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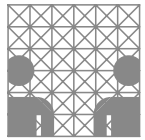

Fusing Camera and LiDAR to Detect and Recognize Motion

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Technische Aspekte Multimodaler Systeme

12. November 2018

Content

Introduction / Motivation

- Autonomous Robots/Cars
- Multiple Sensors
  - Camera
  - LiDAR
  - ...
- Sensor Fusion
  - Complete View of the World
  - combining advantages of dif. Sensors
  - Motion Planing

Camera

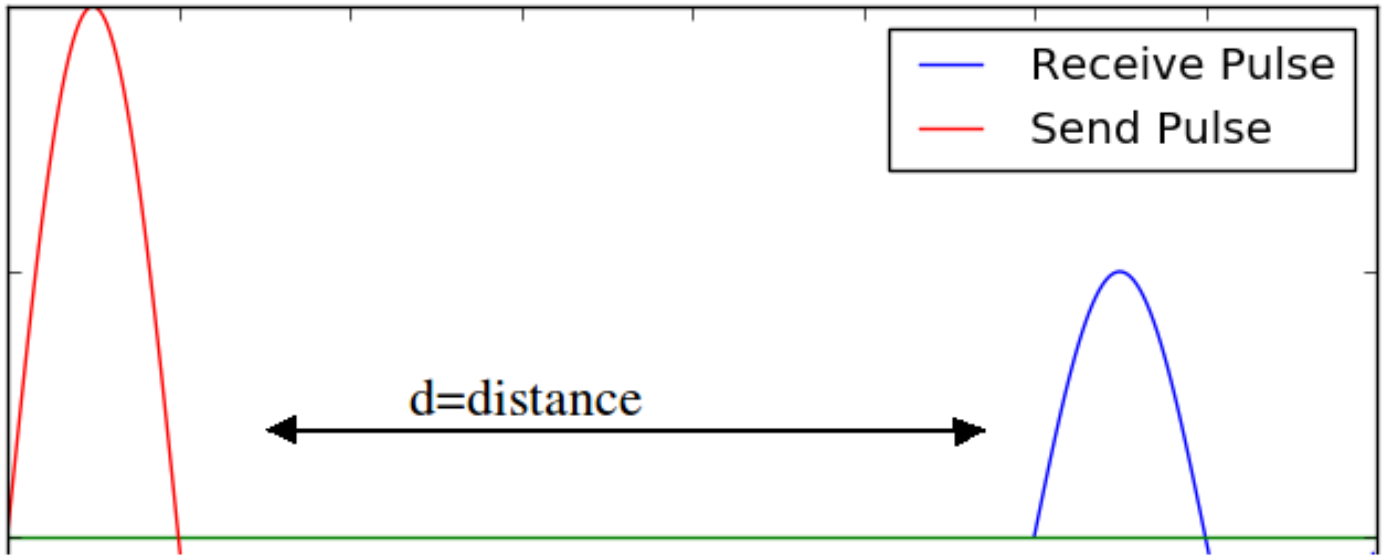
- advantage
  - cheap
  - passive
  - small
  - high resolution
- disadvantage
  - no depth Informations
  - fog / rain
  - intensive Computing

LiDAR

- LiDAR (Light detection and Ranging)
- Laser
- Sensor
- advantage
  - high distance
  - depth Information
  - density Information
- disadvantage
  - expensive
  - no color Informations
  - active

