# Teleoperated Visual Inspection and Surveillance with Unmanned Ground and Aerial Vehicles

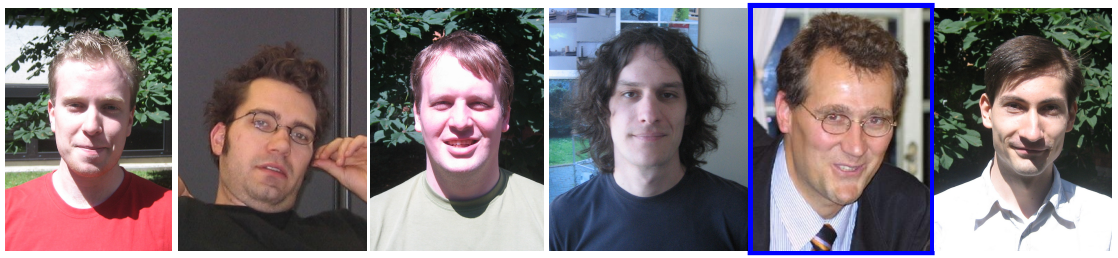
Fraunhofer Institut Intelligente Analyse- und Informationssysteme


B-IT APPLIED SCIENCE INSTITUTE

Fachhochschule Bonn-Rhein-Sieg

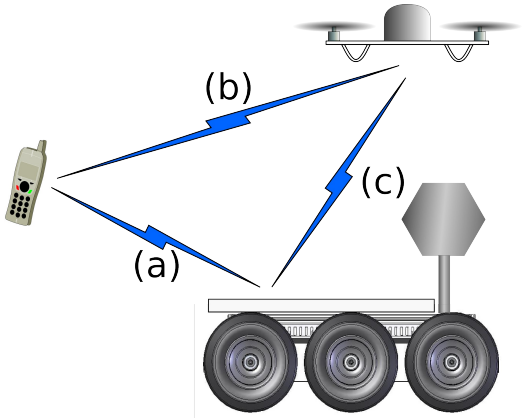
Fraunhofer Institut Intelligente Analyse- und Informationssysteme

Sebastian Blumenthal[1], Dirk Holz[1], Thorsten Linder[1],
Peter Molitor[2], ***Hartmut Surmann[2]*** and Viatcheslav Tretyakov[1]



# Outline

- Motivation
- Plattform
- Teleoperated Robot Control
- Vision System
  - Human visual attention
- Quadrotor
- Conclusion

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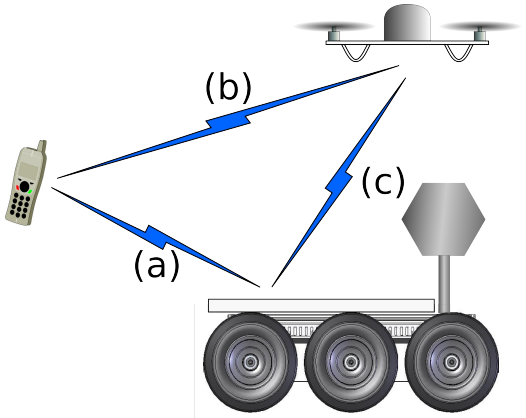
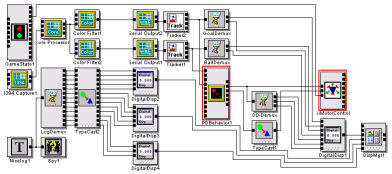



# Research Questions



*Finding a principle approach to building up and maintaining situation awareness including attention*

(Spatio-temporal models, observation models)

***Mobile Robots***

- ***Computer Vision***
- ***6DoF (P)SLAM***
- ***Robot Cognition***
- ***.....***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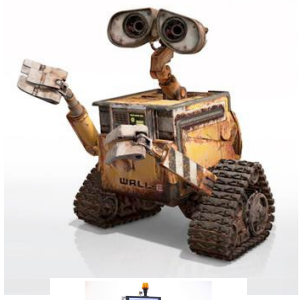
# Applications benefiting from the research questions



- USAR (Urban Search and Rescue)
- Education
- Service Robots
- Entertainment
- Production
- …..

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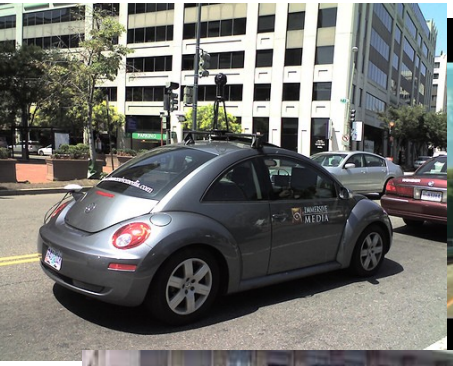
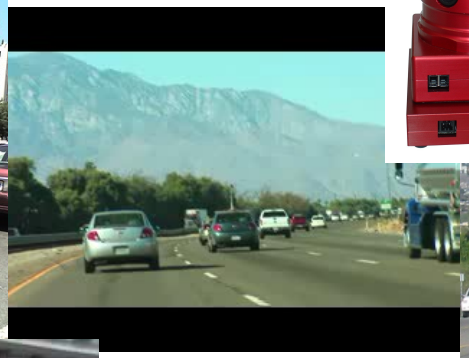
# Google street view



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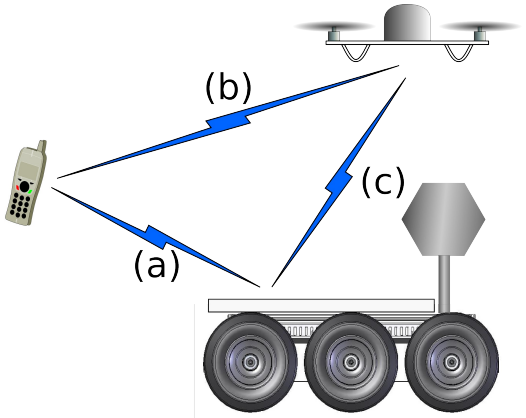
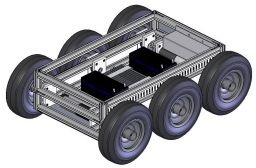
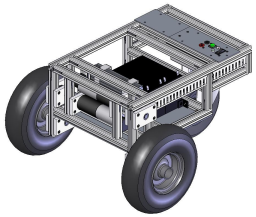
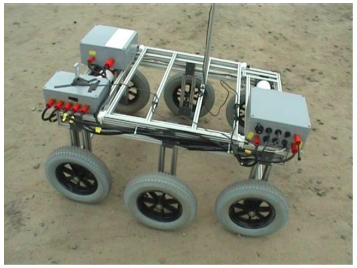


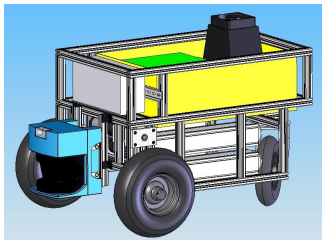

# Plattform (VolksBot® RT, ground vehicle)

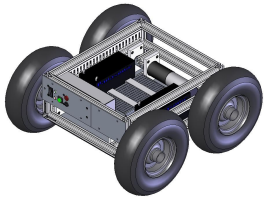
- VolksBot is a robust construction-kit
- Scalable variants by use of common components (hardware and software)
- High payload (40kg)
- Extendable
- Several variants e.g. with a fuel cell or under water
- 2x150 W motors, VMC, 2 x MacMinis (2GHz)









