Publication Overview

2004 – 2020

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https://github.com/jkerdels/pub_overview

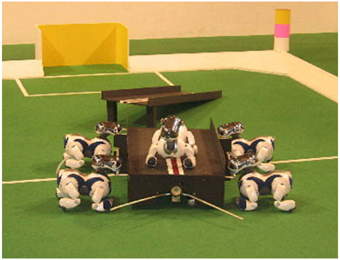
July 28, 2020

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].

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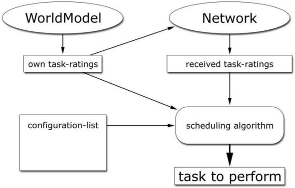
[1] Ingo Dahm et al. *Virtual Robot: Automatic Analysis of Situations and Management of Resources in a Team of Soccer Robots.* Tech. rep. PG 442 Final Report. University of Dortmund, 2004 **PDF** **bibtex**

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**

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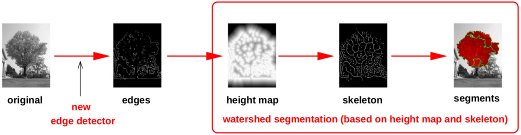
[4] Jochen Kerdels. "Dynamisches Lernen von Nachbarschaften zwischen Merkmalsgruppen zum Zwecke der Objekterkennung". Diplomarbeit. University of Dortmund, Aug. 31, 2006 **PDF** **bibtex**

Diploma Thesis (2/3)

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 cover of “Informatik Spektrum” [6], the main organ of the German Informatics Society (GI).

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[5] Gabriele Peters and Jochen Kerdels. “Image Segmentation Based on Height Maps”. In: *Computer Analysis of Images and Patterns.* Vol. 4673. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2007, pp. 612–619 **PDF** **bibtex**

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

Diploma Thesis (3/3)

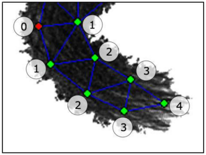
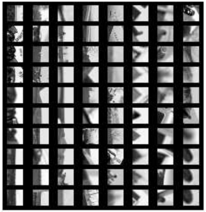


Illustration of distances on a learned topology [7].



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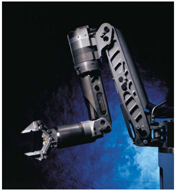
[7] Jochen Kerdels and G. Peters. "A Topology-Independent Similarity Measure for High-Dimensional Feature Spaces". In: *Artificial Neural Networks. 17th International Conference (ICANN 2007)*. Vol. 4669. LNCS Part 2. Porto, Portugal: Springer, Sept. 2007, pp. 331–340 **PDF** **bibtex**

Project C-Manipulator (1/4)

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.

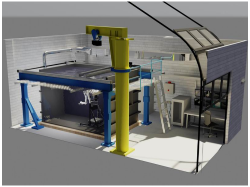
Its main objective was the development of a **manipulator system for deep sea applications** that provides autonomous and assistive functions to the system's operators.



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

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



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

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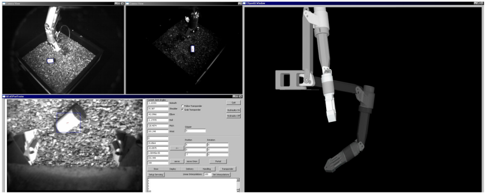
[8] Dirk Spenneberg et al. "C-Manipulator: An Autonomous Dual Manipulator Project for Underwater Inspection and Maintenance". In: *Proceedings of OMAE 2007*. ASME 2007 International Conference on Offshore Mechanics and Arctic Engineering. San Diego, USA, 2007 PDF bibtex

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].

