Autonomous Robot Systems

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Introduction

Sensors are needed for

- Position measurement
- Detection of obstacles
- Measurement of internal states
- Perception of the environment

Position measurements

Relative

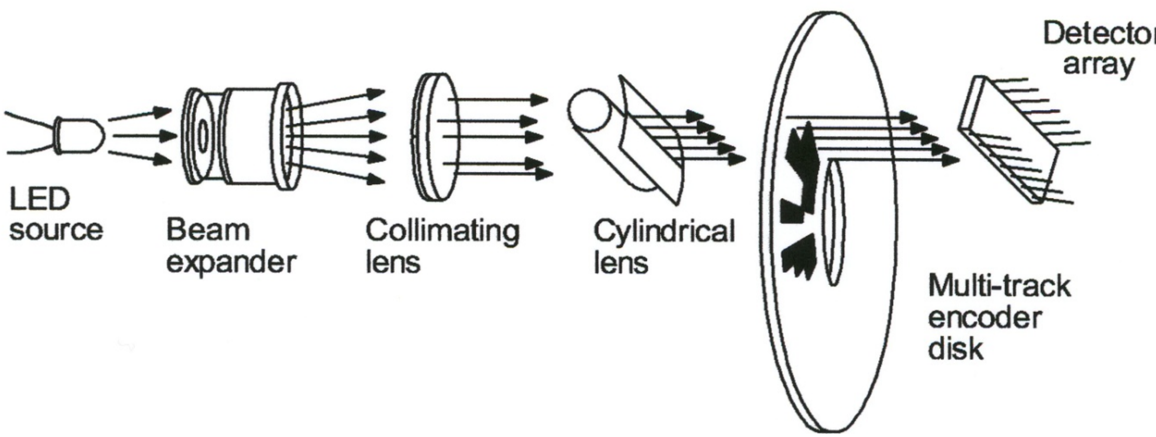
- Odometry
- Inertial navigation

Absolute

- Active beacons
- Artificial landmarks
- Natural landmarks

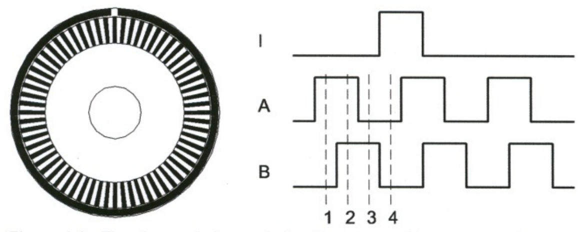
Sensors for dead reckoning

- Encoders
- Resolvers
- Doppler sensors

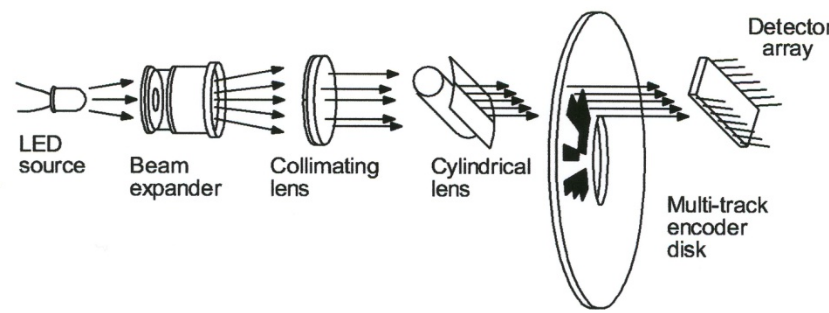


Encoders

- Encoders are used to measure the rotation of the wheels
- Using two channels enables detection of direction and four times as many pulses can be used.



State	Ch A	Ch B
S_1	High	Low
S_2	High	High
S_3	Low	High
S_4	Low	Low



Heading sensors

- Compass
- Gyro

Active beacons

- Ultrasound beacons
- RF beacons
- Global Positioning System
- Wireless LAN localization

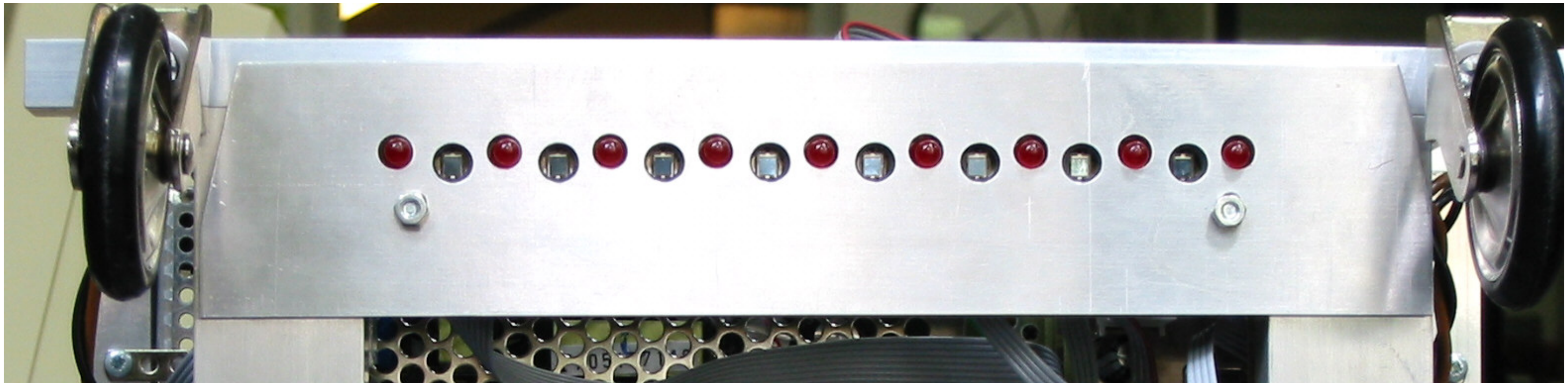
GPS- Satelite positioning

- normal GPS 5-10 m
- differential 0.5-2 m
- RTK-GPS 2-5 cm
- Only working outdoors
- Problems with trees and buildings