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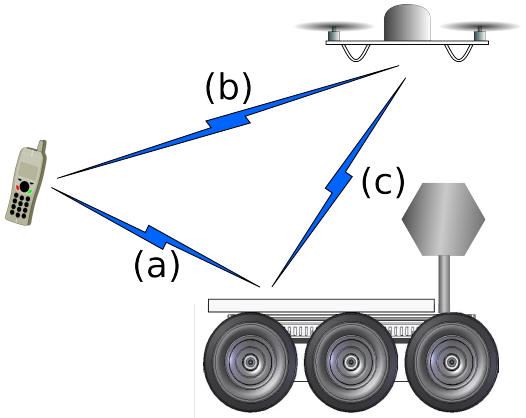
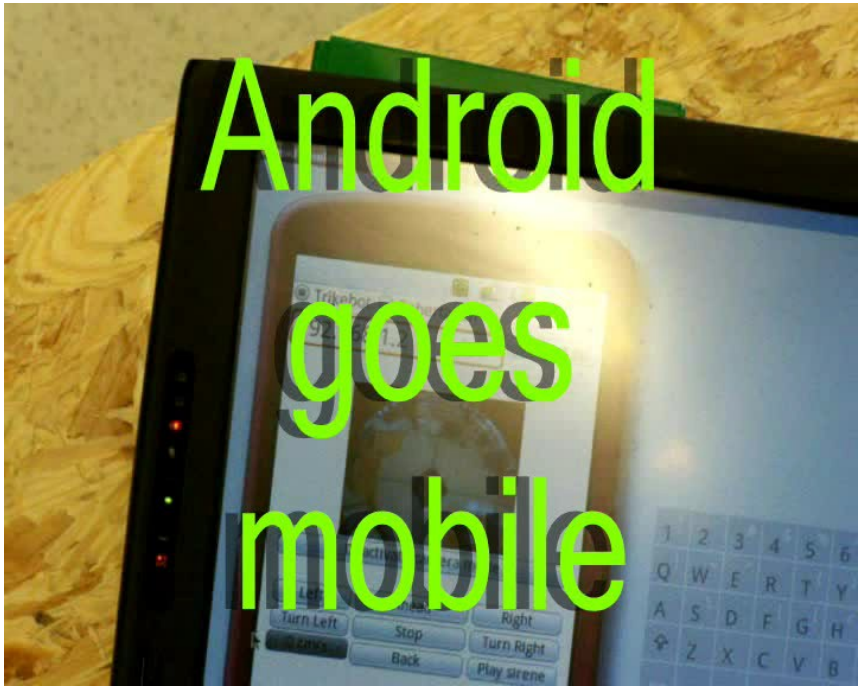



# Tele-operated Robot Control (OCU)

- general purpose computer
- Always available
- High social acceptance and limited teaching
- Man pack able, light weight, small
- long runtime / operation time
- robust and substitutable





**New: Configuration / and or control client loaded directly from the robot** (Business Card)

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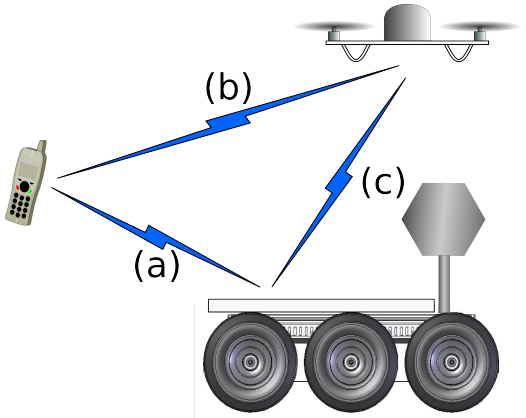


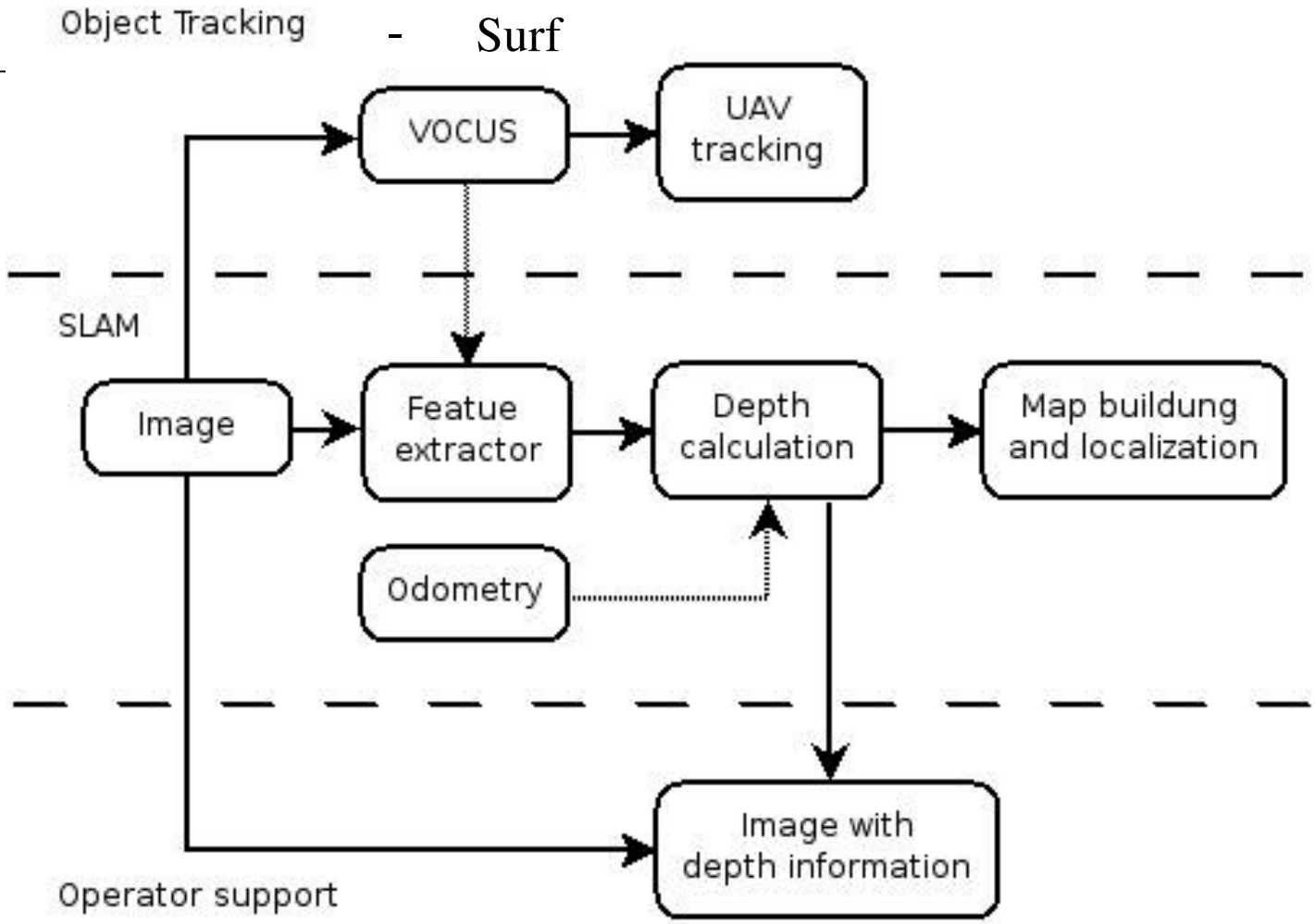

# Vision system, add on Sensors

- OmniVision, SphereCam
  firewire: 1300x1000
  11xUSB 2.0: 1600x1200
- 3D laser scanner
- Control computer (MacMini)
- Motor Controller
- Docking Station
- Bumper, IR, Ultrasonic


