# Publication Overview

2004 – 2020

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https://github.com/jkerdels/pub_overview

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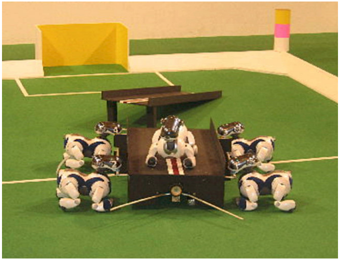
## RoboCup 2004 (1/2)

As an undergraduate I participated in a yearlong **robotics project** in which we programmed ERS-210 and ERS-7 robotic dogs made by Sony to compete in the Standard Platform League (SPL) of the international **RoboCup 2004 competition**.

Our technical report [1] provides an in-depth look into the core challenges of teaching robots to play soccer, the solutions developed by our team, and the involved support infrastructure.

As part of the GermanTeam – a collaboration between the universities of Berlin, Bremen, Darmstadt, and Dortmund – we won the world championship in the SPL as well as the SPL Open Challenge.



Scene from the SPL Open Challenge [1].

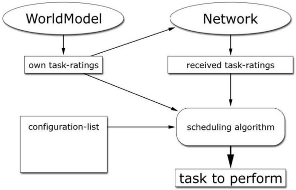
[1] Ingo Dahm et al. *Virtual Robot: Automatic Analysis of Situations and Management of Resources in a Team of Soccer Robots.* Tech. rep. PG 442 Final Report. University of Dortmund, 2004 PDF bibtex

# RoboCup 2004 (2/2)

We developed a **decentral scheduling algorithm** that allows multiple robots to coordinate their behavior to achieve a common goal in a challenging, dynamic environment where communication might be intermittent and the number of robots might change without prior notice [2, 3].

Characteristics of our approach:

- synchronization free
- low-bandwidth broadcast communication
- graceful degradation in case of
    - communication outages
    - loss of team members
- continuous replanning




Schematic of the proposed scheduler [2].

The scheduling algorithm was successfully used during the RoboCup 2004 competition winning the Standard Platform League Open Challenge [1]. video

[2] J. Ziegler et al. *Virtual Robot - Adaptive Ressource Management in Robot Teams*. Technical Report 0204. presented at International RoboCup Worldchampion, Lissboa, July 2004. University of Dortmund, 2004 PDF bibtex

[3] I. Dahm et al. "Decentral control of a robot-swarm". In: *Autonomous Decentralized Systems, 2005. ISADS 2005. Proceedings.* Apr. 2005, pp. 347–351. DOI: 10.1109/ISADS.2005.1452083 PDF bibtex

# Diploma Thesis (1/3)

My diploma thesis [4] presents a novel approach to **discover objects in unlabeled image data** using a combination of traditional methods including image segmentation, feature extraction, clustering, and dynamic programming.

The key idea consists of using **image segmentation to group features** in an image, and use these feature groups to represent the individual segments in a way that is invariant to rotation, scale, and translation.

Such feature segments can then be related to each other by an appropriate distance measure to **identify segments that occur repeatedly** in different contexts.

Finally, neighborhood relations among segments can be learned in a similar fashion to **discover stable feature segment constellations** that indicate the presence of reoccuring structures, i.e., putative objects in the images.

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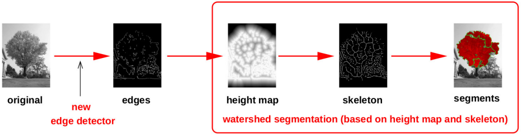
[4] Jochen Kerdels. "Dynamisches Lernen von Nachbarschaften zwischen Merkmalsgruppen zum Zwecke der Objekterkennung". Diplomarbeit. Diplom. University of Dortmund, Aug. 31, 2006 PDF bibtex

In [5] we present details of the **image segmentation** algorithm that was first introduced in my diploma thesis.

The algorithm has a focus on **robustness with respect to noise and discontinuous structures** like tree foliage.




Overview of the segmentation algorithm [5].

The algorithm was featured on the title page of "Informatik Spektrum" [6], the main organ of the German Informatics Society (GI).

[5] Gabriele Peters and Jochen Kerdels. "Image Segmentation Based on Height Maps". In: *Computer Analysis of Images and Patterns*. Ed. by WalterG. Kropatsch, Martin Kampel, and Allan Hanbury. Vol. 4673. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2007, pp. 612–619. ISBN: 978-3-540-74271-5. DOI: 10.1007/978-3-540-74272-2_76. URL: http://dx.doi.org/10.1007/978-3-540-74272-2_76 PDF bibtex

[6] Jochen Kerdels and G. Peters. *Höhenbildbasierte Segmentierung*. Springer–Verlag. Jan. 2007 PDF bibtex

# Diploma Thesis (3/3)

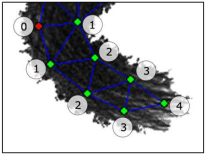
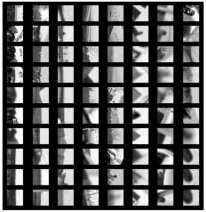



Illustration of distances on a learned topology [7].