LiDAR Calculation

- Calculation Distance

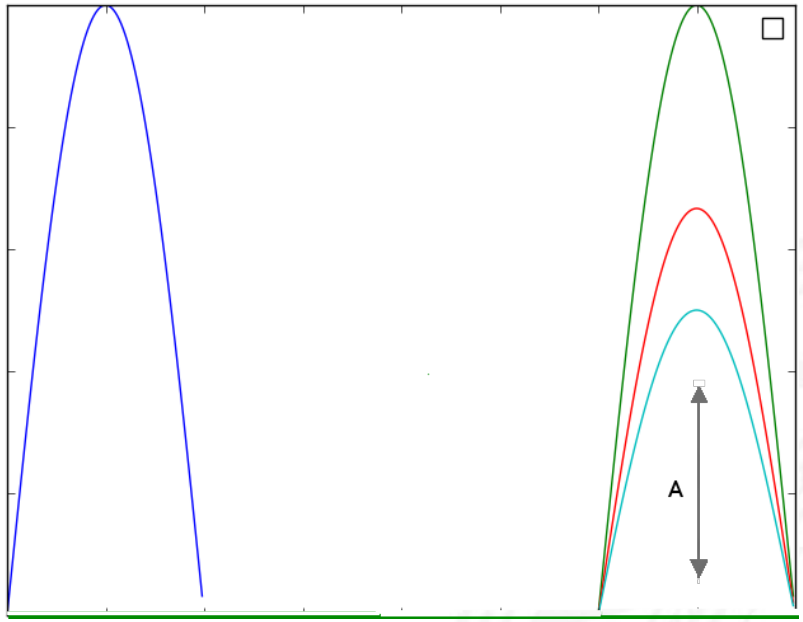


LiDAR Distance

- $d = \frac{c \cdot t}{2}$

LiDAR Calculation (cont.)

- Calculation Density



LiDAR Density

- A = Amplitude
- higher Amplitude = higher Density

Motion Detection & Recognition

- Motion Detection
  - Detects if an object is moving
- Motion Recognition
  - Detects which moving a Object doing
- Gesture Example

Sensor Fusion

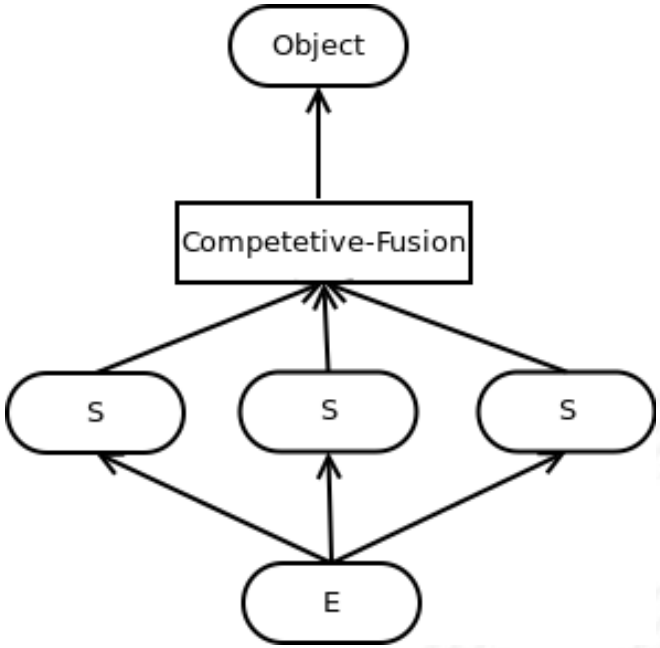
- Combination of Sensor Data
- Redundancy
- Same or different Sensors
- Frequency or Resolution loose

Definition

„is the combining of sensory data ... so the resulting information is in some sense better than would be possible when these sources were used individually“[a]

[a] Elmenreich 2001.