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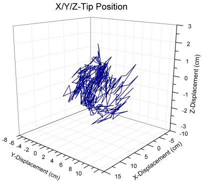
[9] Marc Hildebrandt et al. “Robust Vision-Based Semi-Autonomous Underwater Manipulation”. In: *The 10th International Conference on Intelligent Autonomous Systems*. IOS Press, 2008, pp. 308–315 PDF bibtex

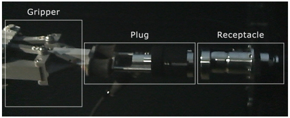
Project C-Manipulator (3/4)



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].

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

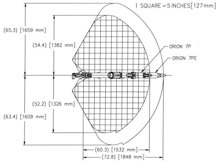
[11] Marc Hildebrandt et al. "A Multi-Layered Controller Approach for High Precision End-Effector Control of Hydraulic Underwater Manipulator Systems". In: *OCEANS MTS/IEEE Conference (OCEANS-09)*. o.A., Oct. 2009 **PDF** **bibtex**

Project C-Manipulator (4/4)

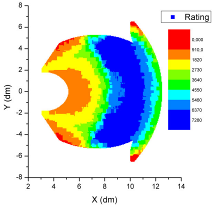
One of the primary tasks of modern ROV deployment is **intervention work**. Intervention in these cases consists of tasks like opening fixtures, or plugging connections.

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].

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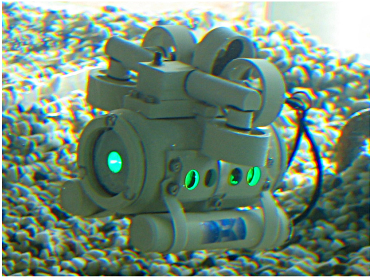
[12] Jan Albiez et al. "Automatic Workspace Analysis and Vehicle Adaptation for Hydraulic Underwater Manipulators". In: *OCEANS MTS/IEEE Conference (OCEANS-09)*. o.A., Oct. 2009 **PDF** **bibtex**

μAUV

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



The μAUV 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.

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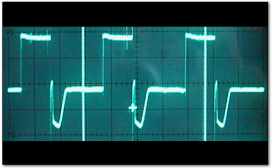
[13] Sascha Fechner et al. “Design of a μAUV”. In: *Proceedings of the 4th International AMiRE Symposium (AMiRE-2007)*. Buenos Aires, Argentinien: Heinz Nixdorf Institut Universiät Paderborn, Oct. 2007, pp. 99–106 **PDF** **bibtex** **best paper award**

[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**

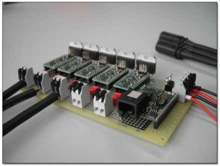
Sensorless Control

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].

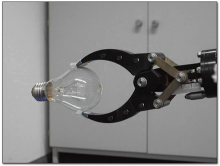
Based on this speed signal it was possible to implement both **position and force control** on this otherwise sensorless manipulator.



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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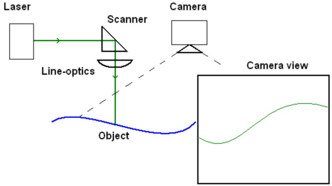
[15] Jochen Kerdels, Jan Albiez, and Frank Kirchner. "Sensorless Computer Control of an Underwater DC Manipulator". In: *Proceedings of OCEANS '08 (MTS) / IEEE KOBE-TECHNO-OCEAN '08*. IEEE, Apr. 2008 **PDF** **bibtex**

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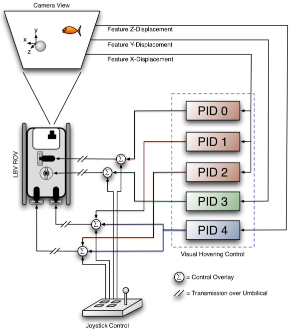
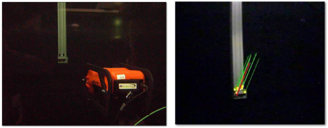
[16] Marc Hildebrandt et al. "A practical underwater 3D-Laserscanner". In: *Proceedings of the MTS/IEEE Conference on Oceans, Poles and Climate*. MTS/ IEEE Oceans. IEEE, 2008 **PDF** **bibtex**

Visual Hovering



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].

