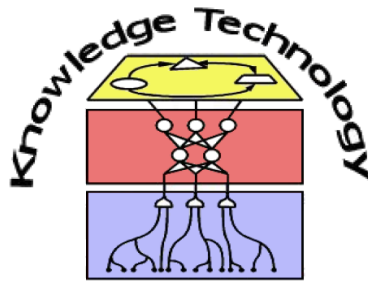


Knowledge Processing with Neural Networks

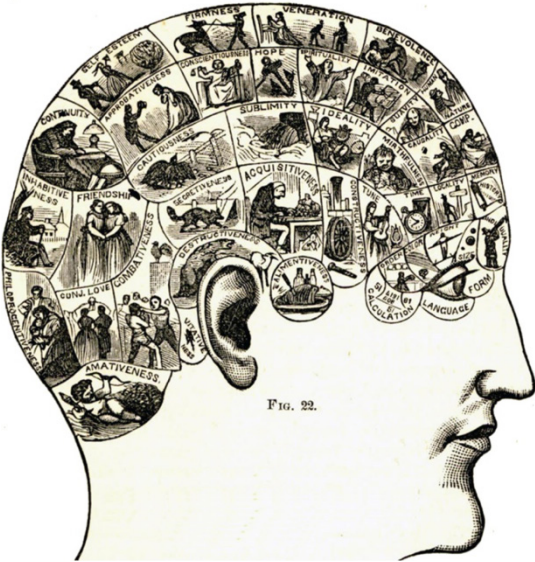
Overview and Introduction

Prof. Dr. Stefan Wermter



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

Neural Computing: The brain as the most exciting inspiration for computing



“Man is still the most extraordinary computer of all. “ [John F. Kennedy 1963]



but only because of neural
computing



Motivation for this module

- To provide an insight into building neural and hybrid neural/symbolic architectures in 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

Spoken language choice?

- 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
- Module in Intelligent Adaptive Systems

Logistics

- **Lecture**

Thursday 10:15, D-220

- **Seminar presentations**

- Suggested as a block on 11.7, 16.7, or 17.7
- Your Choice!** Will be discussed after this lecture

- **Examinations: verbal in English or German, July 2014, September 2014**

- **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**

Integrated Subject “Neuroinformatics”

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

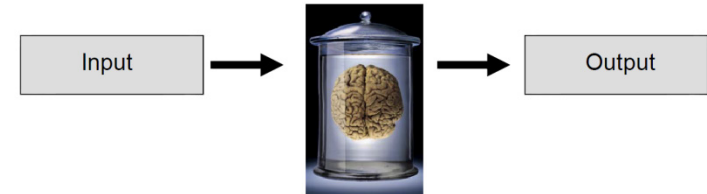
Neuroinformatik I				
Lecture	Allgemeine Psychologie	Franz	WS, Tue 16-18, Thu 12-14	Audimax 2, ESA A
Lecture	Bio-inspired Artificial Intelligence	Wermter	WS, Thu 10-12	D-220
Integrated Seminar	Bio-inspired Artificial Intelligence	Magg, Wermter	WS, As a block	F-235
Neuroinformatik II				
Lecture	Biopsychologie	Hötting	WS , Wed 10-12 Mon 14-16	Audimax 2, Erzwiss H
Lecture	Knowledge Processing with Neural Networks	Wermter	SS, Thu 10-12	D-220
Integrated Seminar	Knowledge Processing with Neural Networks	Weber, Wermter	As a block	

- The Examination for Neuroinformatik II will include all courses.

IAF “Neuroinformatics” 2: Biopsychology

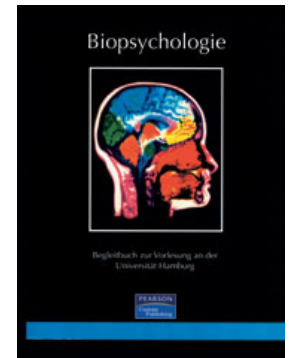
- ***Should have been heard last semester!***

- 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...