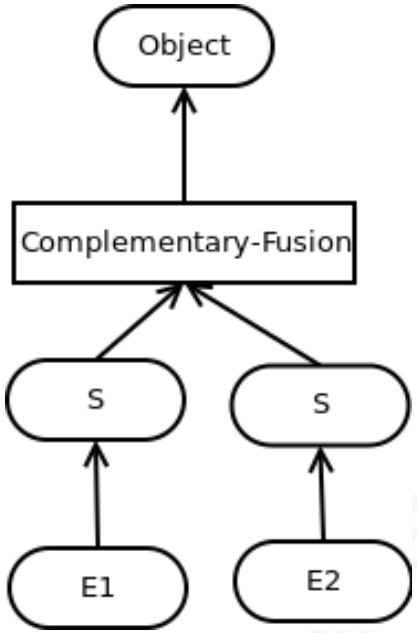
Competitive



Sensor Fusion Competitive

- Airplane →Redundancy

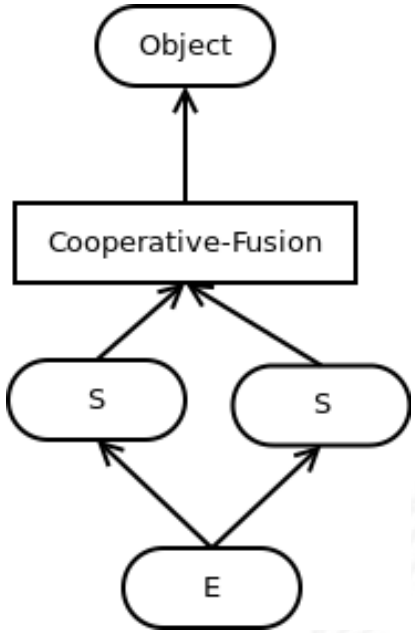
Complementary



Sensor Fusion Complementary

- Camera in the Front/Back

Cooperative

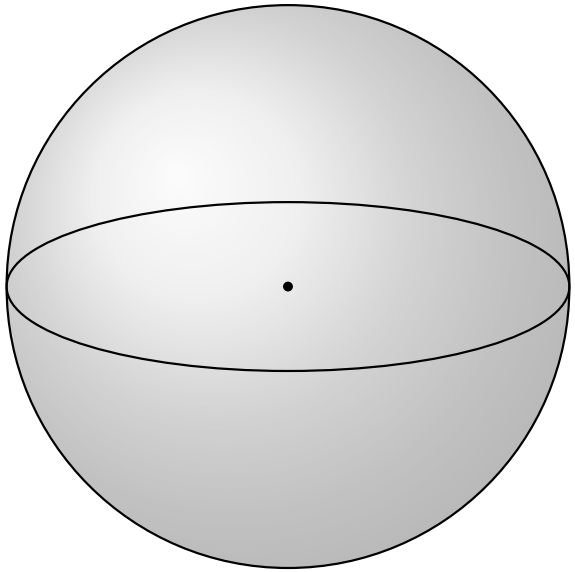


Sensor Fusion Cooperative

- LiDAR Cameras Systems in Cars/Robots
- 2 Sensors to increase accuracy

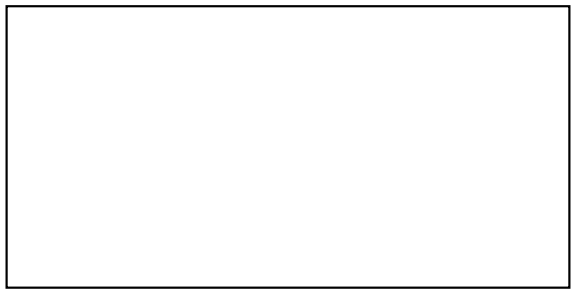
A Short Video Demo

Fusion



Lidar View

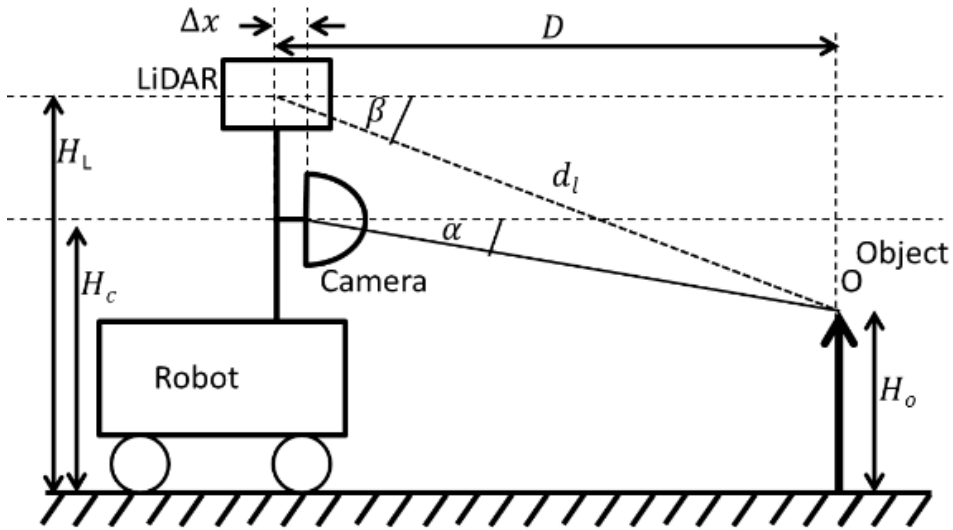
Fused View



Camera View

Fusion (cont.)

