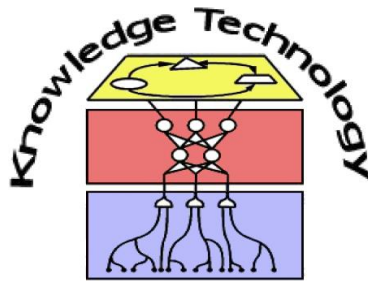


Neural Networks

Lecture 1: Overview and Introduction

Prof. Dr. Stefan Wermter, Dr. Weber
Knowledge Technology Research Group



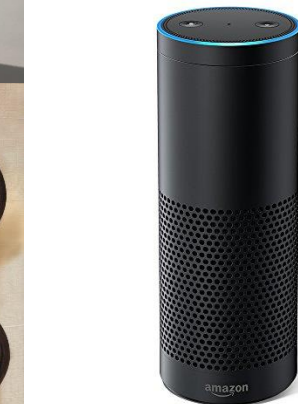
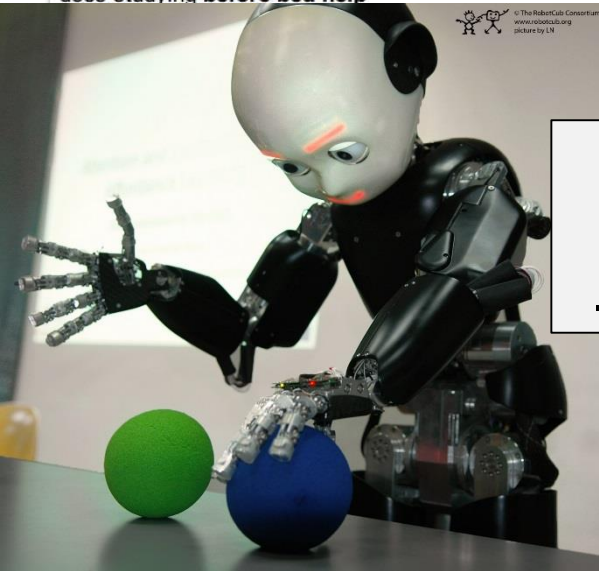
<http://www.informatik.uni-hamburg.de/WTM/>



does studying |

does studying **economics make you selfish**
does studying **burn calories**
does studying **economics inhibit cooperation**
does studying **make you tired**
does studying **make you hungry**
does studying **economics breed greed**
does studying **make you smarter**
does studying **make you lose weight**
does studying **with music help**
does studying **before bed help**

© The RobotCub Consortium
www.robotcub.org
picture by UN



Artificial
Neural Networks
...are everywhere.



...inspired by our own brain and mind



“Man is still the most extraordinary computer of all.” [John F. Kennedy]

“The new century of the brain.”
[Yuste, Church]

“Best examples for intelligent systems can be found in the brain.”
[Wermter]

“Nobody phrases it this way, but I think that artificial intelligence is almost a *humanities* discipline.

It's really an attempt to understand human *intelligence* and human *cognition*.”

[Sebastian Thrun]

Motivation for this module

- To provide an insight into building neural architectures for intelligent systems
- To give examples of intelligent system architectures in cognitive robotics, natural language processing,....
- To provide introduction and deepening in neural networks
- To provide background and basis for possible undergraduate or postgraduate projects, MSc and PhD studies
- Research-informed teaching mode on neural networks

Module delivered in English

- Module in Int. MSc. Intelligent Adaptive Systems
- International education gets more and more important for research, industry, business...
- ...from international schools to colleges and universities
- We want to help students to prepare for a career in industry or academia with an international English language element
- Most relevant computer science literature in English
- Slides will be in English and we deliver this module in English

Logistics

- Lecture

Thursday 10:15, D-220

- Seminar presentations

- As 2-4 blocks around Jul/Aug

- Examinations: verbal in English or German, July / September (Wermter, Weber)

- You can take this

- as a single module (*Vertiefung Master Informatik, Core lecture Master Intelligent Adaptive Systems*) ...
- or as part of the *Integriertes Anwendungsfach Neuroinformatik*

Your Choice!