Classification of feature vectors into 8 pairwise neighboring nodes. Columns represent nodes. Each column contains examples of 10 feature vectors mapped onto the respective node [7].

In [7] we present details of the **feature similarity measure** that was first introduced in my diploma thesis. The measure utilizes a **learned topology** of the feature space and does not rely on distance in Euclidean space.

Key ideas:

- Utilize a growing neural gas (GNG) to learn a piecewise representation of the feature space as well as its topology.
- Determine the shortest path between all pairs of nodes in the topology.
- The (dis)similarity between two features $f_1$ and $f_2$ is then given as the shortest path between those nodes $g_1$ and $g_1$ onto which the features are mapped by the GNG.

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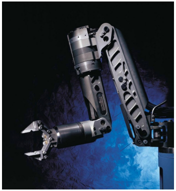
[7] Jochen Kerdels and G. Peters. "A Topology-Independent Similarity Measure for High-Dimensional Feature Spaces". In: *Artificial Neural Networks. 17th International Conference (ICANN 2007), September 9-13, Porto, Portugal. September 9-13, Porto*. Ed. by Joaquim Marques de SÃ¡ Et al. Vol. 4669. LNCS Part 2. Porto, Portugal: Springer, Sept. 2007, pp. 331–340 PDF bibtex

**C-Manipulator** [8] is a research project that was conducted from 2006 to 2009 at the German Research Center for Artificial Intelligence (DFKI) in Bremen.

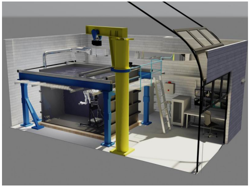
Its main objective was the development of a **manipulator system for deep sea applications** that provides autonomous and assistive functions to the system's operators.

The project used a **hydraulic ORION 7P** by Schilling Robotics as its main robotic arm. As main sensors, the system was equipped with two overhead cameras used for stereo vision and a single camera mounted to the wrist for visual servoing.

The project was finished successfully with an open water test in coastal waters. **video**



The ORION 7P manipulator
((c) Schilling Robotics)



3D rendering of the underwater testbed
(Jan Albiez, DFKI)

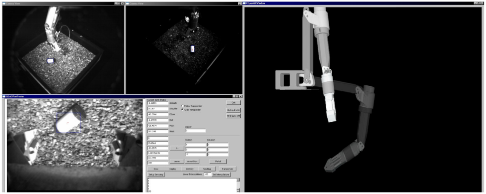
[8] Dirk Spenneberg et al. "C-Manipulator: An Autonomous Dual Manipulator Project for Underwater Inspection and Maintenance". In: *Proceedings of OMAE 2007*. ASME 2007 International Conference on Offshore Mechanics and Arctic Engineering. San Diego, USA, 2007 **PDF** **bibtex**

# Project C-Manipulator (2/4)

In [9] we report on **early results** of the C-Manipulator project that introduce a number of improvements over the traditional, manual control of underwater robotic arms:

- We developed a **fast inverse kinematic closed form solution** that allows movements in cartesian space and guarantees numerical stability.
- We implemented a two-phase, **semi-autonomous gripping** of objects. video

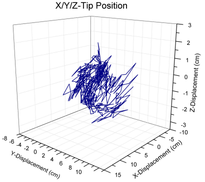
The Orion 7P in our underwater testbed [9].



View of the control software. The left side contains all three camera images. The right side shows a 3D representation of both the current (solid) and future (transparent) positions of the manipulator [9].

[9] Marc Hildebrandt et al. "Robust Vision-Based Semi-Autonomous Underwater Manipulation". In: *The 10th International Conference on Intelligent Autonomous Systems*. Ed. by Wolfram Burgard et al. IOS Press, 2008, pp. 308–315 PDF bibtex

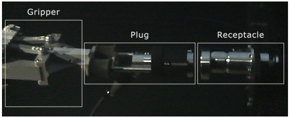
# Project C-Manipulator (3/4)




3d plot of tip displacement during movement compensation [10].

Deep sea robotic arms are usually mounted to remotely operated vehicles (ROV). We developed a **novel algorithm to compensate for disturbances** that does not rely on the station-keeping algorithm of the ROV but compensates vehicle movements directly **via a movement overlay** in the robotic arm [10]. video

We **augmented the built-in controller** of the ORION 7P with a multi-layered controller enabling **high precision end-effector control** well beyond the manipulator's original capabilities [11]. We showcased the achievable precision by the automated plugging of an underwater connector. video




Automated plugging of a Gisma Series 80 underwater connector [11].