- Joint the University of Hamburg in 2010
- Head of Knowledge Technology Group
- 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
 - University of Massachusetts, USA

The challenge: developing cognitive agents ...



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

How to do it? Rule-Based Systems ?

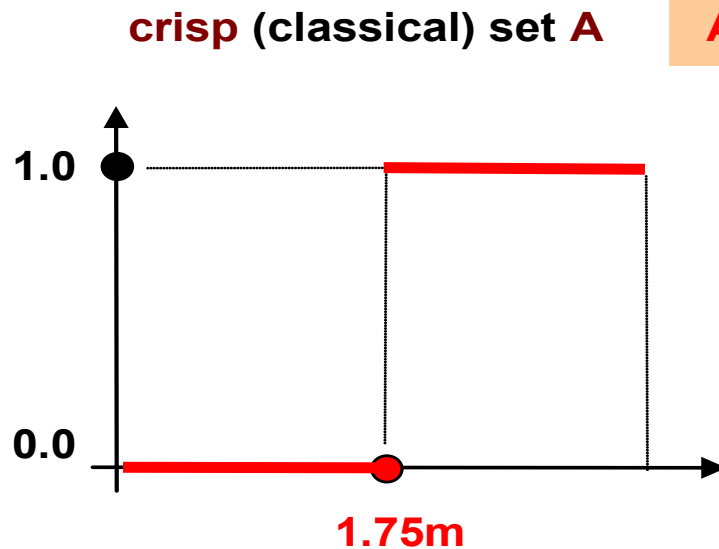
- Use rules to represent knowledge in an **IF...THEN...** form or more complex formalisms
- Use an “inference engine” to **chain the rules** together in different ways
- Allows the ability to **explain decision** by tracing which rules are used and when

Fuzzy Logic

- Based on human reasoning which is imprecise
- Uses a “membership function” to describe how strongly something belongs to a group
- Membership functions can be learned adaptively using neural techniques