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 **video** by Seabotix both under laboratory conditions and in open waters.

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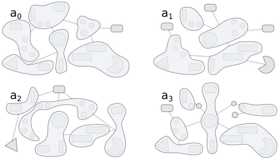
[17] Jochen Kerdels, Jan Albiez, and Frank Kirchner. “A Robust Vision Based Hover Control for ROV”. In: *Proceedings of OCEANS ’08 (MTS) / IEEE KOBE-TECHNO-OCEAN ’08*. IEEE, Apr. 2008 **PDF** **bibtex**

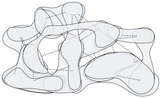
Exploratory Modeling (1/2)

After resigning from my research position at the DFKI and joining Prof. Peters at the University of Hagen **I refocused my work** away from robotic engineering towards more fundamental research aimed at understanding the **processing of information in neurobiological systems** – a topic I pursued already during my spare time at the DFKI.

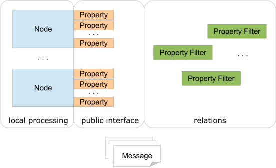
As a basis for this new direction of research we investigated how the **understanding of complex systems** can be improved **by methods of exploratory modeling and simulation**.



The constituents of a complex system may change when analyzed regarding different aspects [18].



Resulting constituents can "conceptually overlap" when they are merged into a single model [18].



Node

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Property
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Node

Property
Property
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Property

Property Filter
Property Filter
. . .
Property Filter

local processing
public interface
relations

Message

Components of the proposed generalized model [18].

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[18] Jochen Kerdels and Gabriele Peters. *A generalized computational model for modeling and simulation of complex systems*. Research Report 4. University of Hagen, Dec. 2012 **PDF** **bibtex**

Exploratory Modelling (2/2)

In [18] we **identify key aspects** that make modeling complex systems difficult:

- The relations between the constituents of a complex system can vary over time in non-trivial ways and thus cannot be specified in advance.
- Mutual influences between constituents of a complex system are not only represented by higher-level categories as in complicated systems but are also indicated by shared, lower-level categories.
- If a complex system is analyzed with respect to different aspects, the resulting constituents for each aspect can "conceptually overlap" when they are merged into a single model of the system.

Using a computational modeling perspective we reduced the problem space further to a single problem that we call the **addressing problem**.

As a solution to the addressing problem we propose a **generalized computational model** that is tailored to the specific needs of modeling and simulating complex systems [18, 19].

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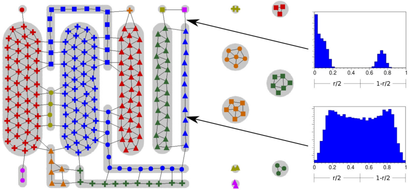
[19] Jochen Kerdels and Gabriele Peters. "Exploratory Modeling of Complex Information Processing Systems". In: *ICINCO (1)*. 2013, pp. 514–521 **PDF** **bibtex**

Local Input Space Histograms (1/3)

Prototype-based clustering methods like the **growing neural gas** (GNG) can suffer from a lack of detail in their input space representation. To amend their descriptive power we introduced the novel concept of **local input space histograms** (LISH) that capture statistical information on the input space lying between neighboring prototypes [20].

In a regular GNG neighboring prototypes are connected by an edge. We added a small histogram to each edge to **capture information on the positions of input samples** relative to the respective best and second best matching prototypes.



Clustering of an inhomogeneous input space (gray areas) with a GNG network of 250 units resulting in 23 clusters (marked by shapes and colors of the units). Histograms of two edges are shown on the right [20].

We were able to demonstrate that this additional information can be utilized to, e.g., **improve clustering** results for challenging, inhomogeneous input spaces.