Hako Tractor with RTK-GPS

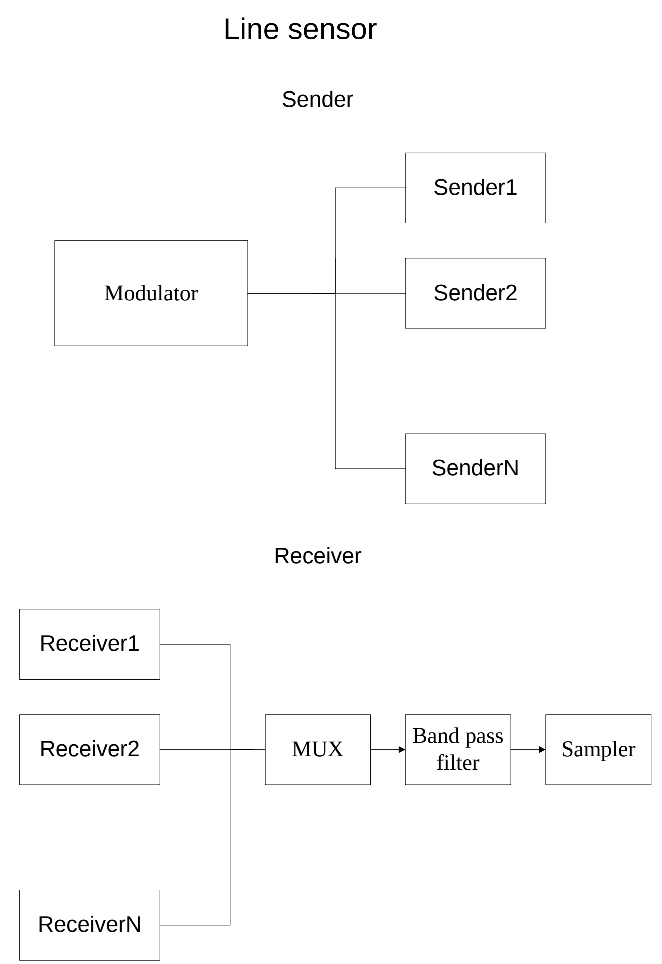
Artificial landmark

- Vision
- Laser scanner
- Reflectance sensor

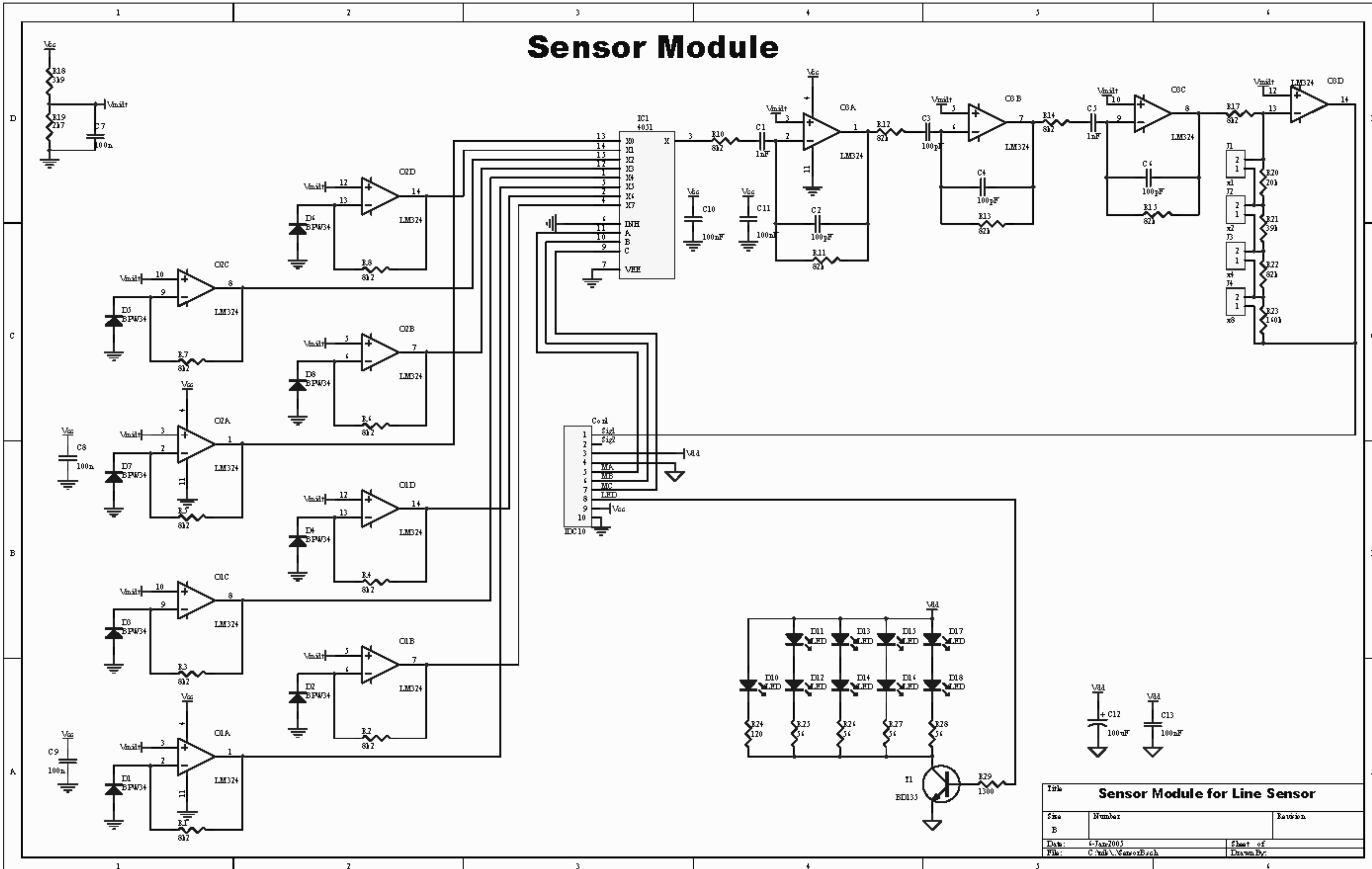


Reflectance sensor

- Modulated light in order to minimize influence of sun etc.
- Calibrate on black (0) and white (1) background