# Vision System

*Alternative (real-time questionable):*

- Sift
- Surf



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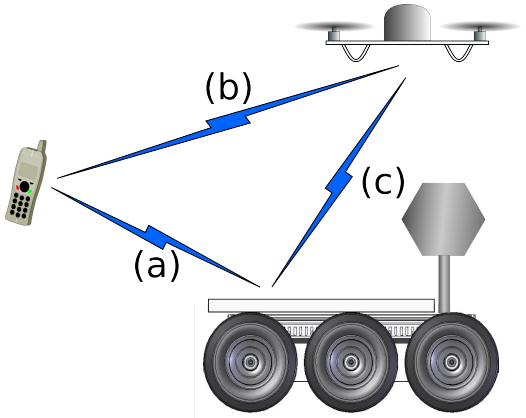
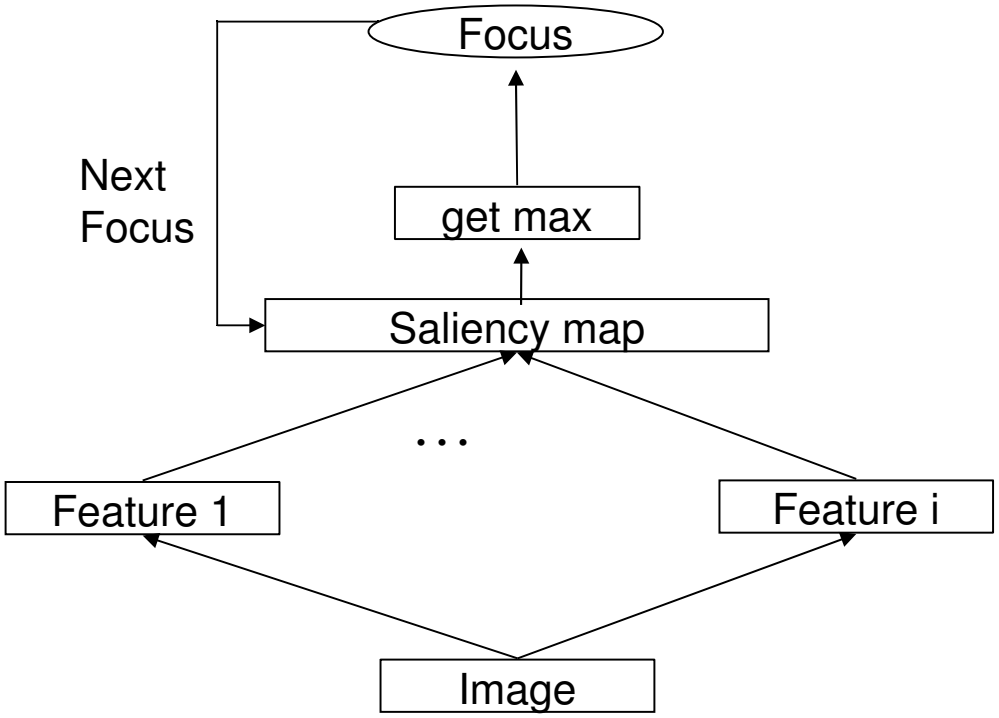



# Simulation of human visual attention

**Computermodell:**




**Research:**

**[Koch,Ullman: Human Neurobiology 1985]**

**[Tsotsos: Early Vision and Beyond, 1995]**

**[Itti,Koch,Niebur: PAMI 1998]**

**[Backer,Mertsching: PAMI 2001]**

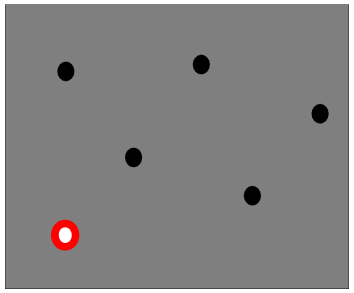
**[Sun,Fisher: AI 2003]**

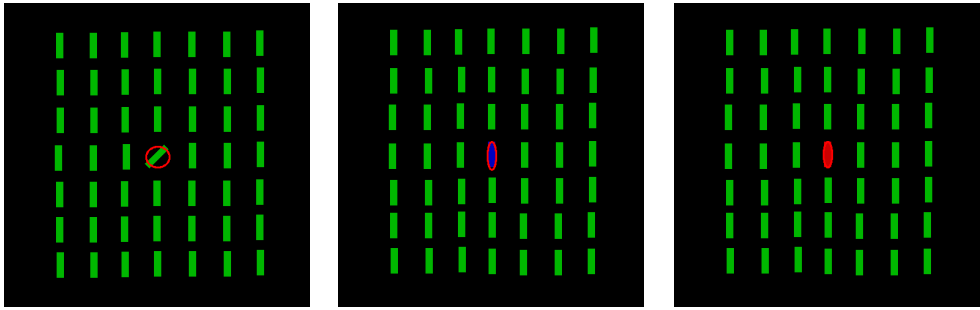
**[Navalpakkam,Rebesco,Itti: Vision Research 2005]**

**[Hamker: CVIU 2005]**

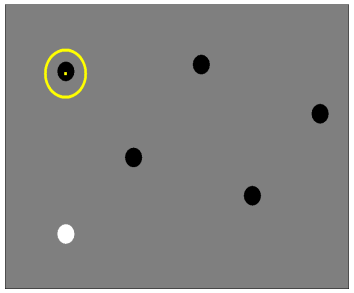
# Example: Vocus (Visual Object detection with a CompUtational attention System)

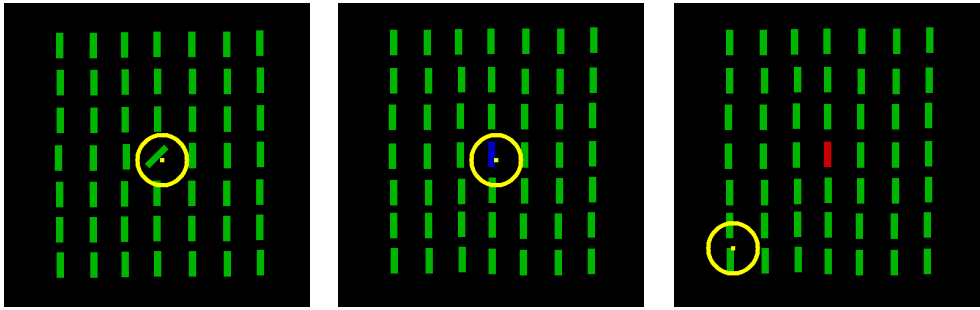
VOCUS
(New: separate Feature Maps, real-time implementation)





NVT combined Feature Maps)





Details in: Frintrop, Nüchter, Surmann: „Visual Attention for Object Recognition in Spatial 3D data“, in WAPCV' 04