- First we need to calibrate



Side view of the sensor setup[1]

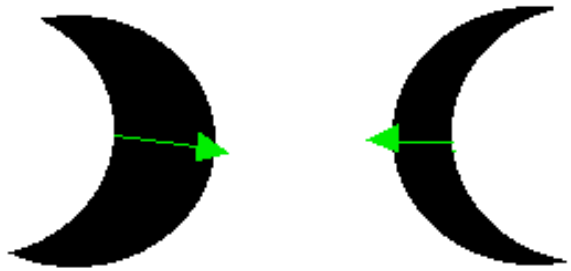
[1] Silva, Roche und Kondoz 2018b.

Movement

First Picture

Second Picture

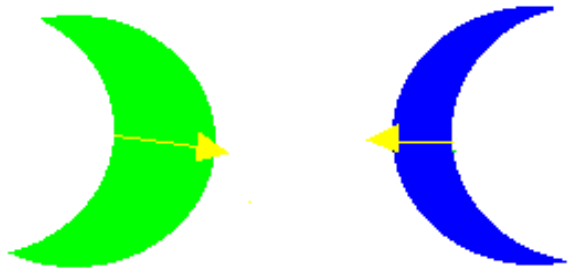
Movement (cont.)



Colliding Picture

- Possible Direction
- Maybe complete Wrong
- adding LiDAR Data

Movement (cont.)

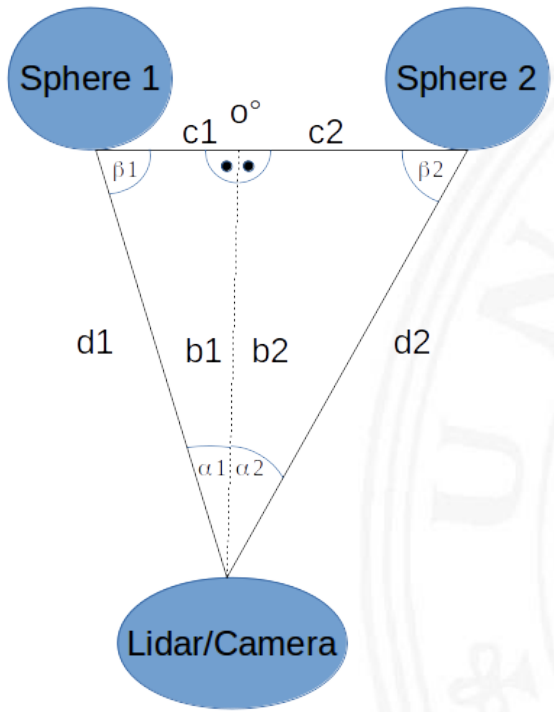


Colliding Picture

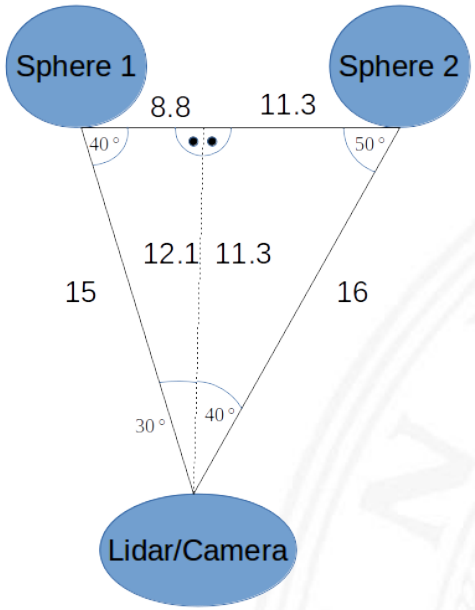
- represented with a color transition
  - green = 0 Speed, blue = negative Speed , red = positive Speed
- speed on Axis
- Movement between object

Movement (cont.)