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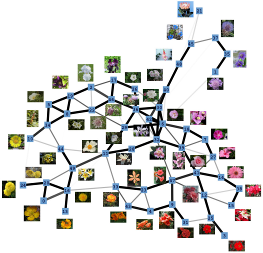
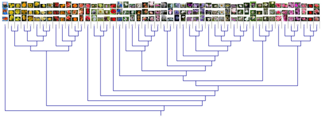
[20] Jochen Kerdels and Gabriele Peters. “Supporting GNG-based clustering with local input space histograms”. In: *Proceedings of the 22nd European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning*. Louvain-la-Neuve, Belgique, Apr. 2014, pp. 559–564 **PDF** **bibtex**

Local Input Space Histograms (2/3)



Force-based graph drawing of an image clustering based on color performed by a LISH enhanced GNG [21].



Hierarchical image clustering based on color performed by a LISH enhanced GNG [21].

In a follow-up work [21] we investigate the utility of LISH enhanced GNGs for **analysing and clustering high-dimensional data**. Our results demonstrate, that the additional information gained about the input space structure can be used to enable and improve visualization and hierarchical clustering.

Furthermore, we show that contrary to common view the **Minkowski distance with $p > 1$ can be a meaningful distance measure** for high-dimensional data.

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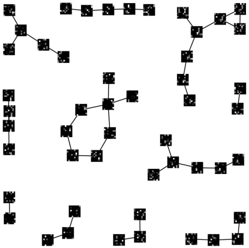
[21] Jochen Kerdels and Gabriele Peters. "Analysis of high-dimensional data using local input space histograms". In: *Neurocomputing* 169 (2015), pp. 272–280 **PDF** **bibtex**

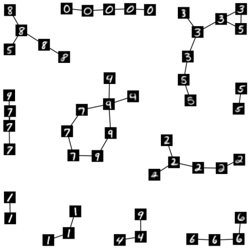
[22] Jochen Kerdels and G. Peters. *Clustering Hochdimensionaler Daten*. Springer–Verlag. Apr. 2015 **PDF** **bibtex** **featured on "Informatik Spektrum" cover**

Local Input Space Histograms (3/3)

Further investigation of the LISH concept [23] showed that information gathered by the LISH can be utilized to form a **relaxed one-hot encoding** as the output of a GNG. Processing this output with a second stage GNG demonstrates that the encoding may serve as a meaningful **sparse representation of high-dimensional input spaces**.



Example of a GNG *r* that processed the relaxed one-hot encoded output of a GNG *h* that processed samples from the MNIST database of handwritten digits. The shown prototypes reveal the sparse patterns resulting from the relaxed one-hot encoding [23].



Prototypes of GNG *h* superimposed on the network of GNG *r*. The shown prototypes correspond to the entry with highest value in the respective prototypes of GNG *r* [23].

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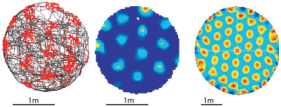
[23] Jochen Kerdels and Gabriele Peters. "A Sparse Representation of High-Dimensional Input Spaces Based on an Augmented Growing Neural Gas". In: *GCAI 2016. 2nd Global Conference on Artificial Intelligence*. Vol. 41. EPiC Series in Computing. EasyChair, 2016, pp. 303–313 **PDF** **bibtex**

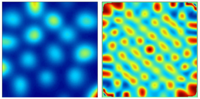
Grid Cell Modeling (1/5)

Grid Cells are **neurons in the entorhinal cortex of mammals** that exhibit very specific patterns of activity that correlates strongly with the allocentric location of the animal.

Virtually all existing computational models of grid cells are **narrow models** that view grid cells as part of a specialized system for navigation.



Typical visualization of the recorded activity of a grid cell [24].



Activity pattern of a grid cell that was simulated by us [24].

We were the first to suggest that grid cell activity might reflect a **general computational principle** that underlies not only the behavior of grid cells but describes the behavior of (some) cortical cell groups in general [25, 24].