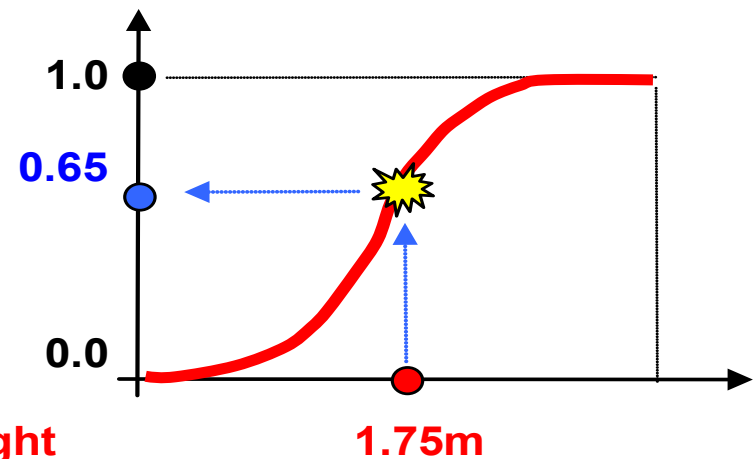
Fuzzy Sets

- 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



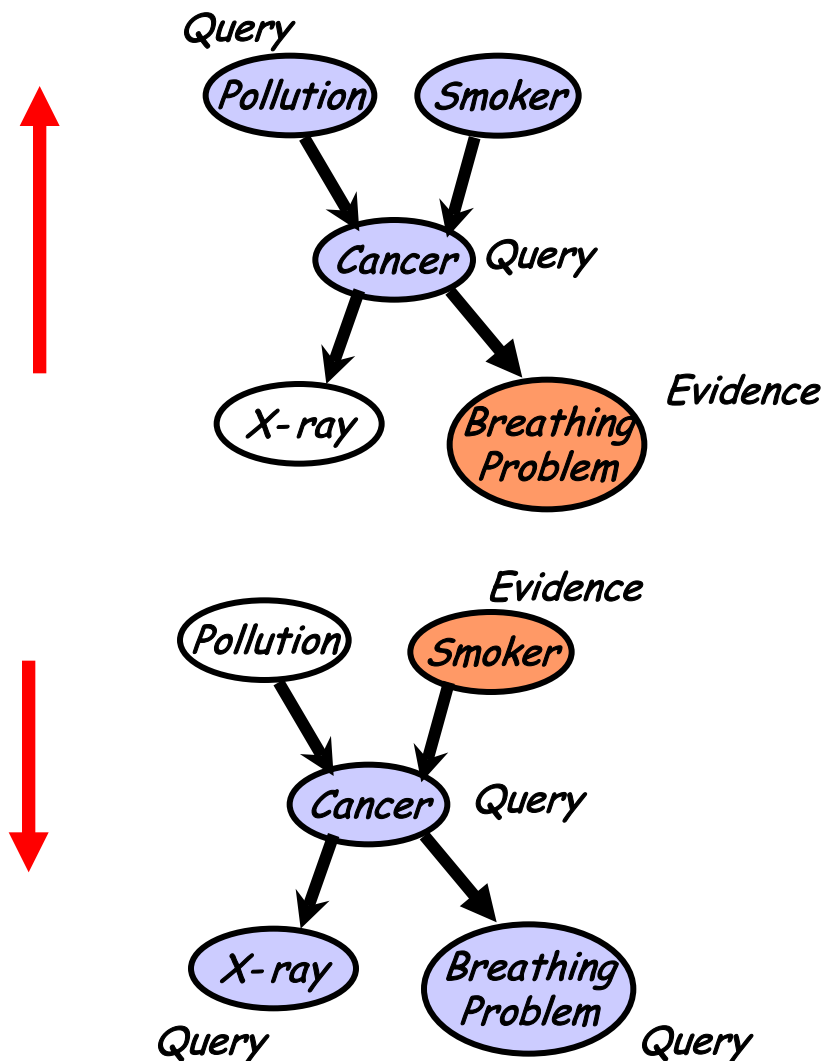
Statistical Methods

- 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

Knowledge Representation in Bayesian Networks

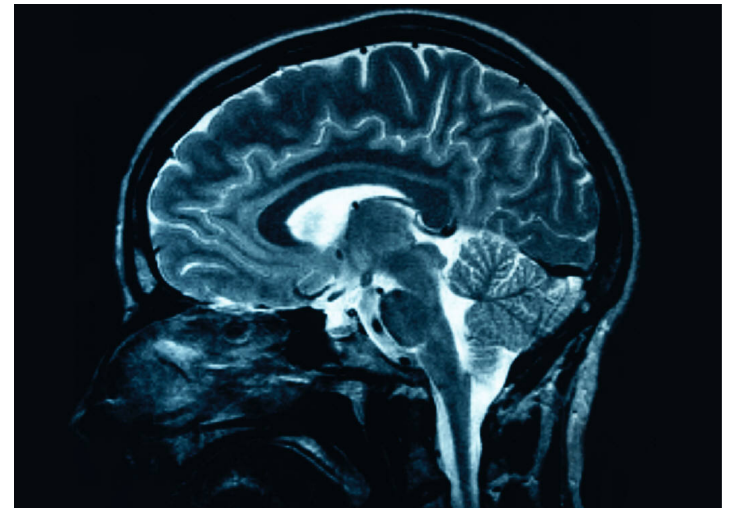
Diagnostic: From **symptoms** to **causes**. Reasoning occurs in opposite direction to network arcs

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



Our Focus: 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 technique



Integration into Hybrid Systems

- The neurocognitive view
 - Neural networks in the brain compute all intelligent behaviour
 - Neural networks are therefore key start to understand intelligent processing
 - Higher cognitive tasks, like reasoning and language are characterised by some form of symbolic processing

- The Knowledge engineering view
 - Integration of these techniques
 - Often more powerful than any single technique
 - Often part of a larger, integrated system