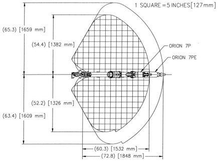

[10] Marc Hildebrandt et al. "Realtime motion compensation for ROV-based teleoperated underwater manipulators". In: *OCEANS 2009 - EUROPE*. 978-1-4244-2523-5. May 2009 PDF bibtex

[11] Marc Hildebrandt et al. "A Multi-Layered Controller Approach for High Precision End-Effector Control of Hydraulic Underwater Manipulator Systems". In: *OCEANS 09 MTS / IEEE Biloxi - Marine Technology for Our Future: Global and Local Challenges. OCEANS MTS/IEEE Conference (OCEANS-09), Marine Technology for our Future: Global and Local Challenges, October 26-29, Biloxi, USA*. o.A., Oct. 2009. ISBN: 978-1-4244-4960-6 PDF bibtex

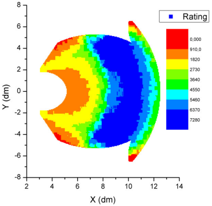
One of the primary tasks of modern ROV deployment is **intervention work**. Intervention in these cases consists of tasks like opening fixtures, or plugging connections.

Robotic operators have to rely solely on visual feedback and their experience to determine if in a given situation a desired position is reachable, and how much dexterity will be available to perform the intended task.

We introduced a **methodology to represent workspace properties** like remaining dexterity with **respect to tele-operation tasks** [12]. The information gained can be used as a signal to an operator or as the basis for motion commands to the ROV carrying the robot arm.




Nominal workspace of the ORION 7P [12].

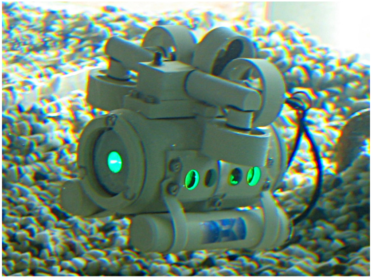



Dexterous workspace of the ORION 7P for a front-down position of the gripper [12].

[12] Jan Albiez et al. "Automatic Workspace Analysis and Vehicle Adaptation for Hydraulic Underwater Manipulators". In: *OCEANS 2009, MTS/IEEE Biloxi - Marine Technology for Our Future: Global and Local Challenges.* o.A., Oct. 2009 PDF bibtex

# $\mu$AUV

The **Micro Autonomous Underwater Vehicle** ($\mu$AUV) was developed and built as a demonstrator for the Hannover trade show in just two months [13, 14]. video



The $\mu$AUV 1 [13].

Vehicle characteristics:

- main body diameter of just 55mm and a body length of 125mm
- autonomous on-board controller
- obstacle detection via active light reflection
- depth measurement via pressure sensor

Successors: $\mu\mathrm{AUV}^2$ and AUVx.

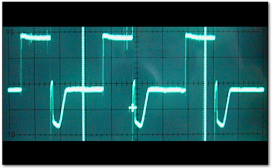

[13] Sascha Fechner et al. "Design of a $\mu$AUV". In: *Autonomous Minirobots for Research and Edutainment (AMiRE-2007). Proceedings of the 4th International AMiRE Symposium (AMiRE-2007), October 2-5, Buenos Aires, Argentinien*. Ed. by U. Rückert, J. Sitte, and U. Witkowski. Best Paper Award. Buenos Aires, Argentinien: Heinz Nixdorf Institut Universiät Paderborn, Oct. 2007, pp. 99–106 PDF bibtex **best paper award**

[14] Jan Albiez et al. "Sensor Processing and Behaviour Control of a Small AUV". In: *Autonome Mobile Systeme AMS 2007- 20. Fachgespräch Kaiserslautern*. Robotics Research Lab of the University of Kaiserslautern. Kaiserslautern, Germany: Springer, Oct. 2007, pp. 327–333 PDF bibtex

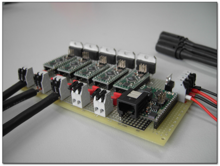
# Sensorless Control

The sub-Atlantic underwater manipulator is an electric robotic arm that provides **no sensor feedback**. To control this arm we developed a **Back-EMF controller** that drives the motors via pulse width modulation and uses the voltage generated by the motors during the off-phase to determine their current speed [15].

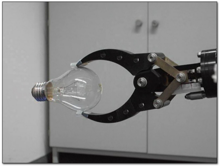
Based on this speed signal it was possible to implement both **position and force control** on this otherwise sensorless manipulator.