Will be discussed after this lecture

Integrated Subject “Neuroinformatics”

- <https://www.inf.uni-hamburg.de/en/inst/ab/wtm/teaching/teaching-iaf-neuroinformatics.html>

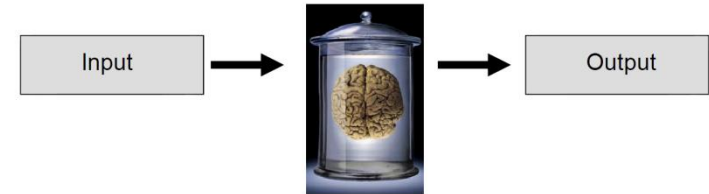
Neuroinformatik I				
Lecture	Allgemeine Psychologie	Jonas, Kao	WS, Tue 14-17,	Audimax 2
Lecture	Bio-inspired Artificial Intelligence	Wermter	WS, Thu 10-12	D-220
Integrated Seminar	Bio-inspired Artificial Intelligence	Wermter, Alpay	WS, As a block	D-220
Neuroinformatik II				
Lecture	Biopsychologie	Bruns	WS , Wed 10-12 Mon 14-16 (2nd w.)	Audimax 1, Erzwiss H
Lecture	Neural Networks	Wermter	SS, Thu 10-12	D-220
Integrated Seminar	Neural Networks	Weber, Wermter	SS, As a block	D-220

- The Examination for Neuroinformatics II will include all courses.

IAF “Neuroinformatics” 2: Biopsychology

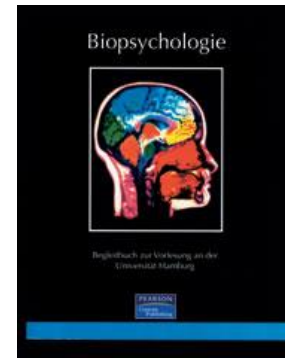
- ***Should have been heard last semester!***

- Will be offered again next winter semester



- **Topics:**

- Neurons, action potential, synapses, anatomy
- Qualitative and quantitative methods
- Visual and auditory systems
- Vestibular, gustatory and olfactory systems
- Somatosensory and sensorimotor systems
- Plasticity and lateralisation
- Sleep, emotions, and stress



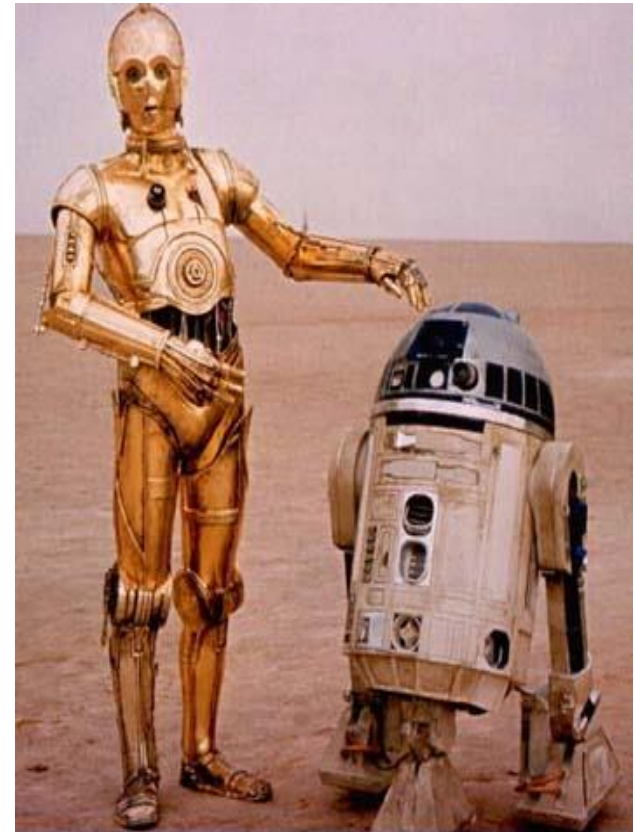
Remarks about slides

- These slides/notes are meant to facilitate access
- They are “pointers” to the learning
- Slides are not meant to replace text books or journals

A bit about us...

- Knowledge Technology Group
 - www.knowledge-technology.info
- Prof Wermter started the team at the University of Hamburg in 2010
- Main research interest in Neural and Hybrid (Neural Symbolic) Knowledge Technology
- Previously at
 - University of Sunderland, UK
 - ICSI / University of California, Berkeley, USA
 - University of Hamburg / Dortmund
 - University of Massachusetts, USA

The challenge: building neurocognitive agents ...