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[25] Jochen Kerdels and Gabriele Peters. "A Computational Model of Grid Cells Based on Dendritic Self-Organized Learning". In: *Proceedings of the International Conference on Neural Computation Theory and Applications*. 2013 **PDF** **bibtex** **nominated for best paper award**

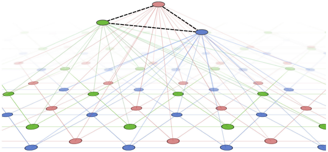
[24] Jochen Kerdels and Gabriele Peters. "A New View on Grid Cells Beyond the Cognitive Map Hypothesis". In: *8th Conference on Artificial General Intelligence (AGI 2015)*. July 2015 **PDF** **bibtex**

Grid Cell Modeling (2/5)

My dissertation [26] investigates **entorhinal grid cells** in detail covering their neurobiological and functional properties [27], as well as existing computational models and their associated functional hypotheses.

The main contribution of my work is the introduction of a **new computational model** that views grid cell activity as expression of a **general computational principle**.

At the core of this general principle lies the **novel conjecture** that cortical neurons learn a representation of their **entire** input space while competing locally with their peers.



Schematic view of a two-layer RGNG network used to simulate a group of grid cells [26].

The dissertation was honoured with the **faculty award** for the best scientific work in 2017. [laudation: **video** , presentation: **video**]

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[26] Jochen Kerdels. "A Computational Model of Grid Cells based on a Recursive Growing Neural Gas". PhD thesis. Hagen, 2016 **PDF** **bibtex**

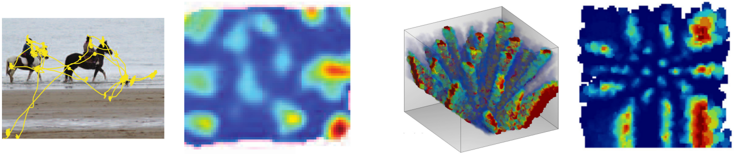
[27] Jochen Kerdels and Gabriele Peters. "A Survey of Entorhinal Grid Cell Properties". In: *arXiv e-prints*, arXiv:1810.07429 (Oct. 2018), arXiv:1810.07429. arXiv: `1810.07429 [q-bio.NC]` **PDF** **bibtex**

[28] Jochen Kerdels and G. Peters. *Simulation von Gitterzellen als Spezialfall eines allgemeinen neuronalen Verarbeitungsprinzips*. Springer–Verlag. June 2018 **bibtex** **featured on "Informatik Spektrum" cover**

Grid Cell Modeling (3/5)

Killian et al. discovered **grid-like activity** of entorhinal cells that was not correlated with location but rather with the animal's **gaze direction**.

Since our model is based on a general computational principle and does not rely on assumptions regarding navigation and orientation we were able to **model and replicate the observed phenomena** [29, 30].



Grid-like activity that correlates with saccadic eye movements was observed in primates by Killian et al. (left). Modeling binocular eye movements with our computational model results in a three-dimensional activation space that recreates the observed patterns when reduced to the two-dimensional viewing plane of the primate studied by Killian (right) [29, 30].

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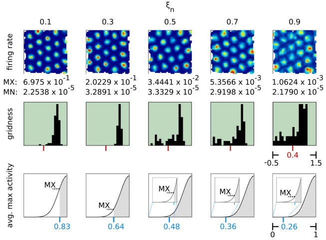
[29] Jochen Kerdels and Gabriele Peters. "Modelling the Grid-like Encoding of Visual Space in Primates". In: *Proceedings of the 8th International Joint Conference on Computational Intelligence, IJCCI 2016, Volume 3: NCTA, Porto, Portugal, November 9-11, 2016.* 2016, pp. 42–49 **PDF** **bibtex** **best paper award**

[30] Jochen Kerdels and Gabriele Peters. "A Possible Encoding of 3D Visual Space in Primates". In: *Computational Intelligence: International Joint Conference, IJCCI 2016 Porto, Portugal, November 9–11, 2016 Revised Selected Papers.* Cham: Springer International Publishing, 2019, pp. 277–295 **PDF** **bibtex**

Grid Cell Modeling (4/5)

Noise Resilience is a necessary property of neurobiological systems as they experience a wide range of interference factors and are built out of components that are non reliable in general.