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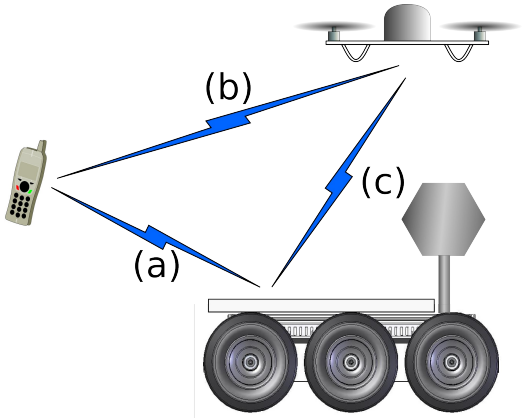
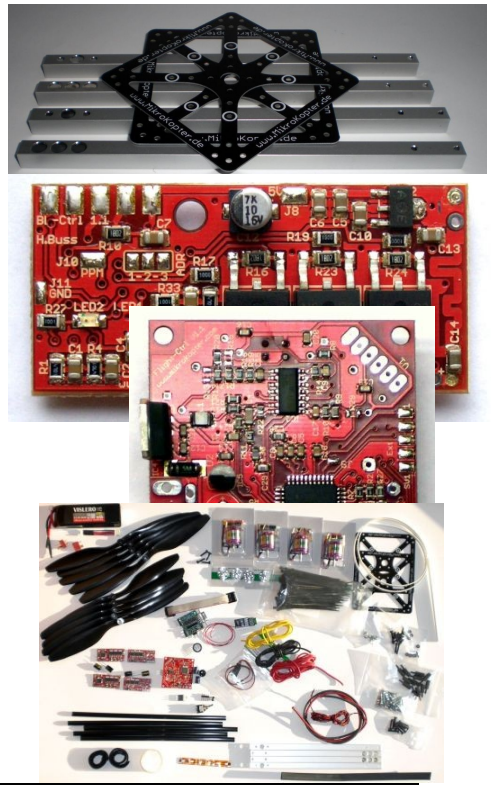



# Mikrokopter (Aerial Vehicle)

**VTOL construction kit: Size:650x650x220mm**
**Weight: 590g**



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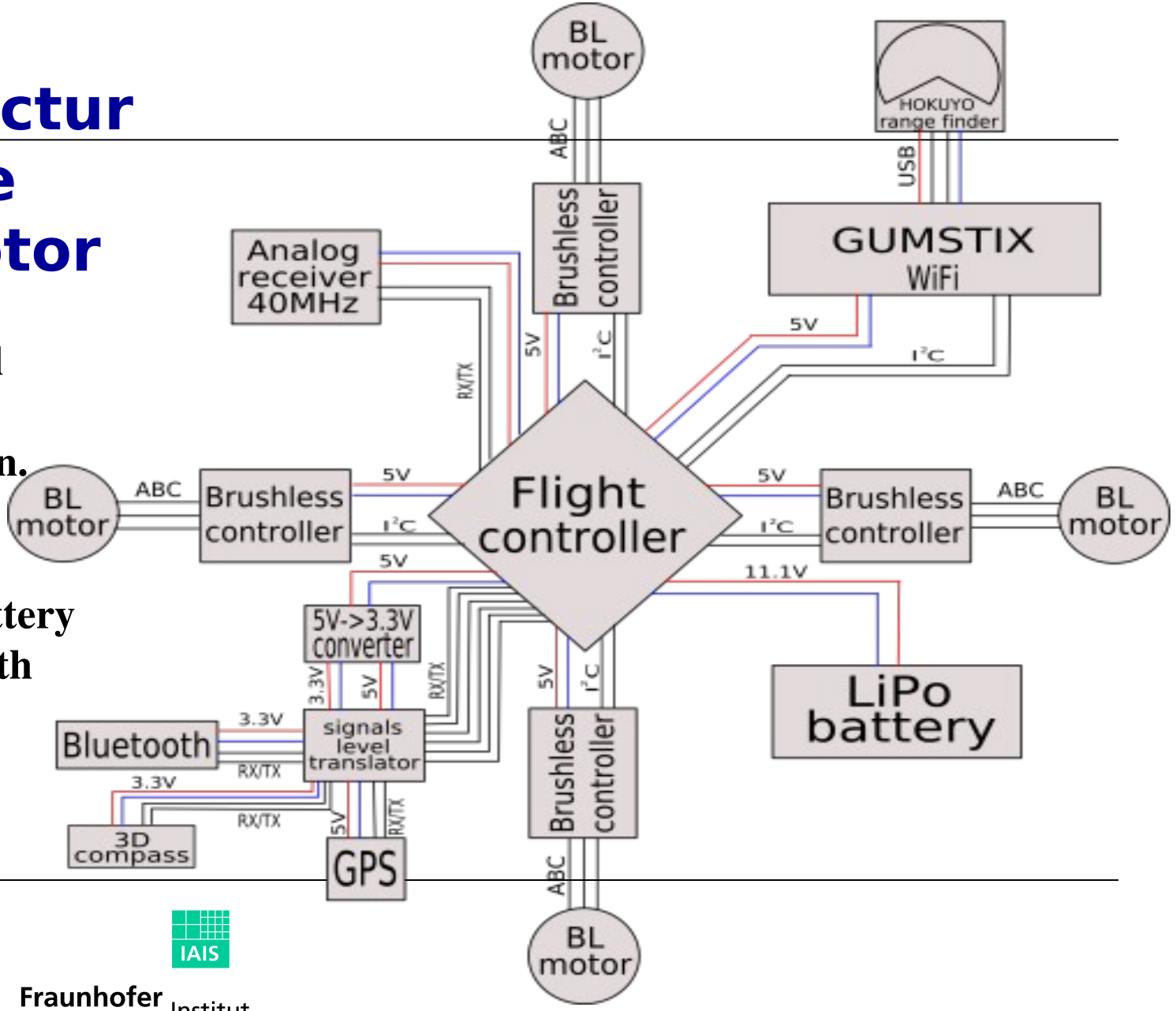
# Architecture of the Quadrotor

- 20MHz Atmel
- Payload 350g
- op.time 20 min.