Linesensor



Sensor Module
IC1
4051
Conn
IDC10
Sensor Module for Line Sensor
Title
Size
B
Number
Revision
Date:
6-Jan-2005
File:
Sheet of
Drawn By:

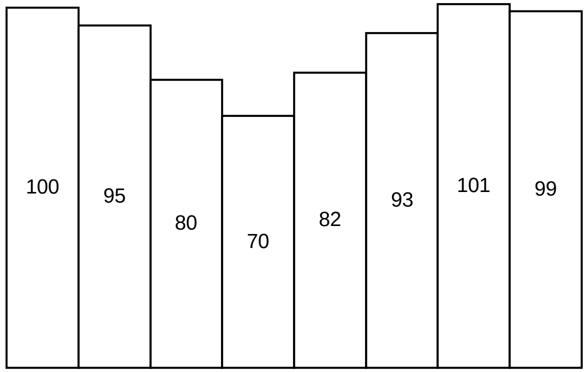
Line sensor algorithms

- Lowest intensity
- Centre of mass
- Centre of mass of lowest intensity and neighbours

$$x_c = \frac{\sum x_i I_i}{\sum I_i}$$

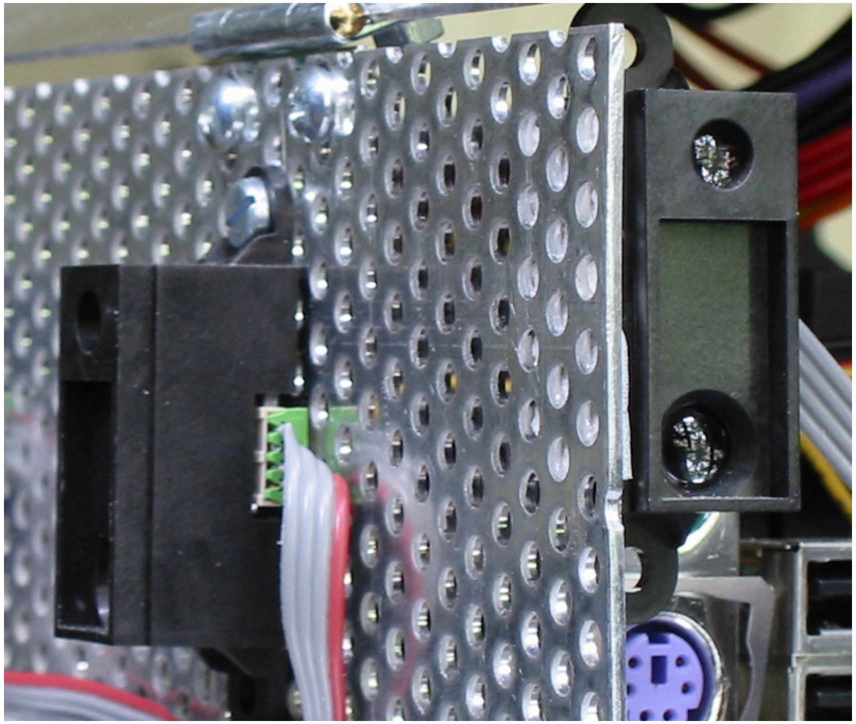
- Interpolation between lowest intensity and neighbourns