- trigonometric functions
- Arithmetic

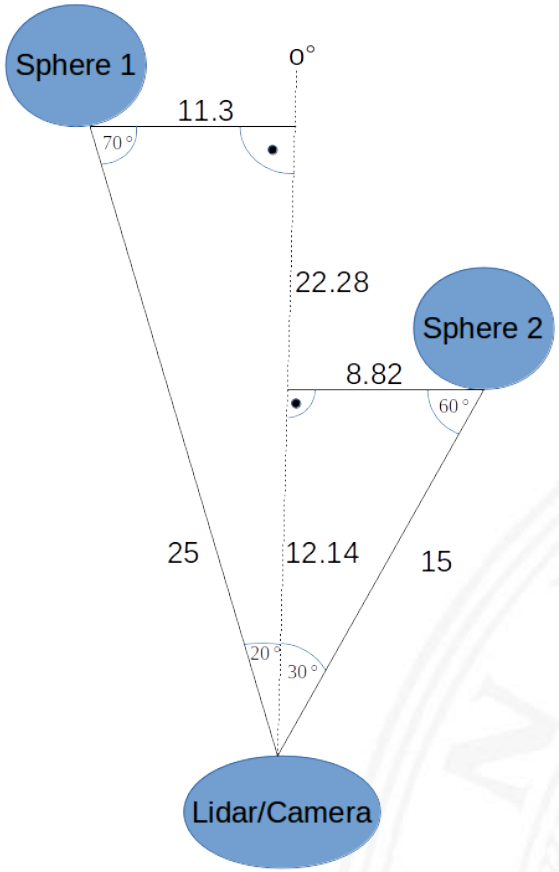


Movement (cont.)