- 2100 mAh battery
- WiFi, bluetooth radio link
- I²C bus





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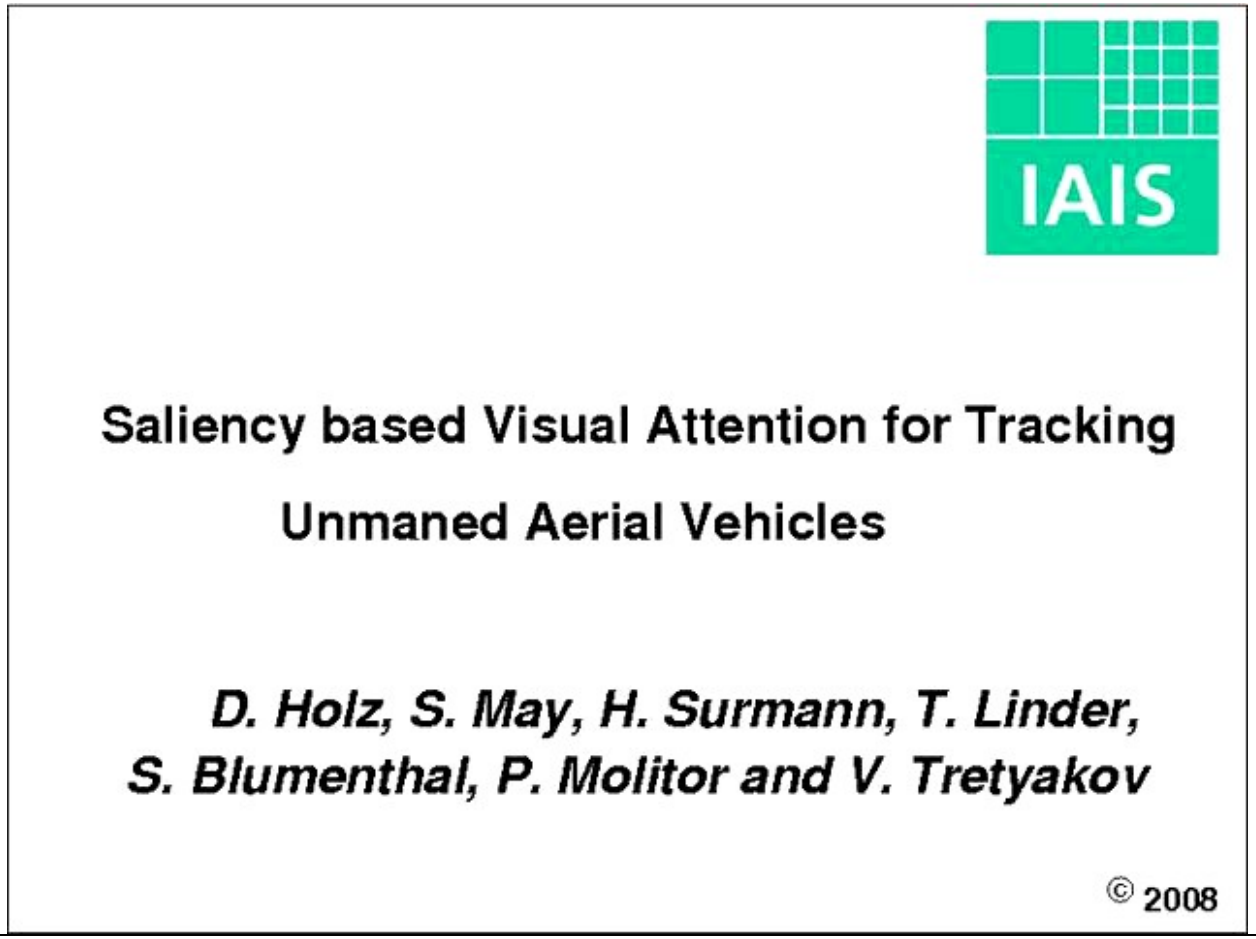
# Tracking of the Quadrotor with Vocus




*Most attentive object is marked with a red square.*

# Conclusion

- Ground Vehicle (VolksBot)
- Aerial Vehicle (Mikrokopter)
- Teleoperation
- Vision system (Vocus)
- Quadroter

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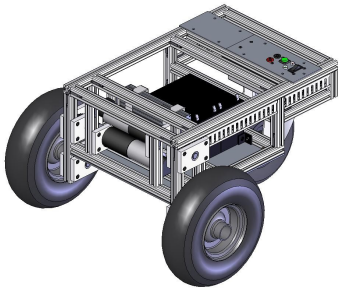
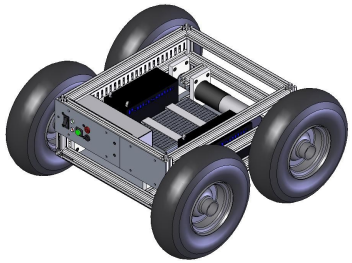
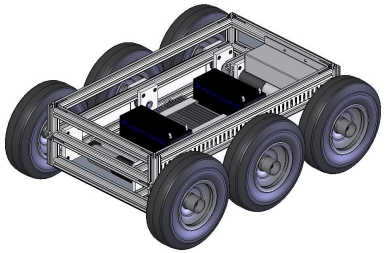
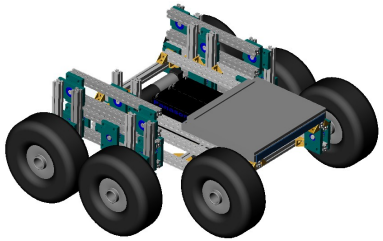
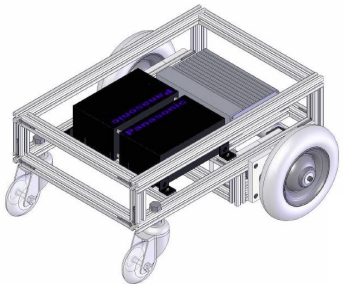
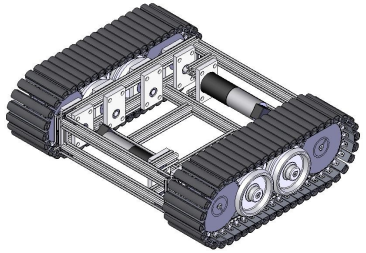
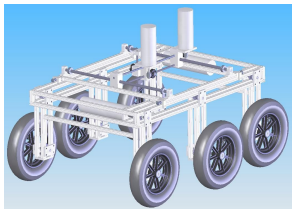
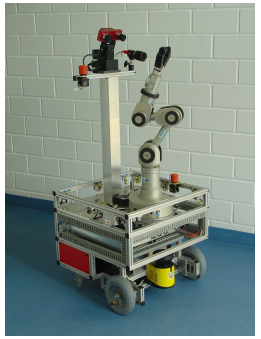
# www.volksbot.de

**Thank you for your attention!**





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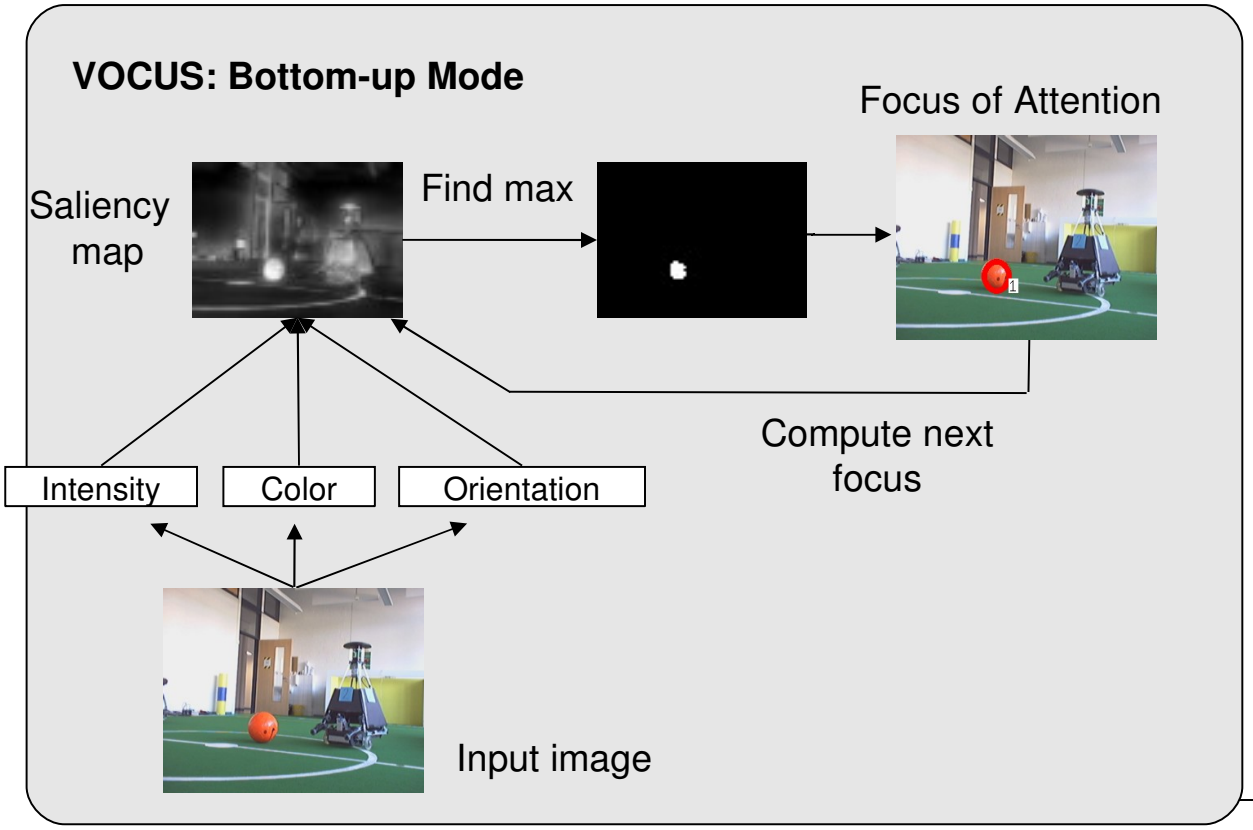
# Simulation of visual attention