Agents need to reason, communicate, learn and develop many complex tasks...

How to do it? Rule-Based Systems?

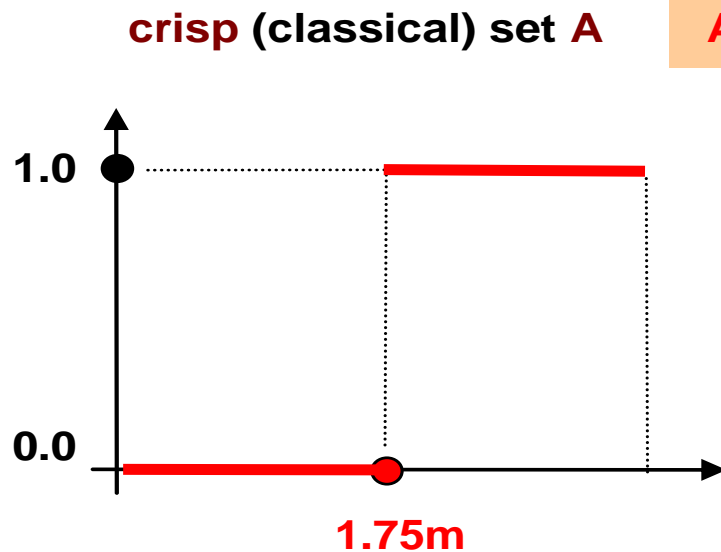
- Use rules to represent knowledge in an IF...THEN... form or more complex formalisms
- Use an “inference engine” to chain the rules together in different ways
- Allows the ability to explain decision by tracing which rules are used and when
- Strict symbolic logic rules alone may be brittle... extensions for learning and robustness possible?

Making strict symbolic reasoning more flexible: Fuzzy Logic

- Based on human reasoning which is imprecise, incomplete
- Uses a “membership function” to describe how strongly something belongs to a group
- Membership functions can be learned adaptively using for instance neural techniques
- Leads to powerful hybrid neural symbolic architectures

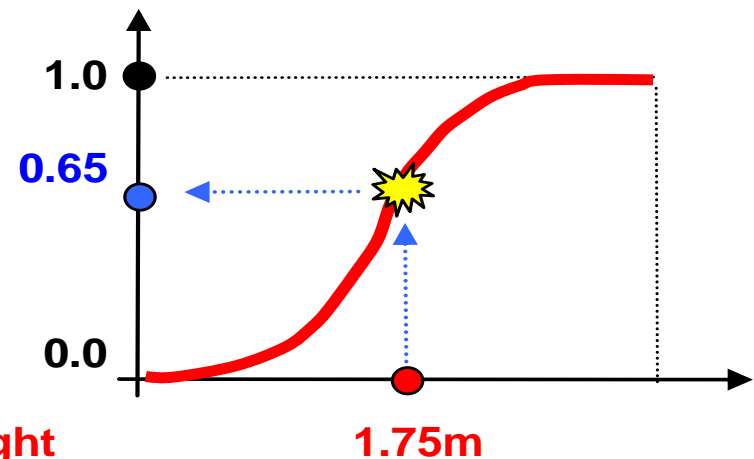
Fuzzy Sets

- The notion of membership in fuzzy sets becomes **a matter of degree** (real number in the closed interval $[0,1]$)
- **Membership** of an element in fuzzy set is measured by a *function that attempts to describe vagueness*



