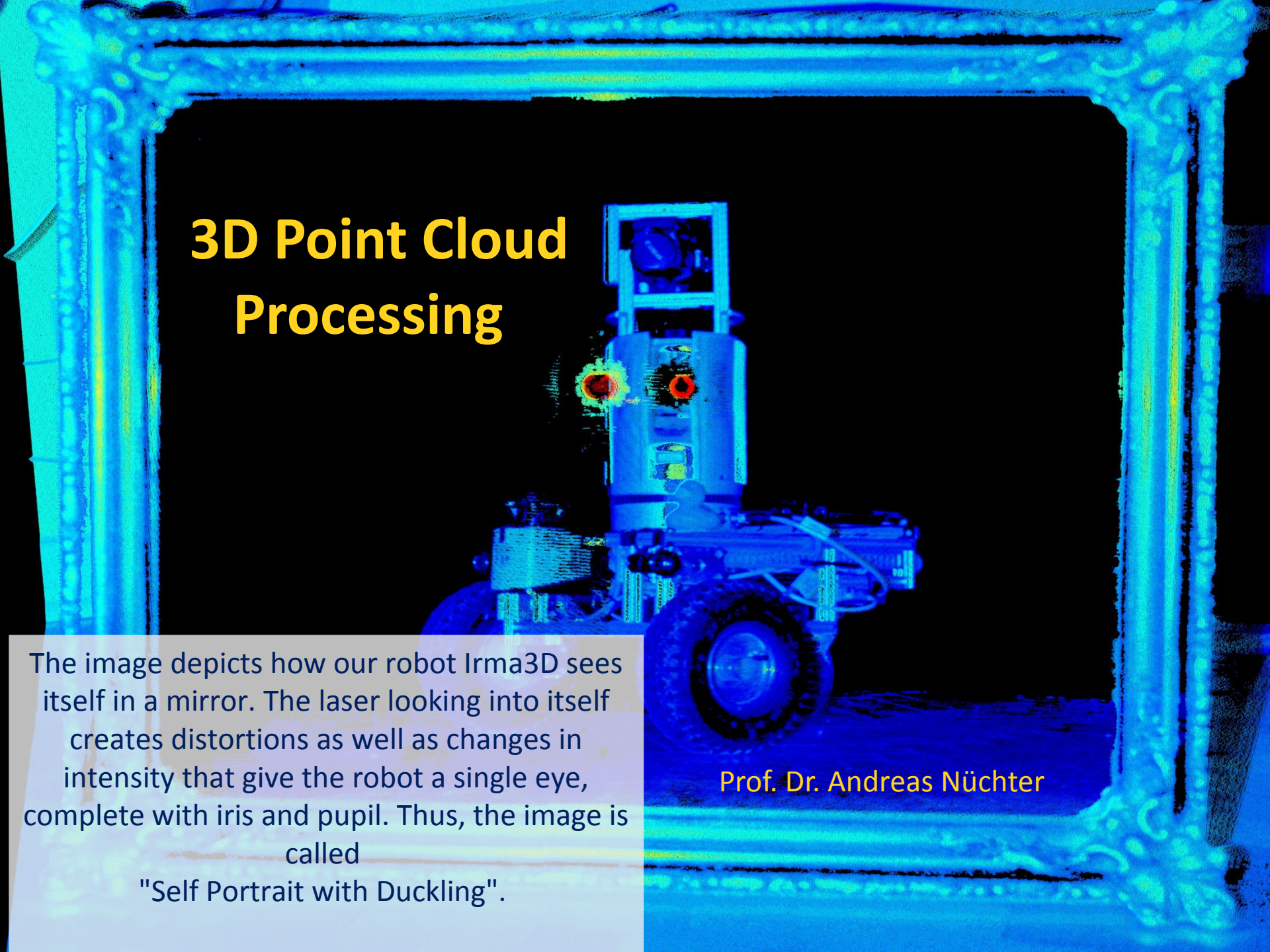
3D Point Cloud Processing



The image depicts how our robot Irma3D sees itself in a mirror. The laser looking into itself creates distortions as well as changes in intensity that give the robot a single eye, complete with iris and pupil. Thus, the image is called
"Self Portrait with Duckling".

