Teleoperated Visual Inspection and Surveillance with Unmanned Ground and Aerial Vehicles

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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
- .....
Applications benefiting from the research questions

- USAR (Urban Search and Rescue)
- Education
- Service Robots
- Entertainment
- Production
- …
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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  - Human visual attention
- Quadro rotor
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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

Object Tracking

VOCUS

UAV tracking

SLAM

Image

Featue extractor

Depth calculation

Map building and localization

Odometry

Image with depth information

Operator support
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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
Architectural of the Quadrotor

- 20MHz Atmel
- Payload 350g
- op.time 20 min.
- 2100 mAh battery
- WiFi, bluetooth radio link
- I²C bus
Tracking of the Quadrotor with Vocus

Saliency based Visual Attention for Tracking Unmaned Aerial Vehicles

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

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Most attentive object is marked with a red square.
Conclusion

- Ground Vehicle (VolksBot)
- Aerial Vehicle (Mikrokopter)
- Teleoperation
- Vision system (Vocus)
- Quadroter
www.volksbot.de

Thank you for your attention!

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Simulation of visual attention

**VOCUS: Bottom-up Mode**

Find max

Focus of Attention

Compute next focus

Saliency map

Intensity  Color  Orientation

Input image

Extended the work from Itti et al:

Itti, Koch, Niebur: "A model of saliency-based visual attention for rapid scene analysis", in PAMI '98
Top-down Attention

Bottom-up saliency map

Most salient region in rectangle

Weights

Intensity  Color  Orientation

Training image

Goal object is marked with a red square.

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
Simulation of visual attention

Top down search

Test image

Bottom-up search

Top-down search

Bottom-up saliency map

Top-down saliency map

Global Saliency map \( S \)

Focus of Attention

Excitation map \( E \)

Inhibition map \( I \)

Intensity

Color

Orientation

Uniqueness weight \( w \)

E: if \( w_i > 1 \): Map \( * w_i \)

I: if \( w_i < 1 \): Map \( * (1/w_i) \)

Focus of Attention

Weights

Bottom-up

Top-down

Uniqueness weight \( w \)

Test image

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Simulation visueller Aufmerksamkeit

Bottom-up Mode

Top-down Mode:
Suche Schlüsselanhänger
Multisensorielle und multimodale Objekterkennung

- **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)
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
- …
ProfiBot-Basismodell
ProfiBot-Module
Application of 3D sensor systems

- Environment recognition and Obstacle avoidance
- Mapping (2D, 3D)
- Surveying
- Object detection

Outlook:
- Recognition of Object function
- Mobile object manipulation
3D-Laserscanner

Voxel colored with Laser remission values


V. Becanovic, T. Günther and A. Bredenfeld, Modelling of Neuromorphic Vision Sensors in ODE, IEEE ICRA '05