A = set of TALL people

fuzzy set A



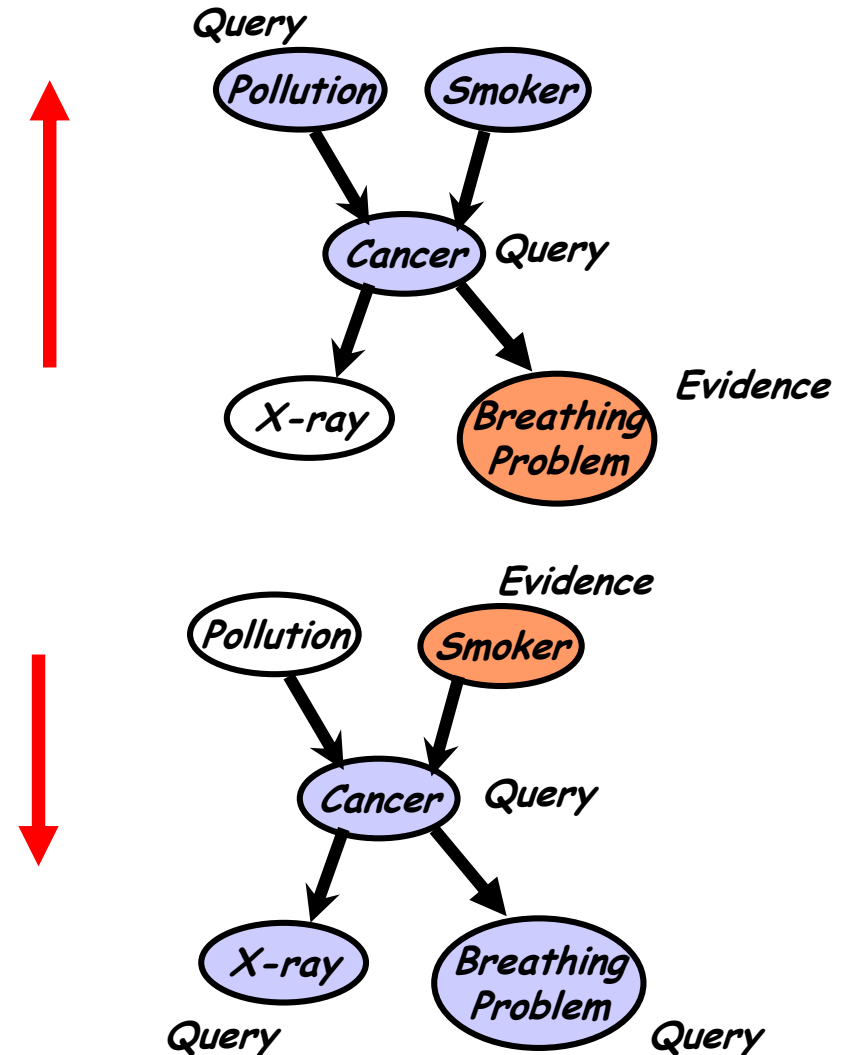
Statistical Methods

- Allow for the incorporation of prior knowledge into decision making models
- Provide an answer to a problem in terms of **probability** of an outcome
- **Robust** and consistent
- **Assumptions** to be made **about distribution functions** etc (not always this information is available)

Hybrid Knowledge Representation e.g. in Bayesian Networks

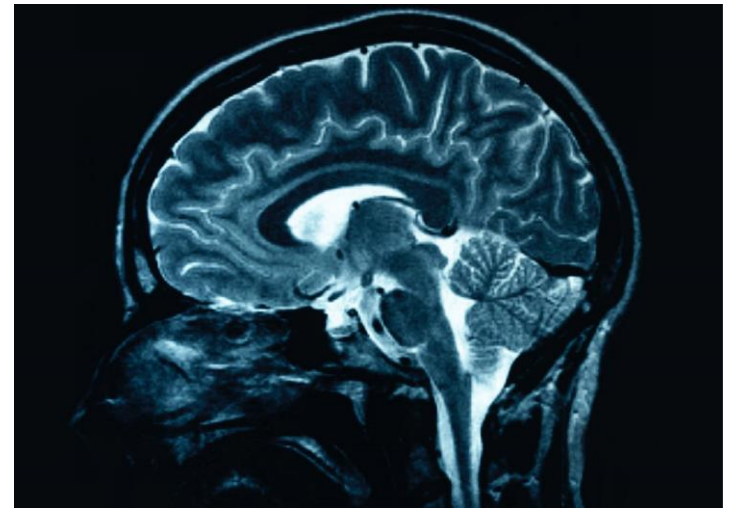
Diagnostic: From **symptoms** to **causes**. Reasoning occurs in opposite direction to network arcs

Predictive: Reasoning from new **causes** to new **effects**, follows the directions of the networks arcs



Focus in this Module: Neural Networks

- Use a simple **mathematical model** of a brain cell
- Many neurons connected together in a layered structure - a **network**
- **Weights** between neurons adjusted to learn mappings of inputs to outputs
- Powerful pattern recognition and generalisation techniques



A favourite Example for these approaches:

Motivating questions... or how to make a coffee

- How is it possible to bridge the large gap between neural network processing in the brain and intelligent performance of humans?
- How is it possible to build more effective systems which integrate neural techniques into intelligent systems?