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

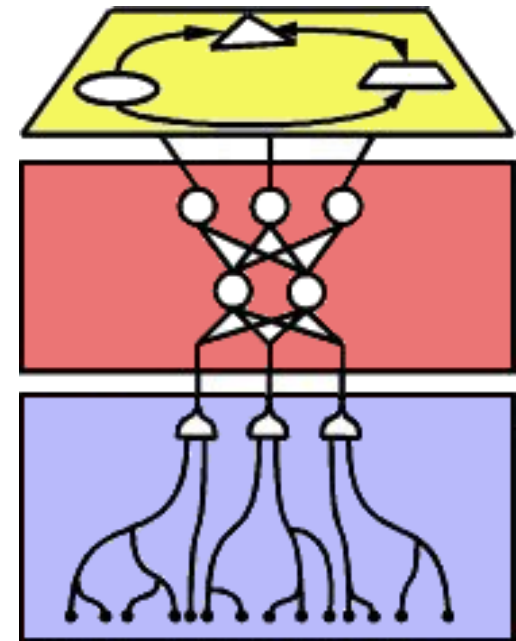
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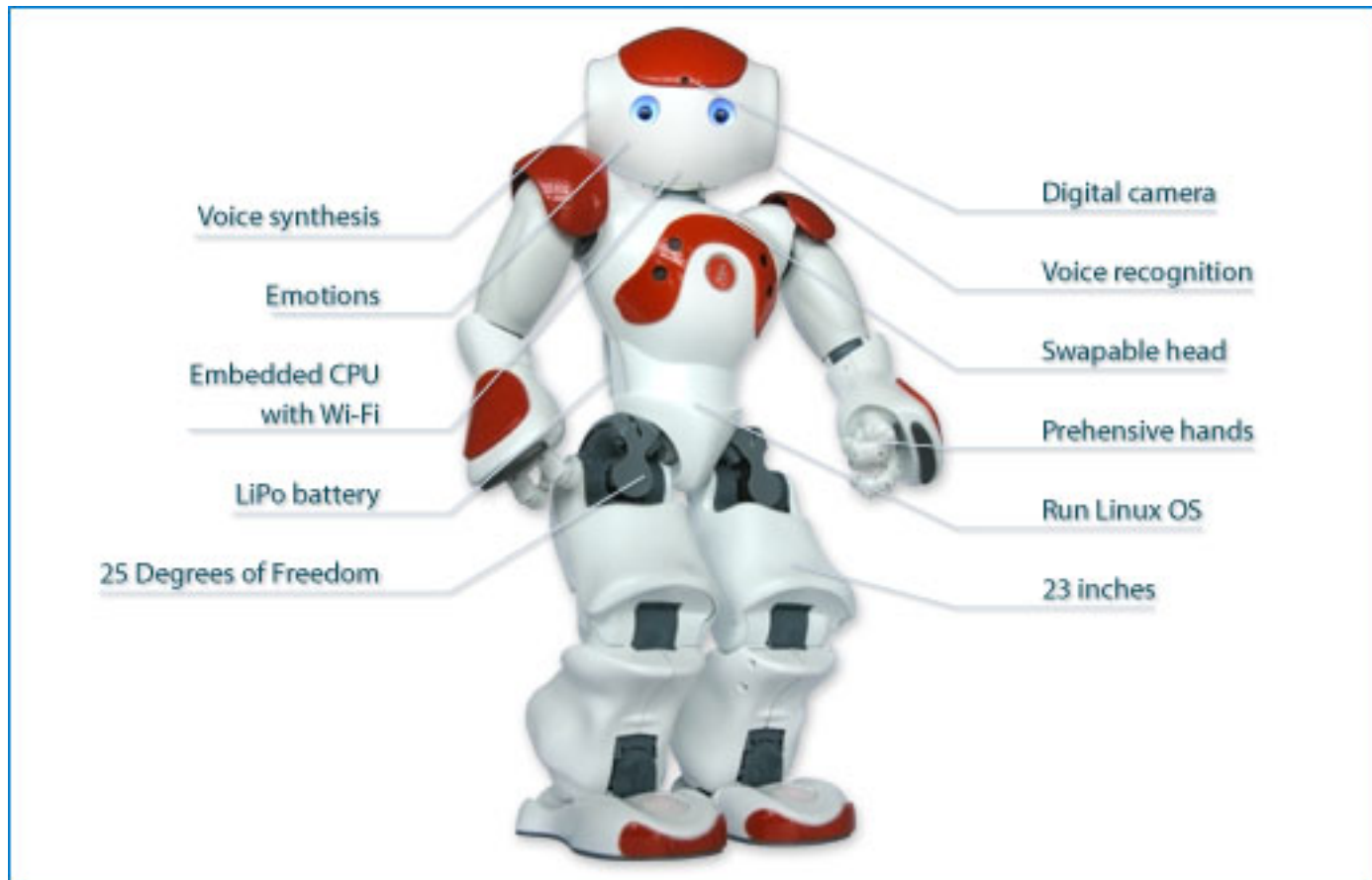
- How is it possible to build more effective systems which integrate neural techniques into intelligent systems?