Black line

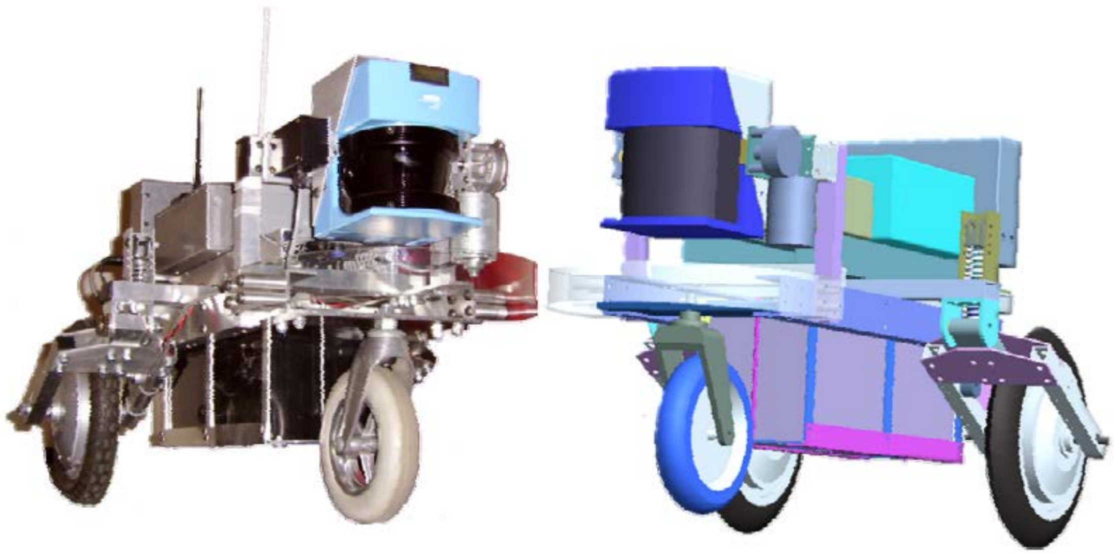


Obstacle detection

- Ultrasound
- Laser scanner
- Vision
- Structured light
- IR sensor
- Bumper



Laserscanner



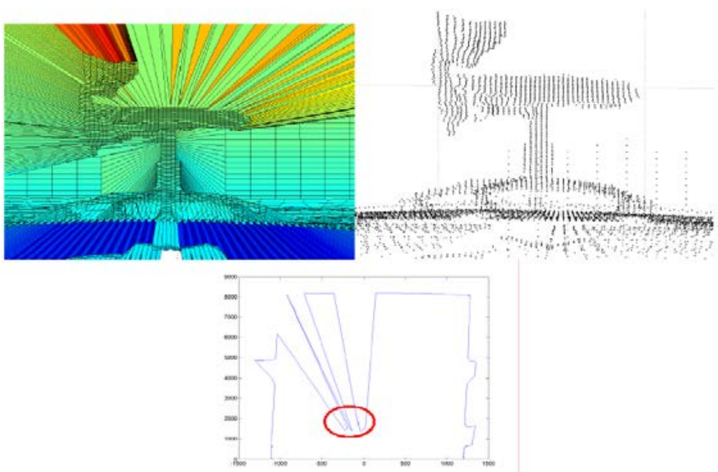
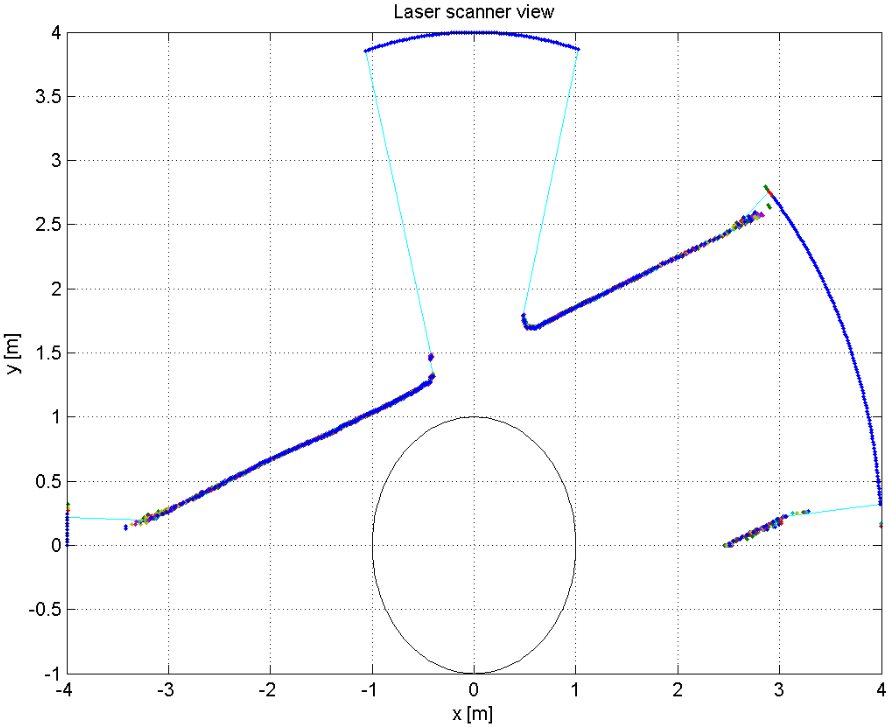
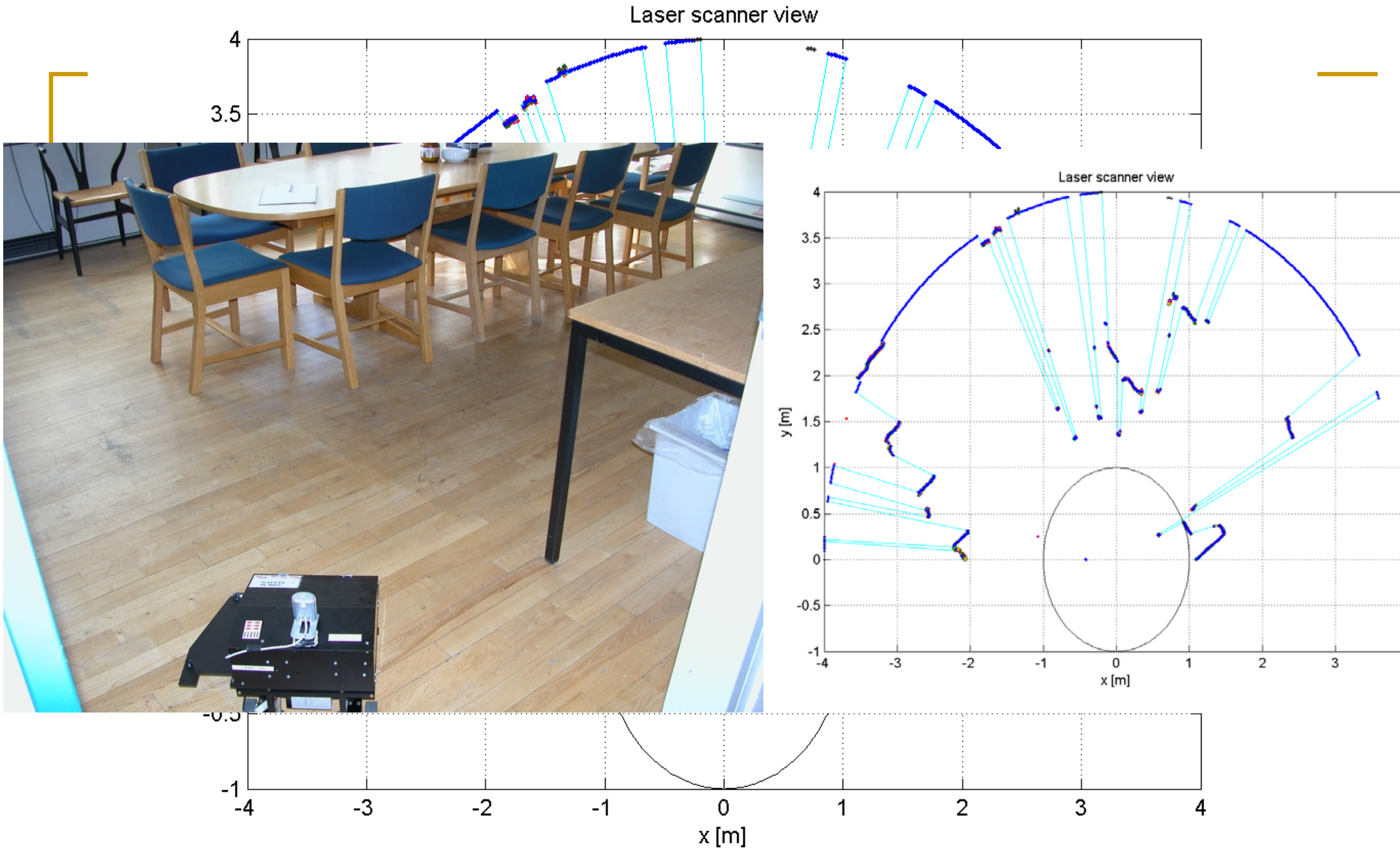