Motivating questions... or how to make a coffee

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Motivating questions... or how to make a coffee

- How is it possible to bridge the large gap between neural network processing in the brain and intelligent performance of humans?
- How is it possible to build more effective systems which integrate neural techniques into intelligent systems?



Approach in Hybrid Neural Systems

■ The neurocognitive view

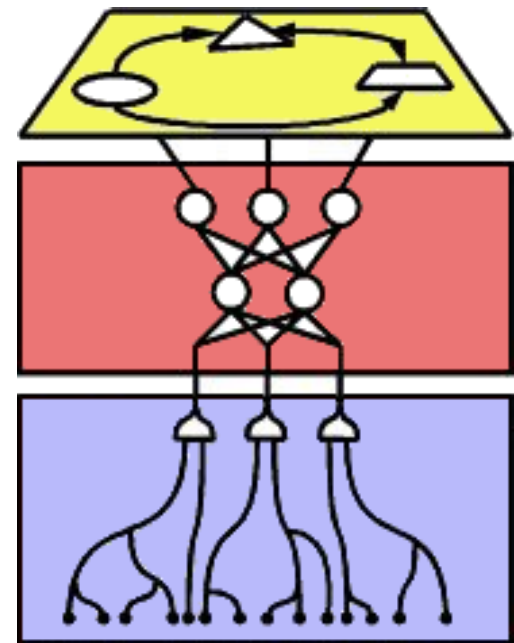
- Neural networks in the brain compute all intelligent behaviour
- Neural networks are therefore key to **model neurally or cognitively** observed behaviour

■ The knowledge technology view

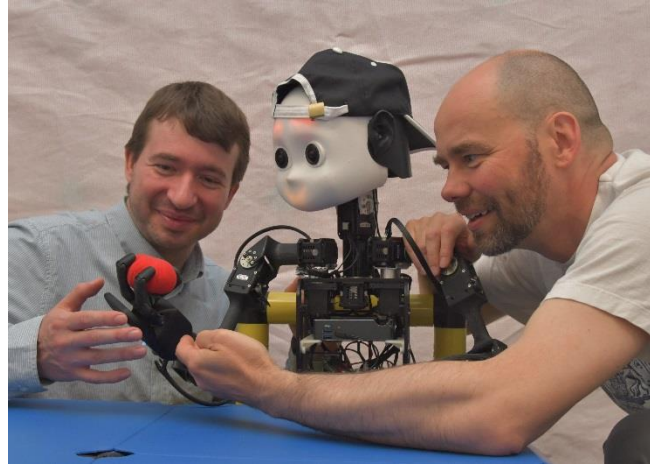
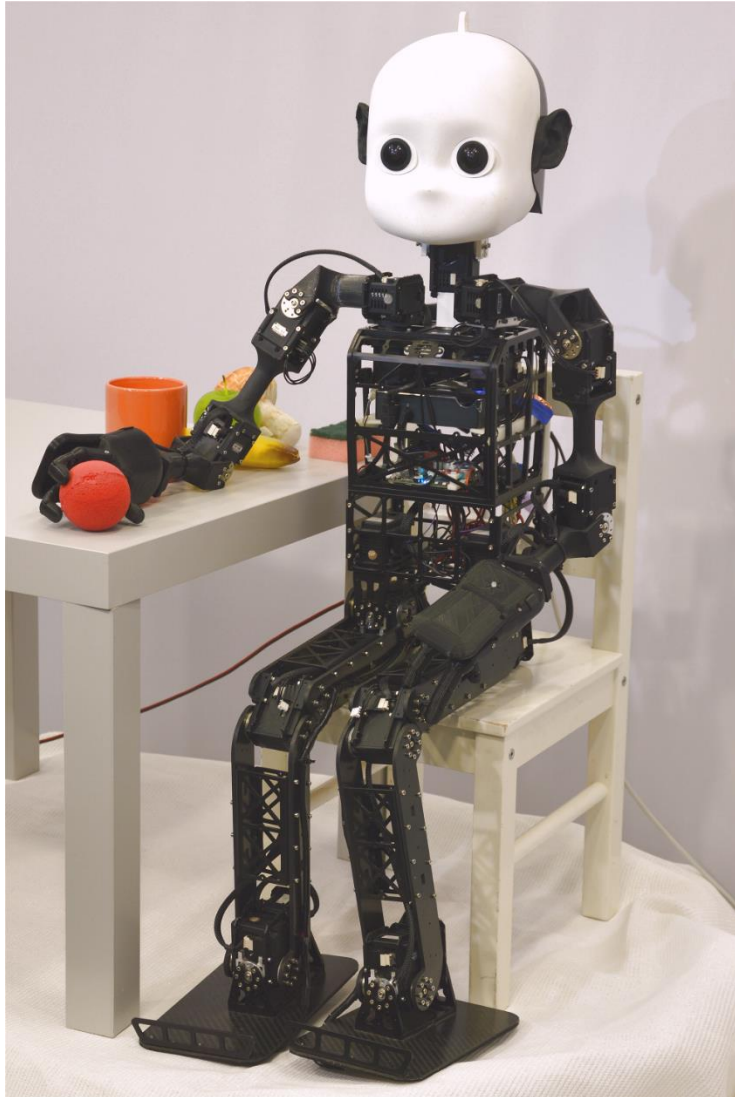
- **Intelligent systems** need both symbolic architecture processing and graded robust learning with neural networks
- **Integration of these techniques** since often more powerful than any single technique
- Neural networks are often part of a larger, integrated intelligent system (e.g. NICO, iCub, Alexa, Siri...)