Saliency based Visual Attention for Tracking Unmaned Aerial Vehicles

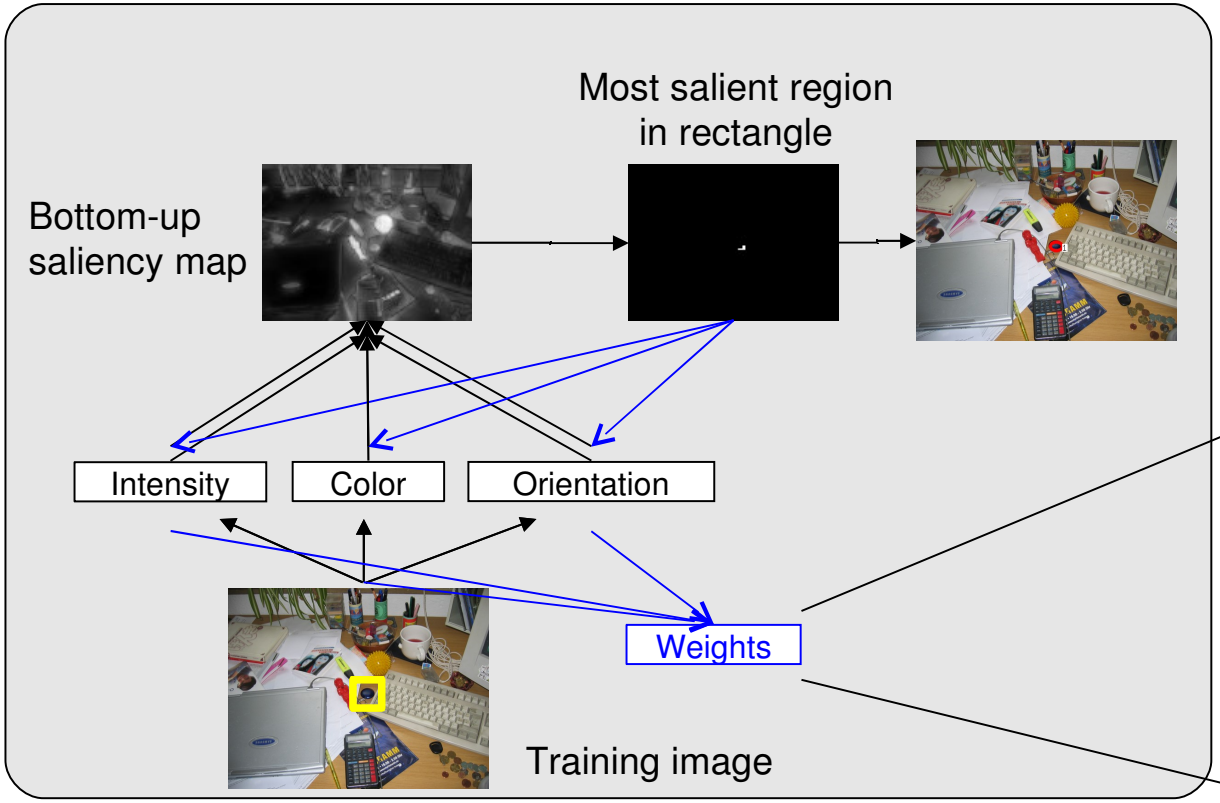
*D. Holz, S. May, H. Surmann, T. Linder, S. Blumenthal, P. Molitor and V. Tretyakov*

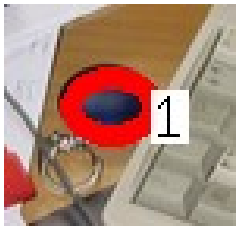


Extended the work from om Itti et al:

Itti,Koch,Niebur: „A model of saliency-based visual attention for rapid scene analysis“, in PAMI *'98*

# Top-down Attention



Int on-off: 0.0
Int off-on: 6.9

Ori 0°: 1.9
Ori 45°: 2.9
Ori 90°: 2.6
Ori 135°: 3.3

Col green: 0.6
Col blue: 8.0
Col red: 1.8
Col yellow: 0.1

Goal object is marked with a red square.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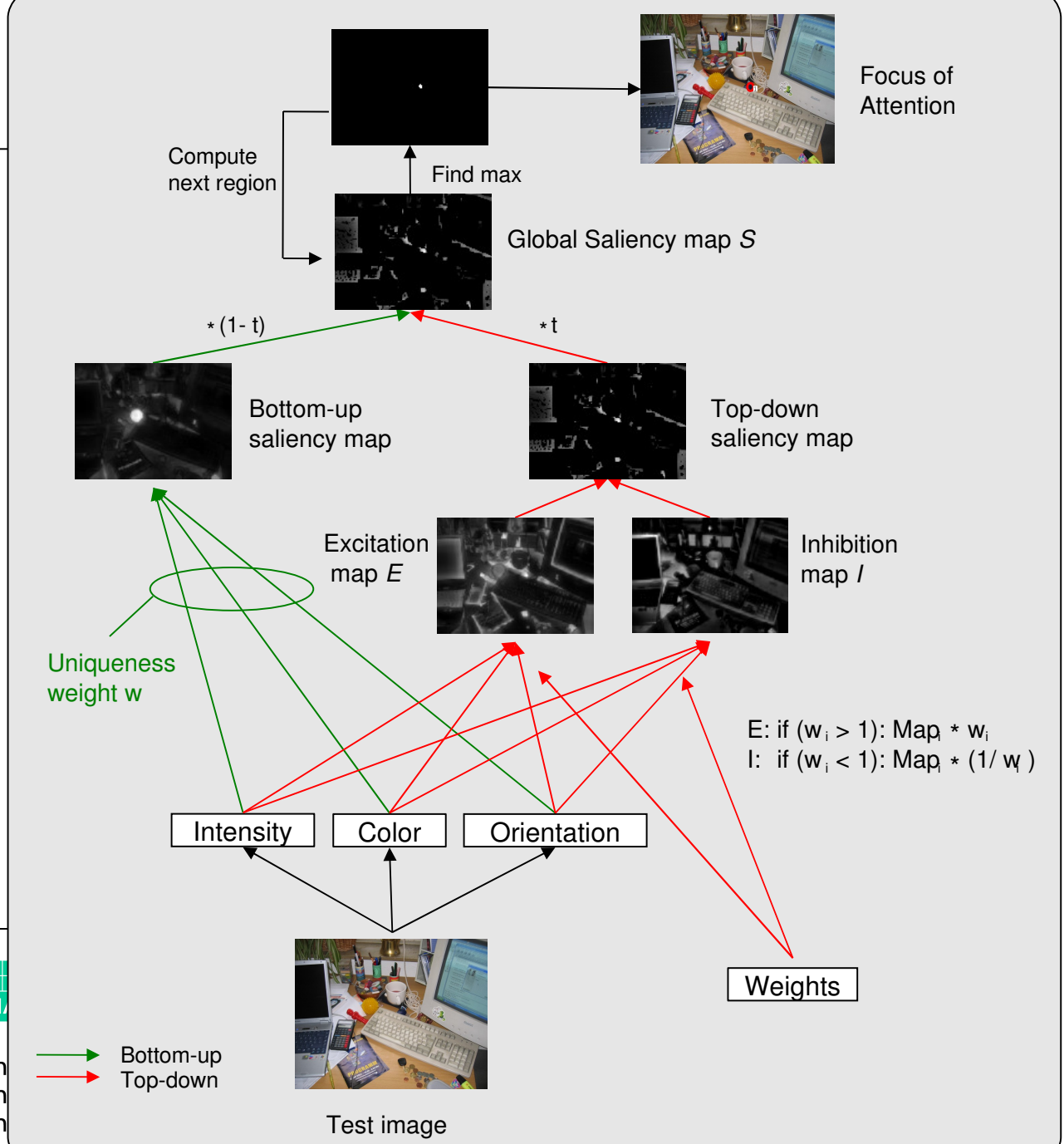
# Simulation of visual attention