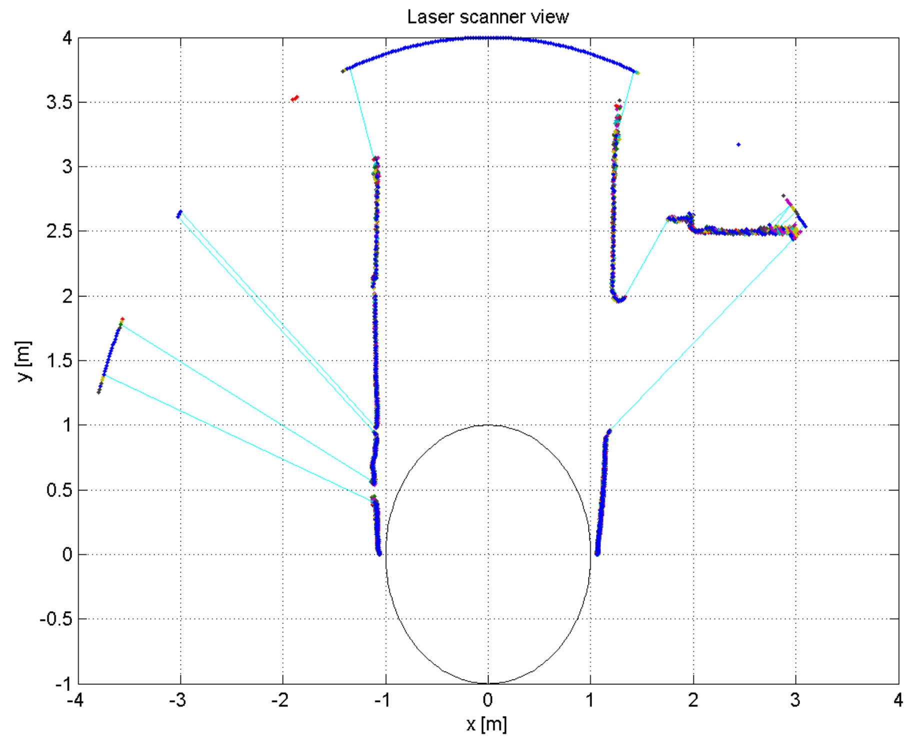
Figure 42 – 3D and 2D scan of an office chair.