Approach in our team: Neural Processing for Learning Cognitive Agents

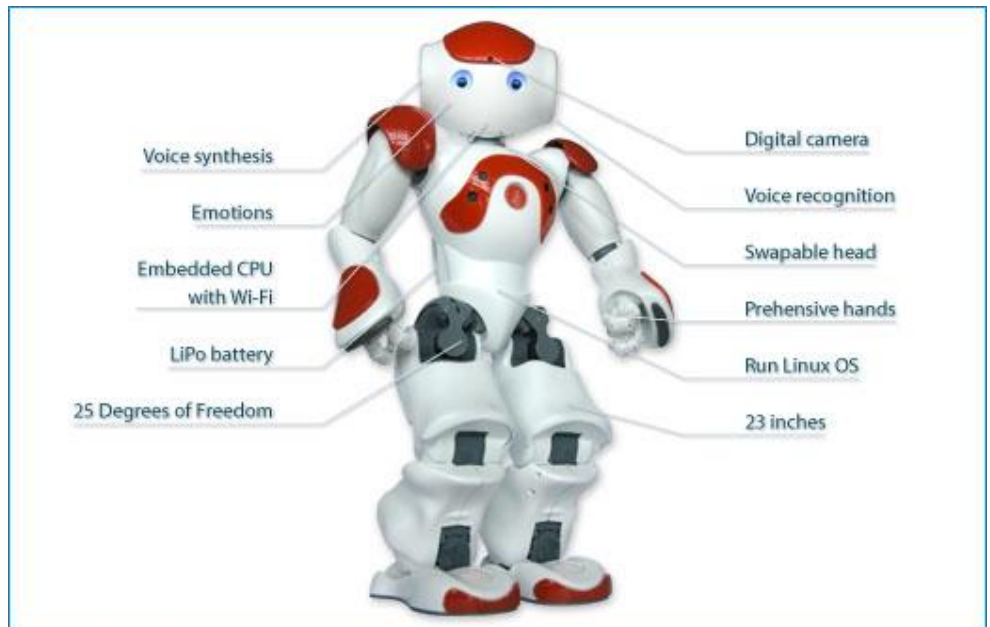
- Symbolic knowledge and planning
- Fast encoding and manipulation
- Interpretable knowledge and rules
- Reactive behavior
- Neural connectionist learning
- Robustness
- Embodied bioinspired computation
- Neuroscience and plasticity
- Spatiotemporal integration