Top down search

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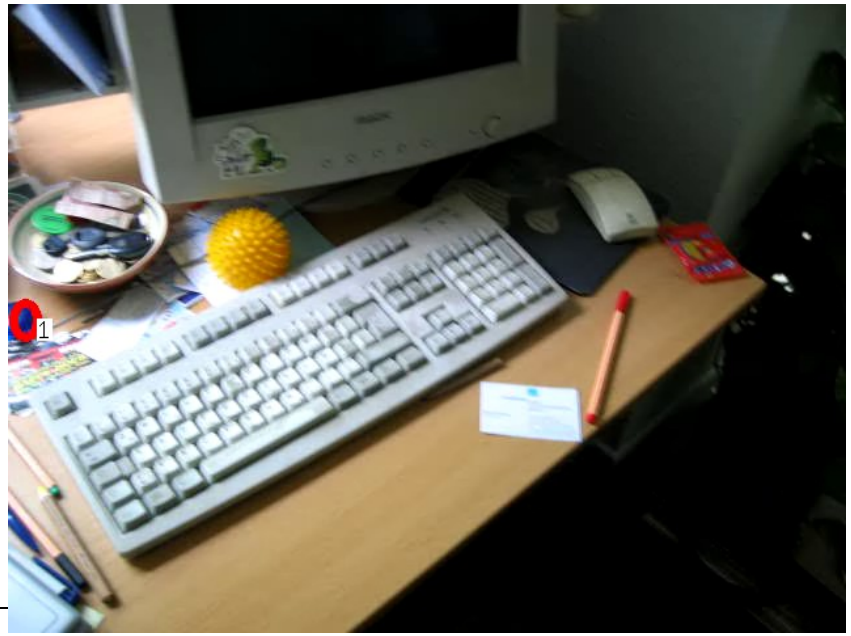
# Simulation visueller Aufmerksamkeit

Bottom-up Mode


Top-down Mode:

Suche Schlüsselanhänger

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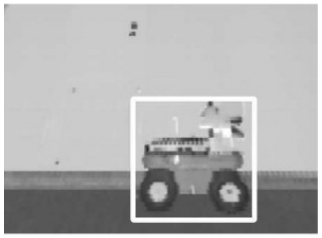
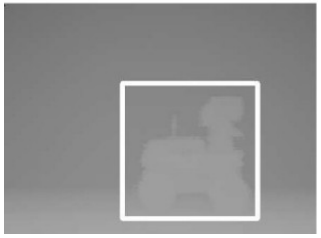
# ultisensorielle und multimodale Objekterkennung

Kamerabild



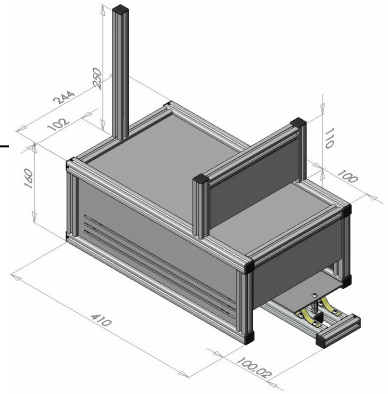
Remissionsbild (Scanner)



Tiefenbild (Scanner)

- Redundanz durch Verwendung von 2D- und 3D-Daten: Kamerabild, Remissionsbild oder Tiefenbild
- Komplementarität durch Ausnutzung von Sensormodalitäten
- Sehr schnelle (20 ms) Erkennung mit adaptiertem Viola-Jones-Klassifikator (auch andere Klassifikatoren möglich, z.B. SIFT)

# Docking station

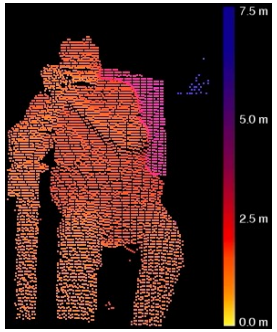


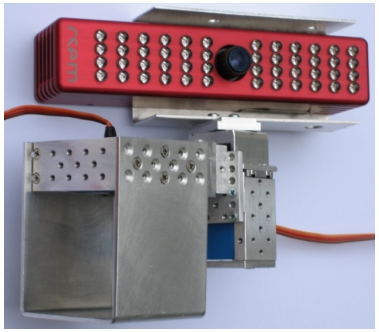

- **Infinit operation time**
- **Navigation based on leading light (2 LEDs and a camera)**

# More Sensors

Mini-3D-Scanner (Hokuyo)
(CSEM)


3D-Kamera Swiss Ranger



Infrared camera (FLIR)
vi

# A module library for mobile robotics

- CAN Module
- ODE Simulator Module
- Generic Joystick Module
- Matlab Module
- Color-Vision Modules
- OpenCV Modules
- Tracking Modules
- DD-Behavior Modules
- CORBA Server Module
- Neuro-Controller Module
- RoboCup MSL Modules
- …