Artificial rate maps (top), gridness distributions (middle), and activity function plots (bottom) of simulation runs with varying levels ξ of noise (columns) added to the inputs. Details in [31].

We investigated the noise resilience of our computational grid cell model and were able to demonstrate that our **model is very robust to noise** due to the prototype-based nature of the underlying algorithm [32].

In a follow-up work we present a **noise compensation mechanism** that aims at equalizing the level of output activity across changing levels of noise [31].

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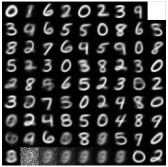
[32] Jochen Kerdels and Gabriele Peters. "Noise Resilience of an RGNG-based Grid Cell Model". In: *Proceedings of the 8th International Joint Conference on Computational Intelligence, IJCCI 2016, Volume 3: NCTA, Porto, Portugal, November 9-11, 2016.* 2016, pp. 33–41 **PDF** **bibtex** **nominated for best paper award**

[31] Jochen Kerdels and Gabriele Peters. "A Noise Compensation Mechanism for an RGNG-Based Grid Cell Model". In: *Computational Intelligence: International Joint Conference, IJCCI 2016 Porto, Portugal, November 9–11, 2016 Revised Selected Papers.* Cham: Springer International Publishing, 2019, pp. 263–276 **PDF** **bibtex**

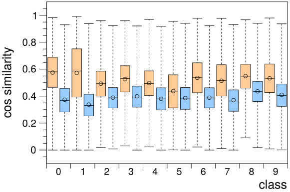
Grid Cell Modeling (5/5)

The dentate gyrus (DG) in the hippocampus of the mammalian brain is known to exhibit strong **pattern separation**. However, how this pattern separation arises in the DG is not well understood.

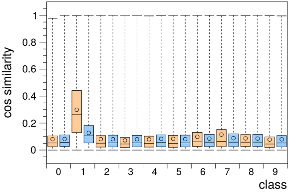
Based on our grid cell model we offer a novel hypothesis regarding this question by demonstrating that **pattern separation can already be performed by entorhinal grid cells**, which are located just one synapse upstream of the DG [33].



Examples of 80 prototypes that form the input space representation of a simulated grid cells [33].



Box plot of the intra-class (orange, left columns) and inter-class (blue, right columns) cosine similarity distributions occurring in the MNIST dataset. Details in [33].



Box plots the intra- and inter-class cosine similarity distributions occurring in simulated multimodal activity vectors of grid cell groups encoding the top, bottom, left, or right halves of the MNIST input samples. Details in [33].

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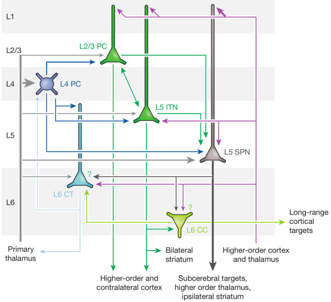
[33] Jochen Kerdels and Gabriele Peters. "Entorhinal Grid Cells May Facilitate Pattern Separation in the Hippocampus". In: *Proceedings of the 9th International Joint Conference on Computational Intelligence, IJCCI 2017, Funchal, Madeira, Portugal, November 1-3, 2017.* 2017, pp. 141–148 **PDF** **bibtex**

Towards a Model of Cortical Function (1/2)

The cortex of mammals has a distinct, low-level structure consisting of six horizontal layers that are vertically connected by local groups of about 80 to 100 neurons forming so-called **minicolumns**.

Based on our previous efforts to model the behaviour of entorhinal grid cells we argue in [34] that a single **cortical column** can function as an independent, **autoassociative memory cell** (AMC) that utilizes a sparse distributed encoding.