SMR with Laserscanner

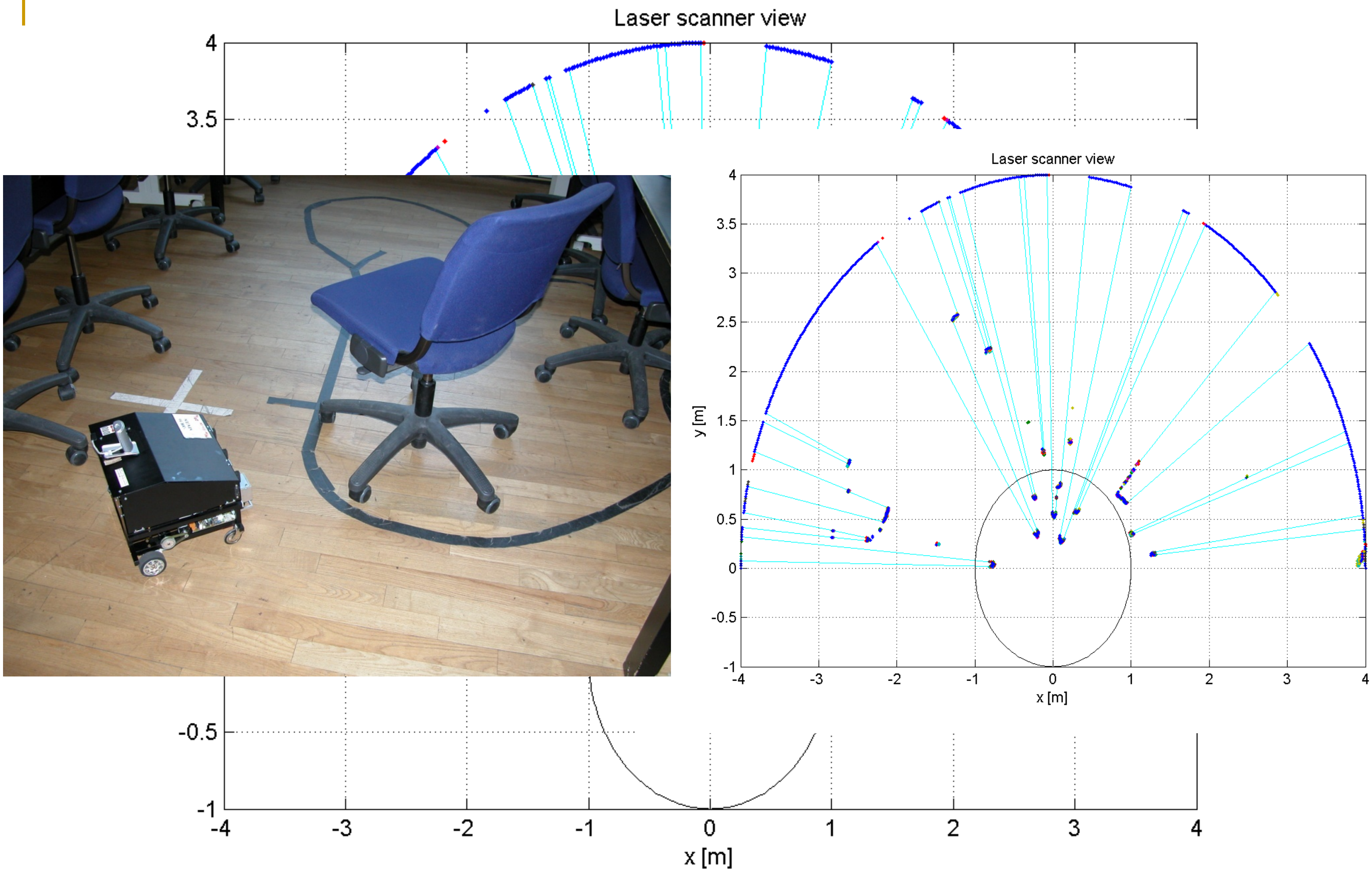
Laserscan




Laser scanner view
4
3.5
-0.5
-1
-4 -3 -2 -1 0 1 2 3 4
x [m]
Laser scanner view
y [m]
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-4 -3 -2 -1 0 1 2 3 4
x [m]



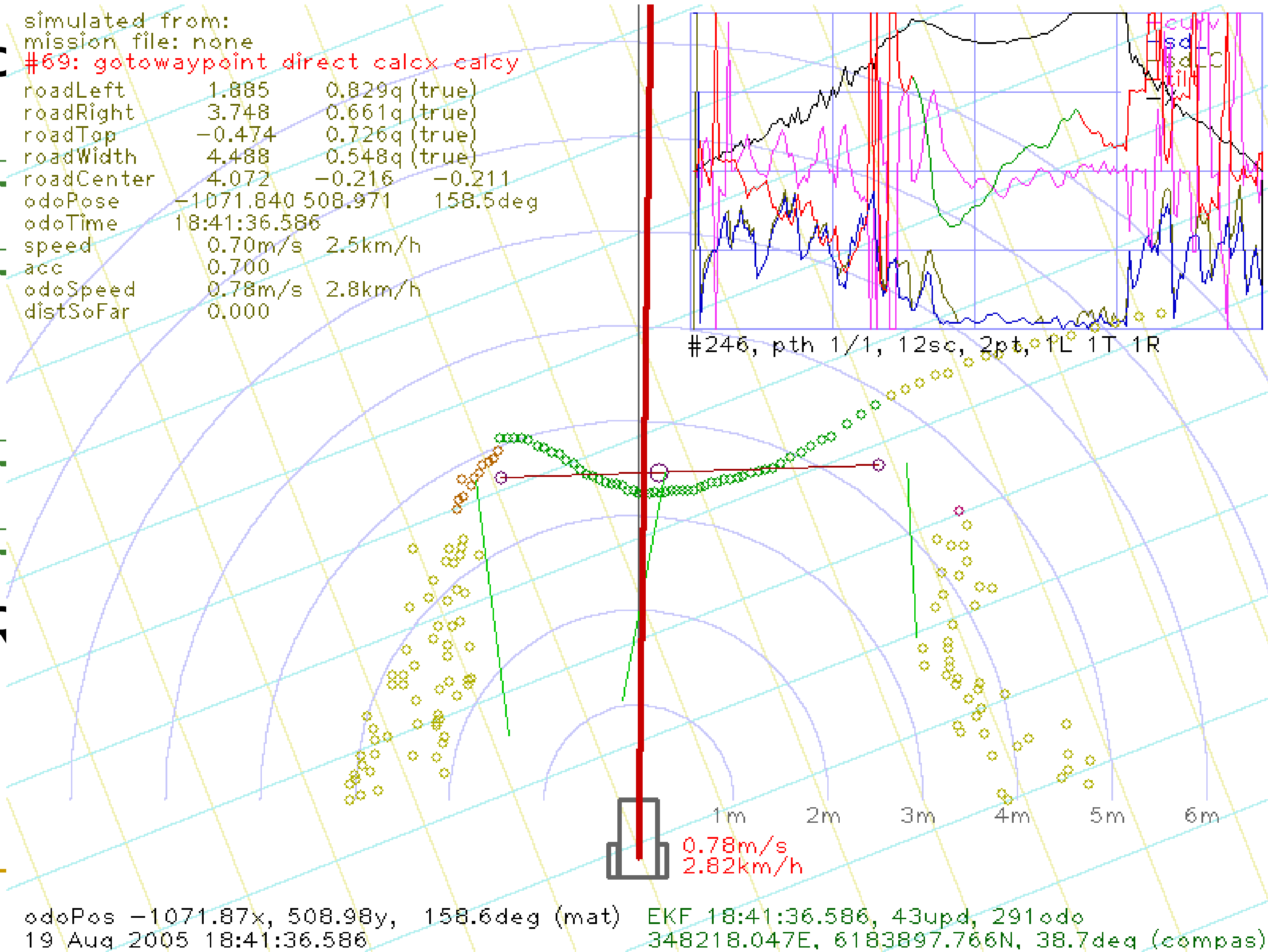
Laser scanner view
y [m]
x [m]
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-4
-3
-2
-1
0
1
2
3
4