Prof. Dr. Andreas Nüchter

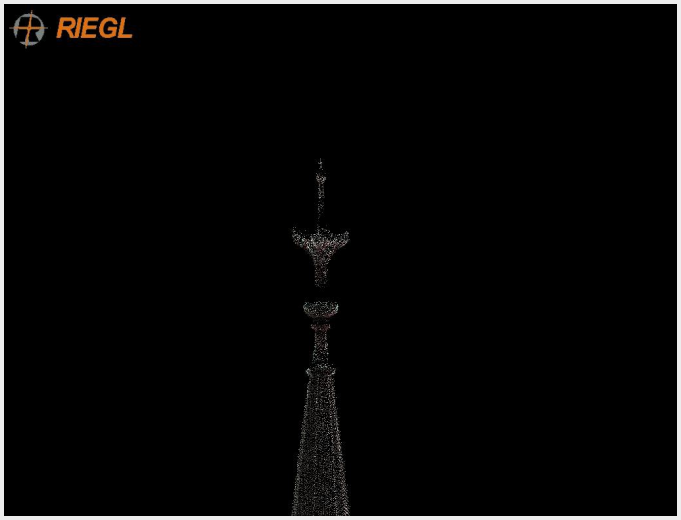
Goals of this Class

I am aiming at enabling students

- To understand the basic principles of all aspects of 3D point cloud processing
- To understand the Simultaneous Localization and Mapping (SLAM) problem
- To enable your to talk to engineers / surveyors / CV-people / CS-people / …
- To solve problems of modern sensor data processing
- To experience that real application scenarios are challenging
  - In terms of computational requirements
  - In terms of memory requirements
  - In terms of implementation issues

What is 3D Point Cloud Processing?