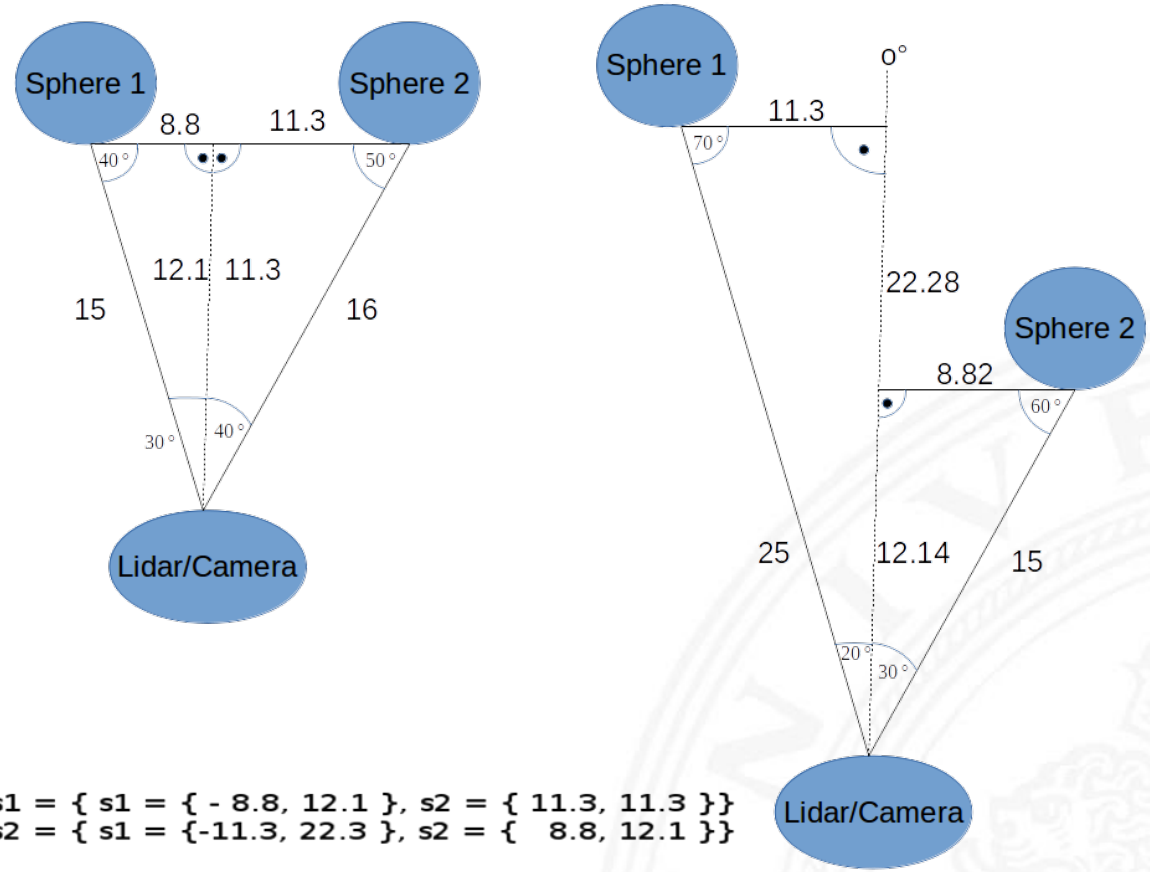
Angle calculation Sphere

Movement (cont.)



Angle calculation Sphere Second

Movement (cont.)

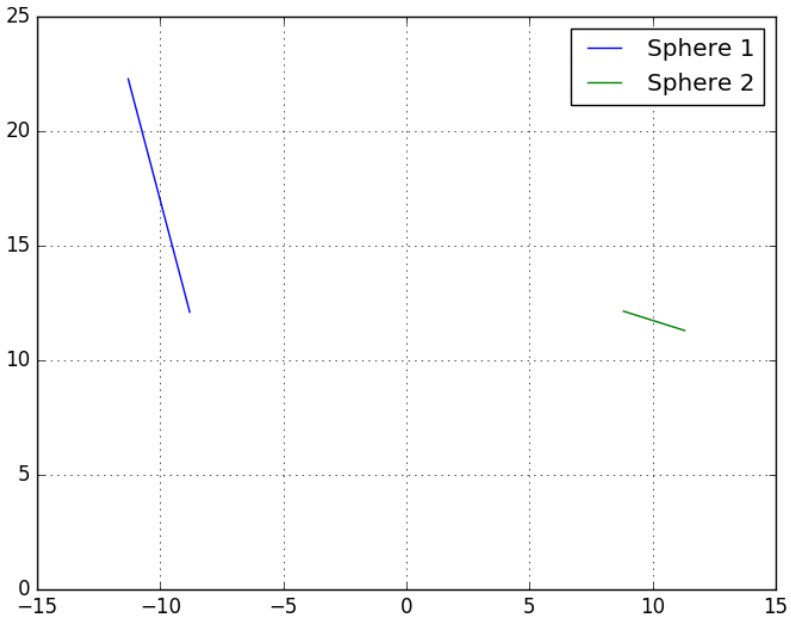



```
pos1 = { s1 = { - 8.8, 12.1 }, s2 = { 11.3, 11.3 }}
pos2 = { s1 = {-11.3, 22.3 }, s2 = {  8.8, 12.1 }}
```

Calcualte Points in Cordinate System

Movement (cont.)

- Plot in a Grid
- (0/0) is the Lidar/Camera Position



Movement between Picture 1 and Picture 2

Conclusion

- More complete picture of the environment
- Problems with different Frequencies, Resolutions ..
- LiDARs are expensive
- We can build a 3D environment
- Possibly Something data lost
- Accurate the Interpolation with higher Polynoms
- Tests with a real LiDAR
- exact Positions of detected Object can calculate
- calculation are Simple trigonometric and normal arithmetic

Questions

- Thanks for your attention
- Questions ?

References

Cho, H. u. a. (2014). "A multi-sensor fusion system for moving object detection and tracking in urban driving environments". In: *2014 IEEE International Conference on Robotics and Automation (ICRA)*, S. 1836–1843. DOI: 10.1109/ICRA.2014.6907100.

Elmenreich, Wilfried (2001). *An Introduction to Sensor Fusion*. Research Report 47/2001. Treitlstr. 1-3/182-1, 1040 Vienna, Austria: Technische Universität Wien, Institut für Technische Informatik. (Besucht am 06. 11. 2018).

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Silva, Varuna De, Jamie Roche und Ahmet M. Kondoz (2018a). "Robust Fusion of LiDAR and Wide-Angle Camera Data for Autonomous Mobile Robots". In: *Sensors*. (Besucht am 06. 11. 2018).

– (2018b). "Robust Fusion of LiDAR and Wide-Angle Camera Data for Autonomous Mobile Robots". In: *Sensors*. (Besucht am 06. 11. 2018).