Voltage characteristic at the motor terminals while a 33% duty cycle PWM is applied [15].



Electronic prototype to demonstrate the Back-EMF approach [15].



Illustrating the sensitivity achievable with back EMF force control [15].

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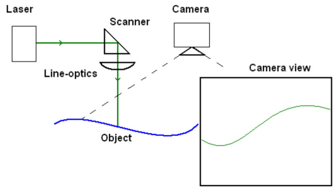
[15] Jochen Kerdels, Jan Albiez, and Frank Kirchner. "Sensorless Computer Control of an Underwater DC Manipulator". In: *Proceedings of OCEANS '08 (MTS) / IEEE KOBE-TECHNO-OCEAN '08. Voyage Toward the Future. (MTS) / IEEE KOBE-TECHNO-OCEAN Conference and Exhibition (OTO-2008), April 8-11, Kobe, Japan*. IEEE, 2008 PDF bibtex

# Underwater 3D-Laserscanner

To explore the concept of **underwater, laser line 3D scanning** we built a prototype system. In particular, we were interested in improving the precision of the scanner by designing a calibration procedure that is simple enough to be applicable in practise.

In [16] we suggest to use a planar calibration object that is fitted with a checkerboard pattern for calibration of the camera and a high contrast region for detecting the laser line.

Our results indicate that this is a feasable approach that could be used in non-laboratory environments without too much effort.




Schematic representation of a laser line 3D scanner [16].

The concept was followed up on by a number of later projects and led to a **spin-off company** (Kraken Robotik) founded by some of my former colleagues.

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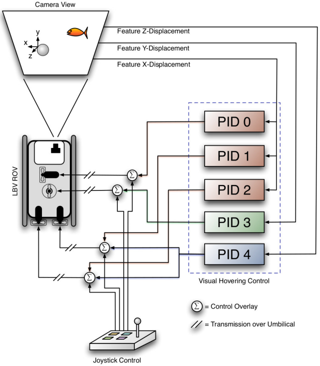
[16] Marc Hildebrandt et al. "A practical underwater 3D-Laserscanner". In: *Proceedings of the MTS/IEEE Conference on Oceans, Poles and Climate*. MTS/ IEEE Oceans. IEEE, 2008 PDF bibtex




Hovering control scheme with 5 PID controllers [17].

LBV hovering in laboratory test tank *locked* on the tip of a 3D gantry crane (left). Tracking of visual features (right) [17].

# Visual Hovering

In [17] we present a **vision-based control** algorithm that enables underwater ROV to hover in front of visible structures compensating, e.g., drift.

We introduce a **novel approach to automatically tune the used keypoint detector** to the level of contrast present in each local region of the camera image. This automatic adjustment enables robust, paramter free operation.

The algorithm was successfully tested on a LBV150 ROV by Seabotix both under laboratory conditions and in open waters.

[17] Jochen Kerdels, Jan Albiez, and Frank Kirchner. "A Robust Vision Based Hover Control for ROV". In: *Proceedings of OCEANS '08 (MTS) / IEEE KOBE-TECHNO-OCEAN '08*. IEEE, 2008 PDF bibtex

# References I


[1] Ingo Dahm, Matthias Hebbel, Walter Nistico, Christoph Richter, Dr. Jens Ziegler, Damien Deom, Jörn Hamerla, Mathias Hülsbusch, Jochen Kerdels, Thomas Kindler, Hyung-Won Koh, Tim Lohmann, Manuel Neubach, Claudius Rink, Andreas Rossbacher, Frank Roßdeutscher, Bernd Schmidt, Carsten Schumann, and Pascal Serwe. *Virtual Robot: Automatic Analysis of Situations and Management of Resources in a Team of Soccer Robots.* Tech. rep. PG 442 Final Report. University of Dortmund, 2004.

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[3] I. Dahm, M. Hebbel, M. Hulsbusch, J. Kerdels, W. Nistico, C. Schumann, and M. Wachter. "Decentral control of a robot-swarm". In: *Autonomous Decentralized Systems, 2005. ISADS 2005. Proceedings*. Apr. 2005, pp. 347–351. DOI: 10.1109/ISADS.2005.1452083.

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# References II


[11] Marc Hildebrandt, Jochen Kerdels, Jan Albiez, and Frank Kirchner. “A Multi-Layered Controller Approach for High Precision End-Effector Control of Hydraulic Underwater Manipulator Systems”. In: *OCEANS 09 MTS / IEEE Biloxi - Marine Technology for Our Future: Global and Local Challenges. OCEANS MTS/IEEE Conference (OCEANS-09), Marine Technology for our Future: Global and Local Challenges, October 26-29, Biloxi, USA*. o.A., Oct. 2009. ISBN: 978-1-4244-4960-6.

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