Approach: hybrid 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



One of our Neurocognitive Platforms in Knowledge Technology



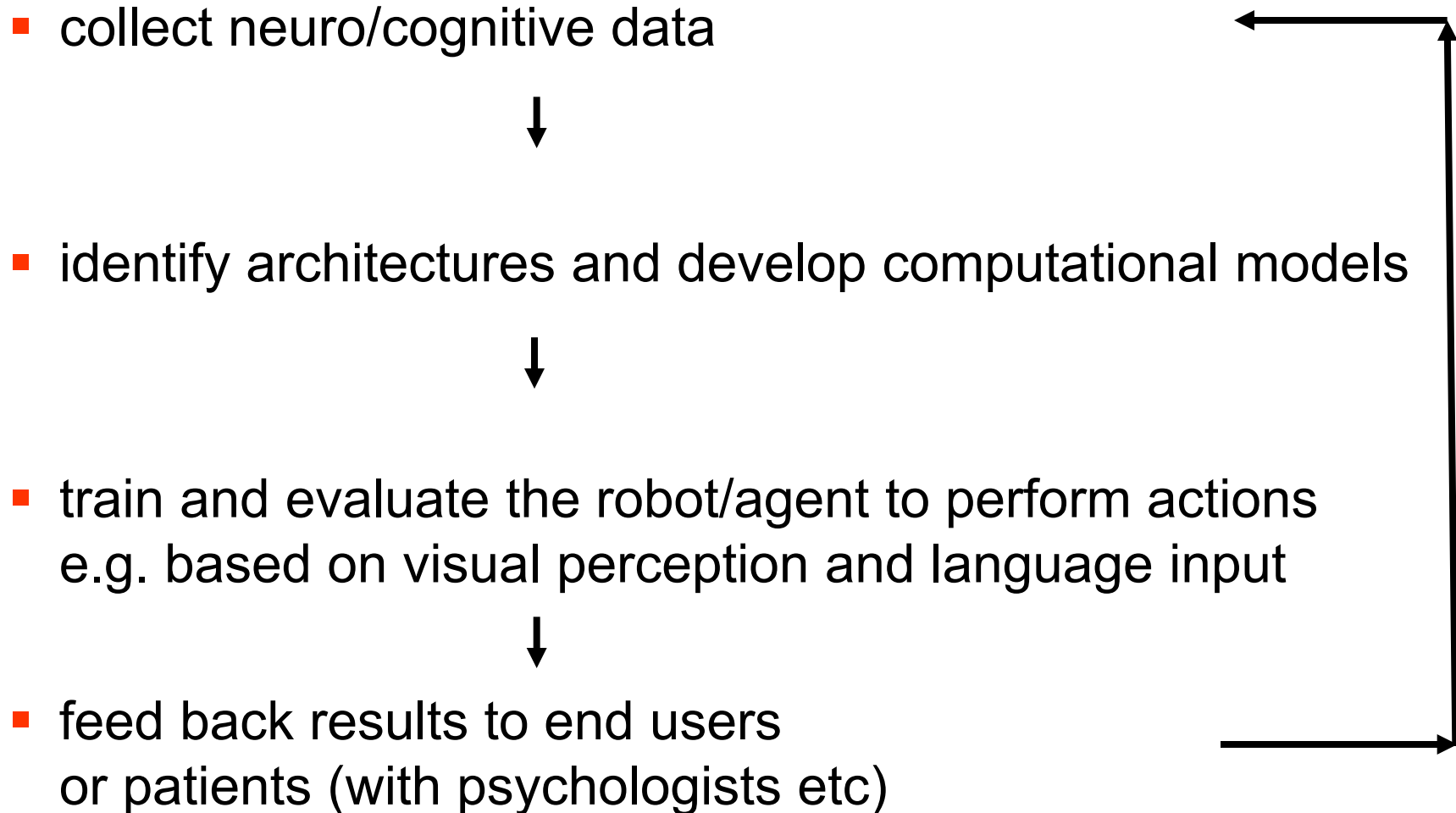
Some initial robotic answers... or how to make a coffee