Some of our Neurocognitive Platforms in Knowledge Technology for the Real World



*left: NICO
bottom: NAO*



On national TV

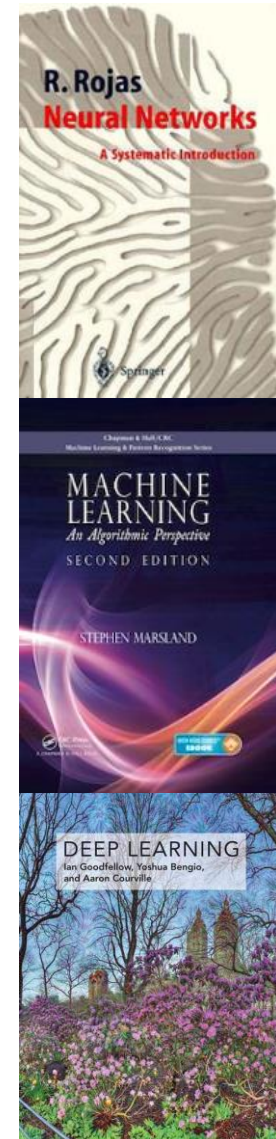


Introduction and topics of the module

- Overview of hybrid knowledge representation
- Neural networks introduction
- Learning in multilayer and recurrent networks
- Localist, distributed learning and shape recognition
- Neural network architectures
- Neuroscience-inspired architectures
- MLP, SOM, RNN, ESN, CNN Architectures
- Deep Learning
- Bioinspired robotic architectures
- ...

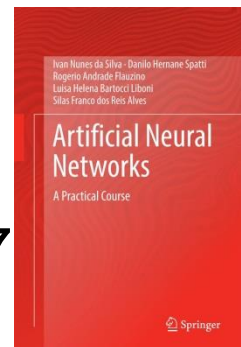
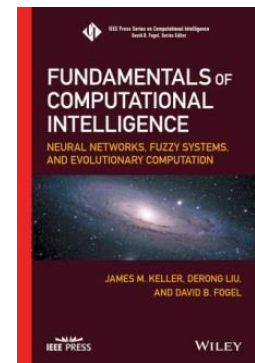
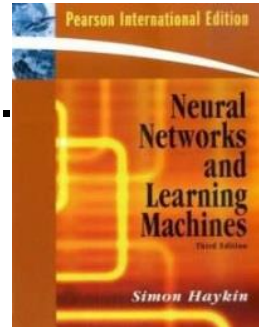
General literature background

- Rojas R. *Introduction to Neural Networks*.
Berlin: Springer, 1996. (free online)
page.mi.fu-berlin.de/rojas/neural
- Marsland, S.
*Machine Learning:
An Algorithmic Perspective*.
Chapman & Hall, 2009.
- Goodfellow I., Bengio Y., Courville A.:
Deep Learning.
MIT Press, 2016. (free online)
www.deeplearningbook.org



Further Reading (Foundations)

- Haykin S. *Neural Networks and Learning Machines*. Prentice Hall, 2008.
- Keller, J.M. et al.: *Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation*. (Chapt. 2,3,4,5) Wiley-IEEE Press, 2016. [1]
- Da Silva I. N., et al. *Artificial Neural Networks – A Practical Course*. Springer International Publishing, Switzerland, 2017



Further Reading (Seminar/Research)

- Wermter S., Sun R. *Hybrid Neural Systems*. Springer Verlag, Heidelberg, 2000.
- Wermter S., Riloff E., G. Scheler (Ed). *Connectionist, Statistical and Symbolic Approaches to Learning for Natural Language Processing*. Springer Verlag, Berlin, 1996.

MINCommSy: Apply for membership (I)

MIN-CommSy - Home

https://www.mincommsy.uni-hamburg.de/

UHH Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Not logged in

User ID:

Password:

Source:

Login

> Create new account
> Forgot your user ID?
> Forgot your password?


Portal message

Neu hier?