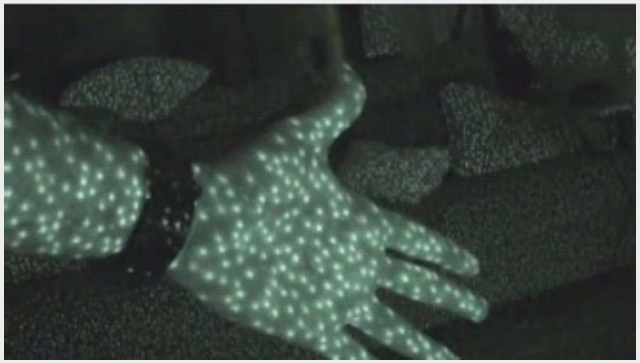
- a few Examples for 3D Point Clouds

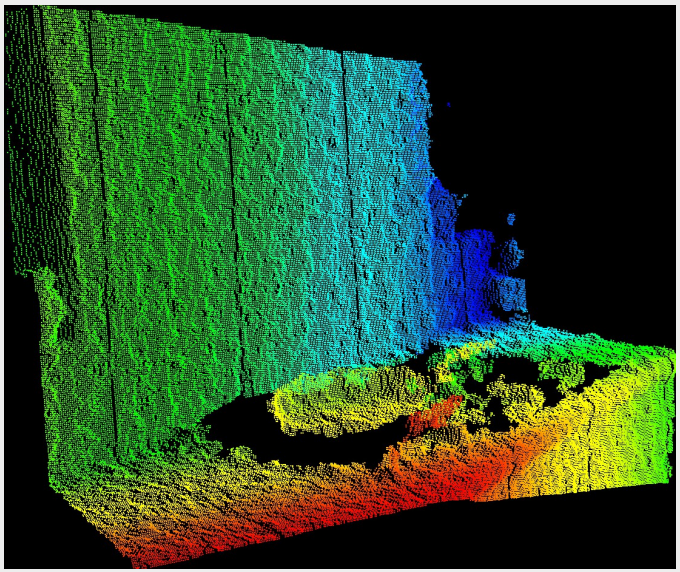


Modern Computer Vision

Microsoft Kinect

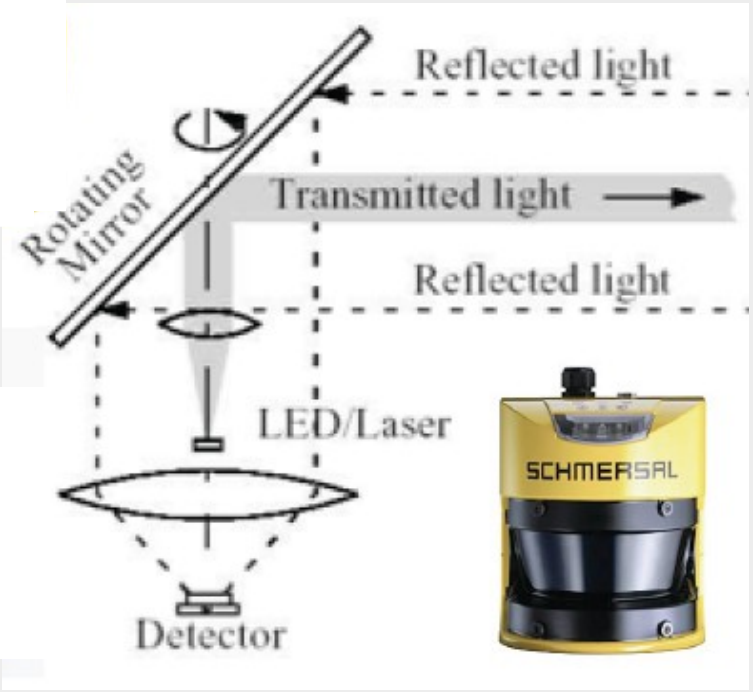
- Video 30 Hz
- RGB video: 8-bit VGA resolution (640 × 480 Pixel)
- Monochrome Video Stream
  (depth information): 11-bit VGA
  2048 depth values
- Depth: 1,2 – 3,5 m, (enhanced: 0,7 – 6 m)
- FOV: 57° (h) × 43°(vert)
- Tilt unit 27°
- Cost effective





More Traditional Laser Scanner

c = 299.792.458 m/s (Vacuum), also
d = 299.792.458 [m/s] x $t/2$ (d Distance[m], t time-of-flight[s])



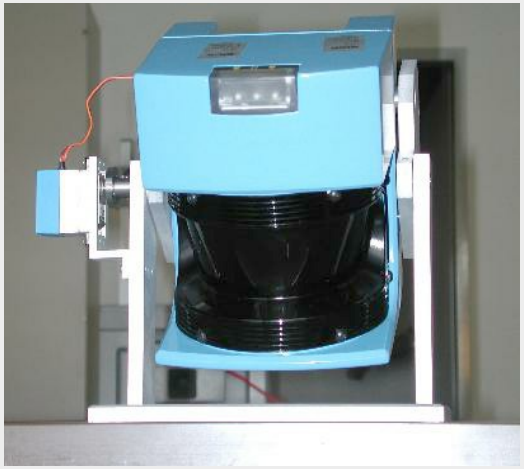
(2D laser scan)

$c \approx$ 0,3 mm/ps

➥ With a resolution of 10mm: Precision of the time-of-flight measurement in the order of pico seconds **(10^{-12} s)** needed!

A Custom Made 3D Laser Scanner

- 3D laser scanner for mobile robots based on SICK LMS



- Based on a regular (e.g., SICK LMS-200) laser scanner
- Relatively cheap sensor
- Controlled pitch motion (120° v)
- Various resolutions and modi, e.g., reflectance measurement {181, 361, 721} [h] x {128, …, 500} [v] points
- Fast measurement, e.g., 3.4 sec (181x256 points)

Mounted on mobile robots for 3D collision avoidance and building 3D maps.

(Video Crash)

(Video NoCrash)