- 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?

Research methodology for better neural models



Introduction and topics of the module

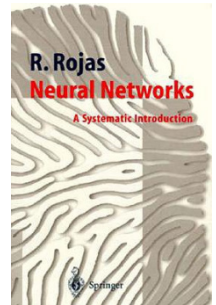
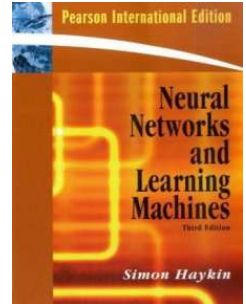
- Overview of hybrid knowledge representation
- Neural networks introduction
- Learning in multilayer and recurrent networks
- Localist, distributed learning and shape recognition
- Neural network architectures
- Hybrid architectures
- Neuroscience-inspired architectures
- Spiking neural networks
- Bioinspired robotic architectures
- ...

Building hybrid nature-inspired computing systems


- Examine the embedding of neural, statistical and/or symbolic representations into knowledge-based adaptive information agents
- Applications can include intelligent information systems, interactive systems, adaptive engineering, data/text mining systems, cognitive and neuroscience-inspired robots, speech/language systems, intelligent web agents and hybrid techniques for medical diagnosis
- Concepts linked to and with examples from our own research projects from the UK and EU

General literature background

- Haykin S. Neural networks and learning machines. Prentice Hall, 2008.
- Rojas R. Introduction to Neural Networks. Berlin: Springer, 1996. (free online)
- Marsland, S. Machine Learning: An Algorithmic Perspective. Chapman & Hall. 2009.
- Wermter S., Sun R. 2000 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.



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WTM: Knowledge Processing with Neural Networks SS2014

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 **Entry:**

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

 **Basics:**


> Apply for membership

Contact persons:

- Stefan Heinrich
- Cornelius Weber
- **Contact via e-mail**

Terms:

- Summer 14

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... to get the slides and recent announcements.

WTM: Knowledge Processing with Neural Networks

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Materials (Items: 4)

Title edited by

<input type="checkbox"/> Lecture Knowledge Processing with Neural Networks	26 Mar 2014	Stefan Heinrich
<input type="checkbox"/> Literature 2	26 Mar 2014	Stefan Heinrich
<input type="checkbox"/> Seminar Organisation	26 Mar 2014	Stefan Heinrich
<input type="checkbox"/> Guidelines for literature research, reading, writing, reviewing, and presenting 2	26 Mar 2014	Stefan Heinrich

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Max. items per page 20 | 50 | All << < Page 1 / 1 > >>

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Browse tags

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E-mail to moderator/s
ask helpdesk

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Summary

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

Link and topics for the Seminar (Dr Cornelius Weber)

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

Outlook