Als Studierende und Beschäftigte der UHH brauchen Sie keine gesonderte MIN-CommSy-Kennung zu beantragen. Loggen Sie sich einfach mit Ihrer „Benutzer-Kennung“ (vormals „STiNE-Kennung“, z.B. Bae1234) und dem zugehörigen Passwort in CommSy ein; achten Sie dabei darauf, dass unter „Quelle“ die Option „STiNE“ ausgewählt ist. Als externe Nutzer_in hingegen klicken auf Sie „Neue Kennung beantragen“ und füllen das Anmeldeformular aus; bei

WTM: Neural Networks SS2018

> Edit workspace
> Delete workspace

Entry: 

> Apply for membership

Description: <http://www.informatik.uni-hamburg.de/WTM/teac...>

Basics:

Contact persons:

- Cornelius Weber
- Contact via e-mail

Terms:

- Summer 17

Con

• In

Workspaces

Listed: 1 to 20 of 441

Title	Moderator/s	Activity
SE2 CommSy SoSe 2016	Christian Späh	
MAST - 16 ST - Empirical Software Engineering (Seminar)	Mathias Ellmann	
Populationsökologie	Veit Hennig	
WTM: Neural Networks SS2016	Cornelius Weber	

Search for workspace

Search in the list of all workspaces

Title, moderation, description:

Type:

*Please select

used workspaces

Choose "Type": "Project workspaces"

MINCommSy: Apply for membership (II)

Alternatively, you might see this:

Changing Language:
Name-Icon > Account >
> Zusatzfunktionen > Sprache

The screenshot shows the 'Rooms' page in MINCommSy. The main list of rooms is on the left, and a 'Restrict list' sidebar is on the right. A red arrow points from the 'TA' icon in the top navigation bar to the 'Search in room' input field. Another red arrow points from the 'Type' dropdown menu in the 'Restrict list' to the text 'choose "Type": "Project rooms"'. The 'Rooms' list contains the following entries:

Room Name	Date	Moderator	Action
Mathe-Vorkurs 2017	06.10.2017	Alexander Haas	Become member
Integriertes Fortgeschrittenenpraktikum 2017/2018	10.10.2017	Christian Wittenburg	Become member
SWT Vorlesung und Übung SoSe2017	15.09.2017	Matthias Riebisch	Become member
Tutorium zu Grundlagen der Chemie	10.10.2017	Sabrina Saidi	Become member
Exkursion Bulgarien und Griechenland 2017	20.04.2017	Isis Alexandra Offen	Become member
SE-Praktikum für Lehrämter (2017)	10.10.2017	Christiane Frede, Jonathan Otto, Detlef Rick	Become member
Orientierungseinheit Physik	09.10.2017	Torben Sobotke	Become member

The 'Restrict list' sidebar includes a search bar, checkboxes for 'Hide rooms without membership' and 'Hide archived rooms', a 'Type' dropdown menu (currently set to 'All'), and a 'Time Pulses' dropdown menu. A 'Suchen' button is at the bottom of the sidebar.

choose "Type":
"Project rooms"

Slides, announcements, background material.

The screenshot displays the CommSy web interface. On the left is a dark sidebar with navigation links: HOME, ANNOUNCEMENTS, MATERIALS (highlighted in red), USER, TOPICS, DISCUSSIONS, and SETTINGS. The main content area has a top navigation bar with 'All rooms' and 'My rooms' dropdowns, and a breadcrumb trail: 'MIN-CommSy / Informatik-CommSy / Project rooms / WTM: Neural Networks SS2018 / Materials'. Below this, a header for 'Materials (4 of 4)' includes 'Sort list' and 'Choose action' dropdowns. The list contains four items, all by 'Cornelius Weber (27.03.2018)':

- Lecture Neural Networks** (marked with a red exclamation mark icon)
- Seminar Organisation**
- Guidelines for literature research, reading, writing, reviewing, and pr...** (includes a document icon)
- Literature and Background**

...make sure to change your default email to one where we can contact you (seminar)!
We'll upload additional (optional) material for those interested (videos, papers, blogs)

Summary

- Previously knowledge representation approaches have mainly focused on symbolic representations
- Objective is to examine the foundations, representations and applications of **neural systems**
- Newer hybrid symbolic/neural/statistical approaches can be more **nature-inspired**
- Drawing inspiration from biological systems, neural systems or cognitive performance

Link and topics for the Seminar (Dr. Cornelius Weber)

- Neuroscience-inspired architectures
- Neuroscience-inspired robotics
- Spiking neural networks
- Midbrain / Cortical architectures
- Multimodal integration
- Mirror neuron theory
- Neural networks and language processing (NLP)
- Hybrid representations in robotics and NLP
- Integration of symbolic, neural and statistical approaches