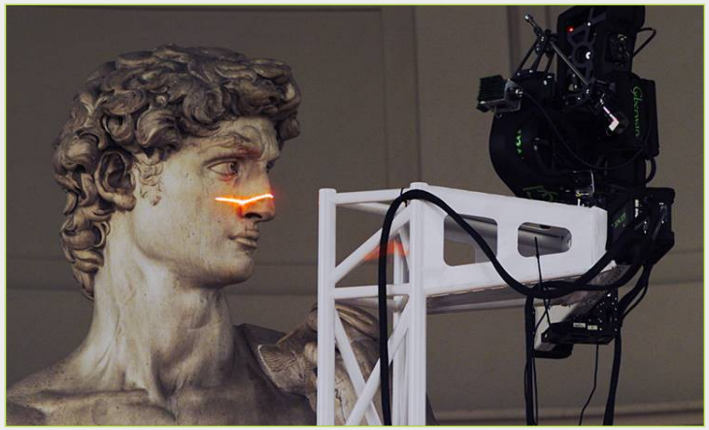
3D Scanning Principles

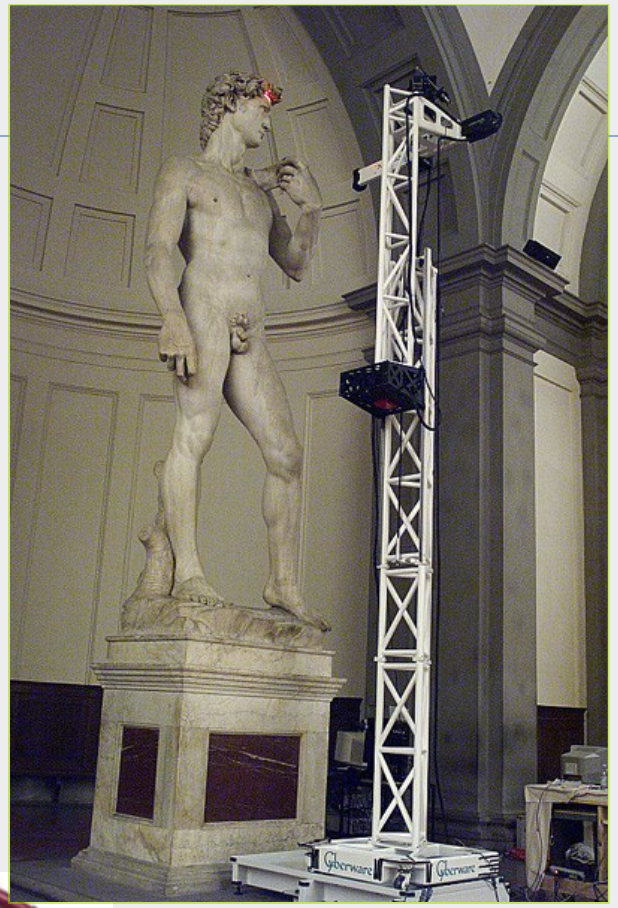
Mode	Symbol	Cont. rotating	pivoting	Advantages
Yaw				+ Complete 360° scans + Good point arrangements - High point density at top
Yaw-Top				+ Fast scanning (half rot.) - High point density at top - Ground not measured
Roll				+ Fast scanning (half rot.) + High point density in front - Unusual point arrangement
Pitch				- High point density at the sides - Small apex angle + Good point arrangements + Easy to build

http://www.rts.uni-hannover.de/index.php/%C3%9Cbersicht_der_m%C3%B6glichen_Scannerkonfigurationen

Professional 3D Scanning

- Professional 3D scanners
  - Structured light (close range)



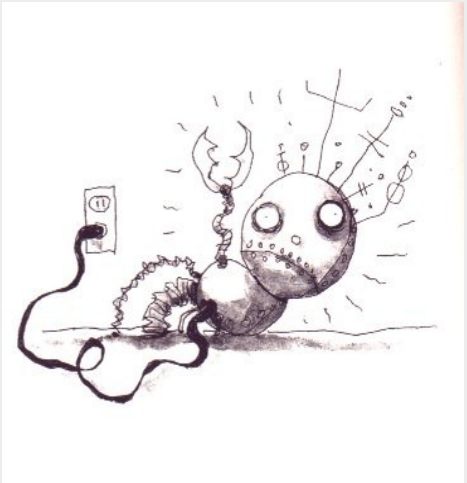


  - pulsed laser vs. time-of-flight (mid and long range)

Laserscanner
LEICA HDS3000

3DTK – Hands-on-experience

- What you should learn now, using the **`show`** program
  - Most robotic data sets acquired by a rotating SICK scanner contain some outliers (it is worse with the kinect)
  - Data sets of professional scanners can be very large



- Things to try
  - Viewing a single small 3D scan acquired in Schloß Dagstuhl

    bin/show –s 1 –e 1 dat
  - Viewing a high resolution outdoor 3D scan

    bin/show –s 0 –e 0 –f riegl_txt –-reflectance bremen_city
  - Viewing a high resolution outdoor 3D scan with colors

    bin/show -s 0 -e 10 --reflectance -f uosr ~/dat/nachbargarten/