Laser scanner view
4
3.5
-0.5
-1
-4
-3
-2
-1
0
1
2
3
4
x [m]
Laser scanner view
y [m]
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-4
-3
-2
-1
0
1
2
3
4
x [m]

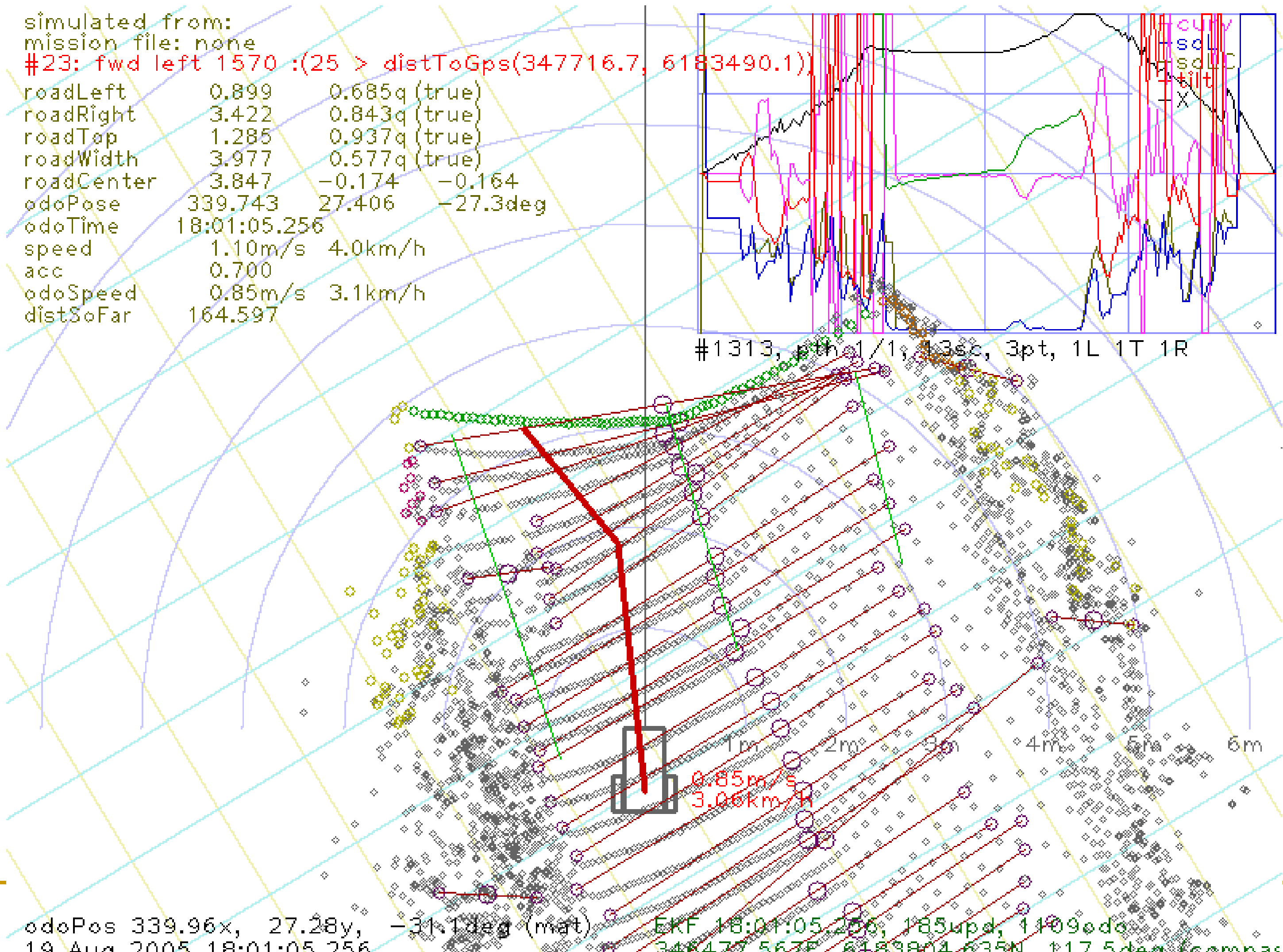
Robot with Laserscanner

Laser Navigation

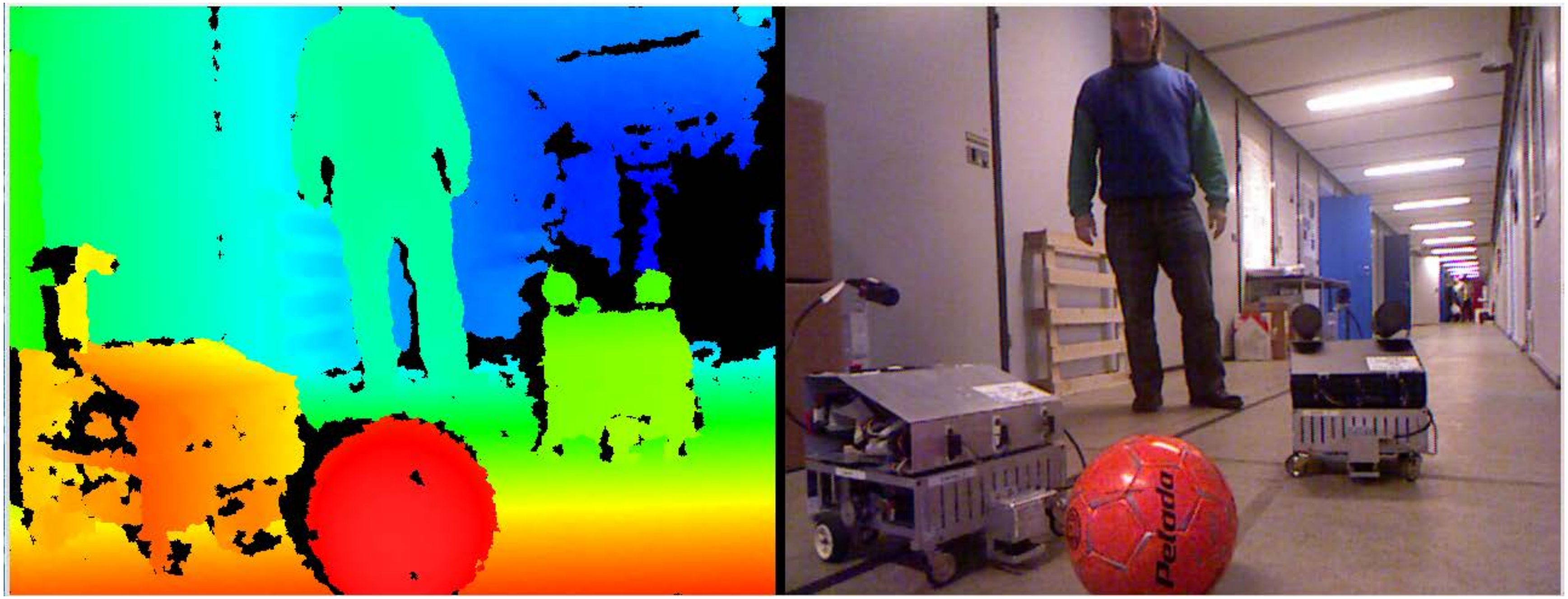
- F
- I
- F



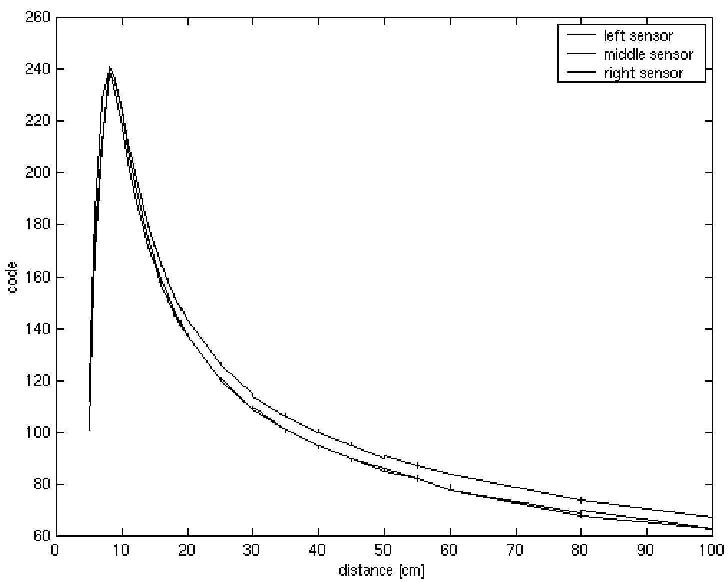
Laser Navigation, more scans



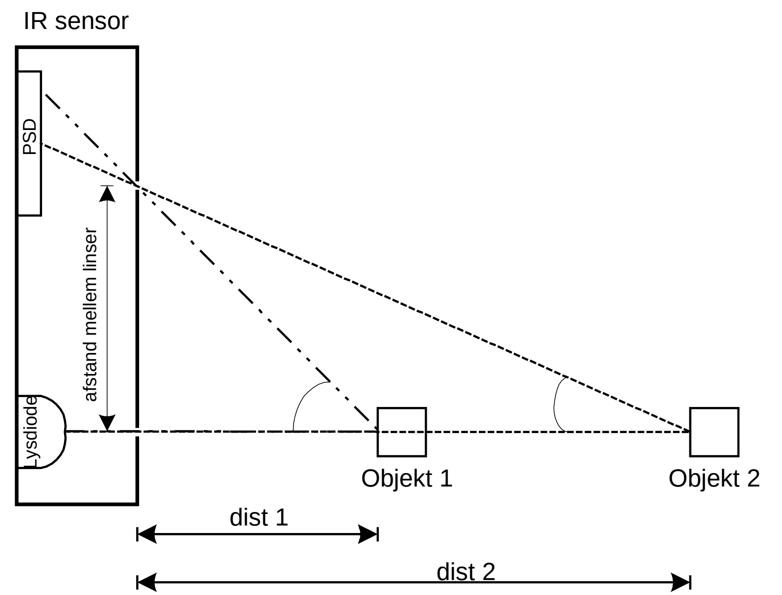
3D kamara (Kinnect)



IR sensors



left sensor
middle sensor
right sensor
code
distance [cm]
260
240
220
200
180
160
140
120
100
80
60
0
10
20
30
40
50
60
70
80
90
100



IR sensor
PSD
afstand mellem linser
Lysdiode
Objekt 1
Objekt 2
dist 1
dist 2

IR sensors

- Output is given as

$$ir_{out} = K_1 \arctan\left(\frac{K_2}{dist}\right) + K_3$$

- Simplified as

$$ir_{out} = \frac{K_A}{dist} + K_B$$

- Inverted

$$dist = \frac{K_A}{ir_{out} - K_B}$$

Use lsqcurvefit in MATLAB

- Function irout=irdist(k,d)
- Initial values 16 and 76

Conclusions

- Calibration must be used to ensure an accurate measurement
- Calibration removes the effect of systematic errors