Publication Overview

2004 – 2020

Jochen Kerdels

Jochen@Kerdels.de
https://github.com/jkerdels/pub_overview

July 23, 2020

Decentral Control in Robot Teams

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 [1, 2].

Characteristics of our approach:

- synchronization free
- low-bandwidth broadcast communication
- graceful degradation in case of
  - communication outages
  - loss of team members
- continuous replanning
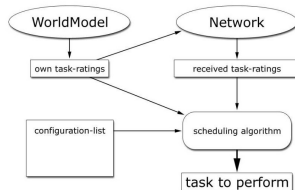
Schematic of the proposed scheduler [1].

The scheduling algorithm was successfully used during the RoboCup 2004 competition winning the Standard Platform League Open Challenge [3]. video

---

[1] 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

[2] 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

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 [3] 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.
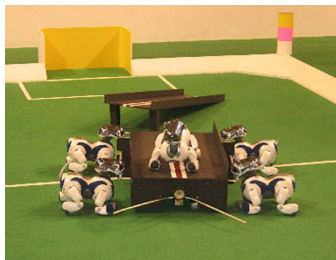
Scene from the SPL Open Challenge [3].

[3] 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**

Diploma Thesis

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.

————————

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

Project C-Manipulator (1/4)

C-Manipulator [5] 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)
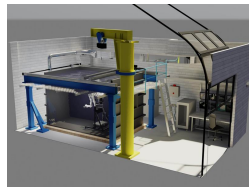
3D rendering of the underwater testbed
(Jan Albiez, DFKI)

----

[5] 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`

5/9

In [6] 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`
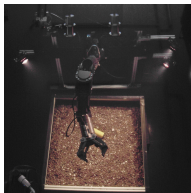
The Orion 7P in our underwater testbed [6].
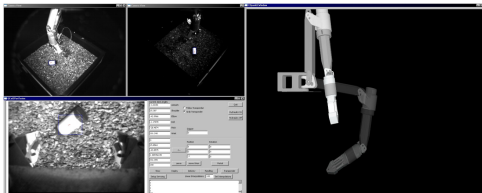
View of the control software. The left side contains all three camera images. The right side shows a 3D representation of both the current (solid) and future (transparent) positions of the manipulator [6].

[6] 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`

X/Y/Z-Tip Position
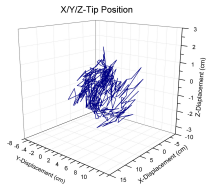
3d plot of tip displacement during movement compensation [7].

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 [7]. <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 [8]. We showcased the achievable precision by the automated plugging of an underwater connector. <video>

Automated plugging of a Gisma Series 80 underwater connector [8].

[7] 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**

[8] 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** [9]. 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.
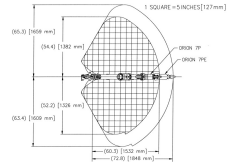
Nominal workspace of the ORION 7P [9].
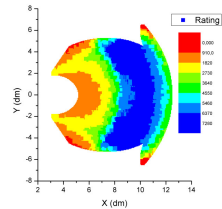
Dexterous workspace of the ORION 7P for a front-down position of the gripper [9].

[9] 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**

References I

[1] J. Ziegler, I. Dahm, M. Huelsbusch, and J. Kerdels. *Virtual Robot - Adaptive Ressource Management in Robot Teams*. Technical Report 0204. presented at International RoboCup Worldchampion, Lissboa, July 2004. University of Dortmund, 2004.

[2] 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.

[3] 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.

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

[5] Dirk Spenneberg, Jan Albiez, Frank Kirchner, Jochen Kerdels, and Sascha Fechner. "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.

[6] Marc Hildebrandt, Jochen Kerdels, Jan Albiez, and Frank Kirchner. "Robust Vision-Based Semi-Autonomous Underwater Manipulation". In: *The 10th International Conference on Intelligent Autonomous Systems*. Ed. by Wolfram Burgard, Rüdiger Dillmann, Christian Plagemann, and Nikolaus Vahrenkamp. IOS Press, 2008, pp. 308–315.

[7] Marc Hildebrandt, Leif Christensen, Jochen Kerdels, Jan Albiez, and Frank Kirchner. "Realtime motion compensation for ROV-based teleoperated underwater manipulators". In: *OCEANS 2009 - EUROPE*. 978-1-4244-2523-5. May 2009.

[8] 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.

[9] Jan Albiez, Marc Hildebrandt, Jochen Kerdels, and Frank Kirchner. "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.