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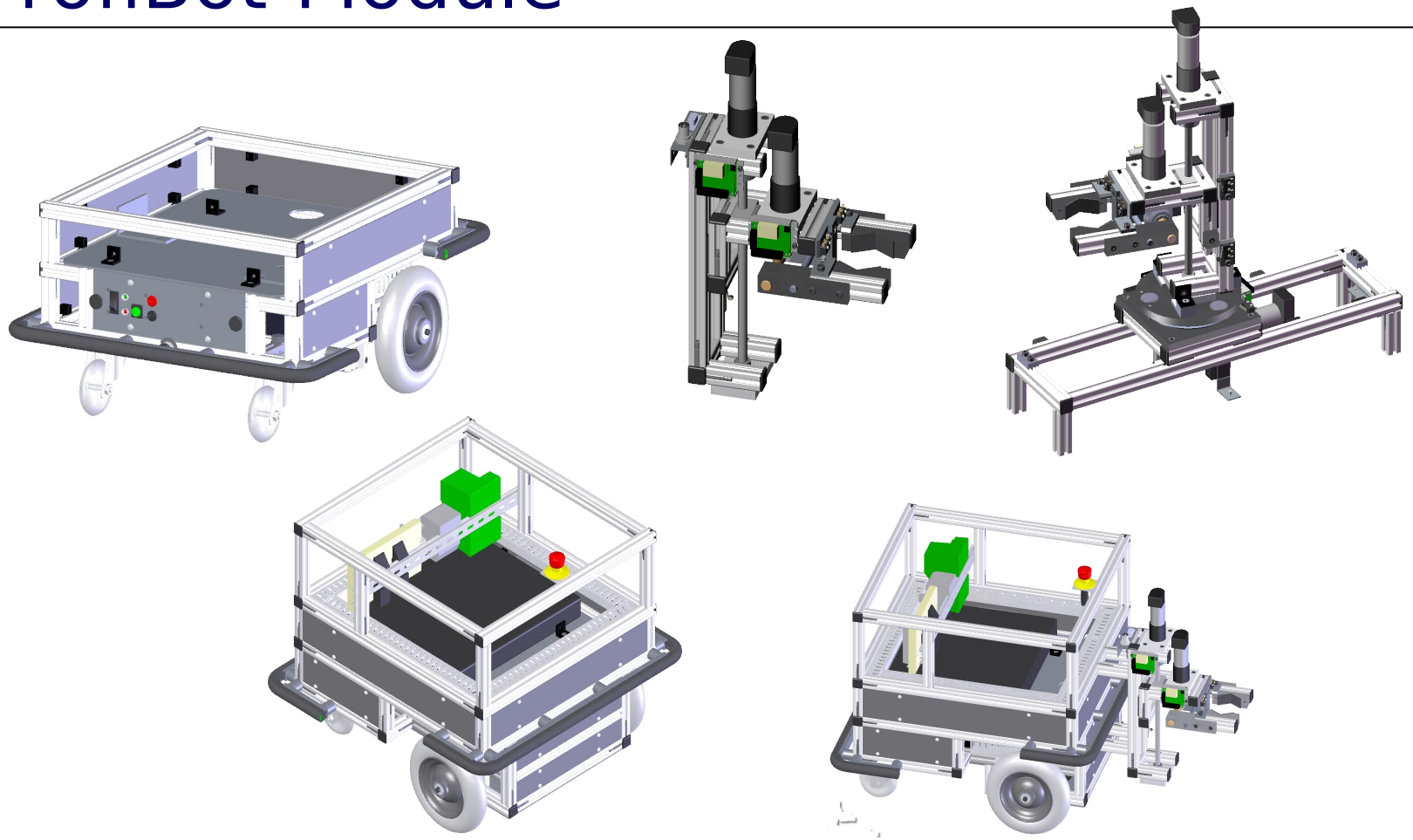
# ProfiBot-Basismodell


# ProfiBot-Module



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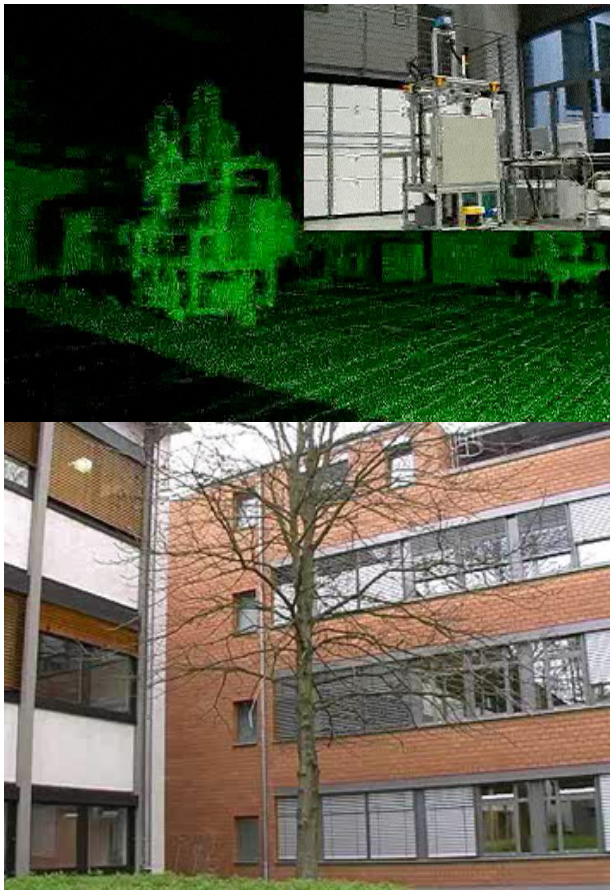
# Application of 3D sensor systems




- Environment recogniti
  and Obstacle avoidanc
- Mapping (2D, 3D)
- Surveying
- Object detection

Outlook:

- Recognition of Object function
- Mobile object manipulation

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# 3D-Laserscanner

Voxel colored with
Laser remission values

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# Publication (partly)


- S. Frintrop, E. Rome, A. Nüchter, & H. Surmann: A Bimodal Laser-Based Attention System. Computer Vision and Image Understanding (CVIU), vol. 100, no. 1-2, pp. 124–151. Special Issue on Attention and Performance in Computer Vision.
- K. Lingemann, H. Surmann, A. Nüchter, & J. Hertzberg, High-Speed Laser Localization for Mobile Robots, Robotics and Autonomous Systems, 4(51), pp. 229–316, June 2005
- A. Nüchter, K. Lingemann, J. Hertzberg, and H.Surmann. Accurate Object Localization in 3D Laser Range Scans, in Proc. 12th International Conference on Advanced Robotics (ICAR '05), pp. 665–672
- S. Mitri, S. Frintrop, K. Pervölz, H. Surmann, & A. Nüchter. Robust Object Detection at Regions of Interest with an Application in Ball Recognition, in Proc. IEEE 2005 Int'l Conf. Robotics and Automation (ICRA '05), pp. 126–131
- L. Paletta, E. Rome & H. Buxton. Attention Architectures for Machine Vision and Mobile Robots, In: Neurobiology of Attention (Encyclopedic Volume) , L. Itti, G. Rees and J.K. Tsotsos (Eds), Academic Press/Elsevier, pp. 642–648, 2004
- A. Nüchter, K. Lingemann, J. Hertzberg, H. Surmann, K. Pervölz, M. Hennig, K. R. Tiruchinapalli, R. Worst, & Th. Christaller, Mapping of Rescue Environments with Kurt3D, in Proc. SSRR '05, pp. 158–163
- I. Stratmann & E. Solda. Omnidirectional Vision and Inertial Clues for Robot Navigation, Journal Robotic Systems, 1(21), January 2004, pp. 33–39
- S. Frintrop, Andreas Nüchter, H. Surmann, & J. Hertzberg. Saliency-based Object Recognition in 3D Data, in Proc. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'04), pp. 2167–2172
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- V. Becanovic, T. Günther and A. Bredenfeld, Modelling of Neuromorphic Vision Sensors in ODE, IEEE ICRA ´05