In [35] we develop our ideas further and argue that **cortical memory is a distributed, dynamic process** that is an intrinsic part of the cortical network both structurally and functionally.



Canonical connectivity of cortical principal cells [34].

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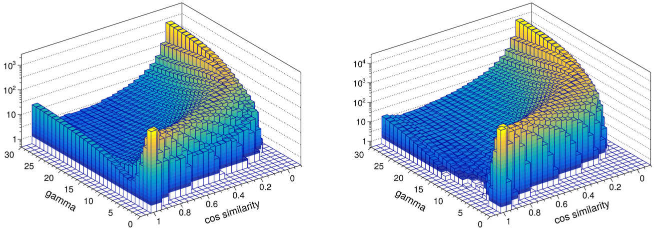
[34] Jochen Kerdels and Gabriele Peters. “A Grid Cell Inspired Model of Cortical Column Function”. In: *10th International Joint Conference on Computational Intelligence (IJCCI 2018), Seville, Spain, September 18-20.* Jan. 2018, pp. 204–210 **PDF** **bibtex**

[35] Jochen Kerdels and Gabriele Peters. “Challenging the Intuition About Memory and Computation in Theories of Cognition”. In: *Proceedings of the 11th International Joint Conference on Computational Intelligence - Volume 1: NCTA, (IJCCI 2019).* INSTICC. SciTePress, Sept. 2019, pp. 522–527 **PDF** **bibtex**

Towards a Model of Cortical Function (2/2)

In [36] we revisit the algorithm underlying our grid cell model and present an **efficient approximation** of the original algorithm that is more robust regarding the formation of the group's input space representation, is structurally less complex, and is computationally more efficient.



Histograms of pairwise cosine similarities between ensemble activity vectors of a modeled neuron group in response to the MNIST test dataset. Left shows cosine similarities for intra-class samples. Right shows the results for inter-class samples. Details in [36].

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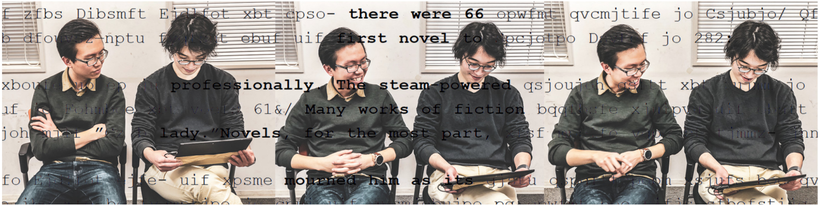
[36] Jochen Kerdels and Gabriele Peters. "Efficient Approximation of a Recursive Growing Neural Gas". In: *Studies in Computational Intelligence, IJCCI 2018, Revised Selected Papers*. Springer International Publishing, 2020 PDF bibtex

Private Reader



The Private Reader Concept: Using eyetracking to make successful "Shoulder Surfing" more difficult. [37].

In a casual conversation with **Prof. Kai Kunze** from Keio University (Japan) we developed the idea that we could use **eye tracking on mobile devices** to make "shoulder surfing" more difficult and thus enhance the privacy in crowded, public spaces.

The main idea consists in **obfuscating the screen content** in those areas, **where the user is currently not looking**.

In [37] students of Prof. Kunze investigated the idea by implementing a prototype and conducting a pilot study.

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[37] Kirill Ragozin et al. "Private Reader: Using Eye Tracking to Improve Reading Privacy in Public Spaces". In: *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services*. Taipei, Taiwan: Association for Computing Machinery, 2019, Article 18 **PDF** **bibtex**

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References IV

[37] Kirill Ragozin, Yun Suen Pai, Olivier Augereau, Koichi Kise, Jochen Kerdels, and Kai Kunze. "Private Reader: Using Eye Tracking to Improve Reading Privacy in Public Spaces". In: *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services*. Taipei, Taiwan: Association for Computing Machinery, 2019, Article 18.