NeuralDynamics

A neuro-dynamic framework for cognitive robotics: Autonomous generation of scene representations and behavioral sequences using online learning

http://www.neuraldynamics.eu/

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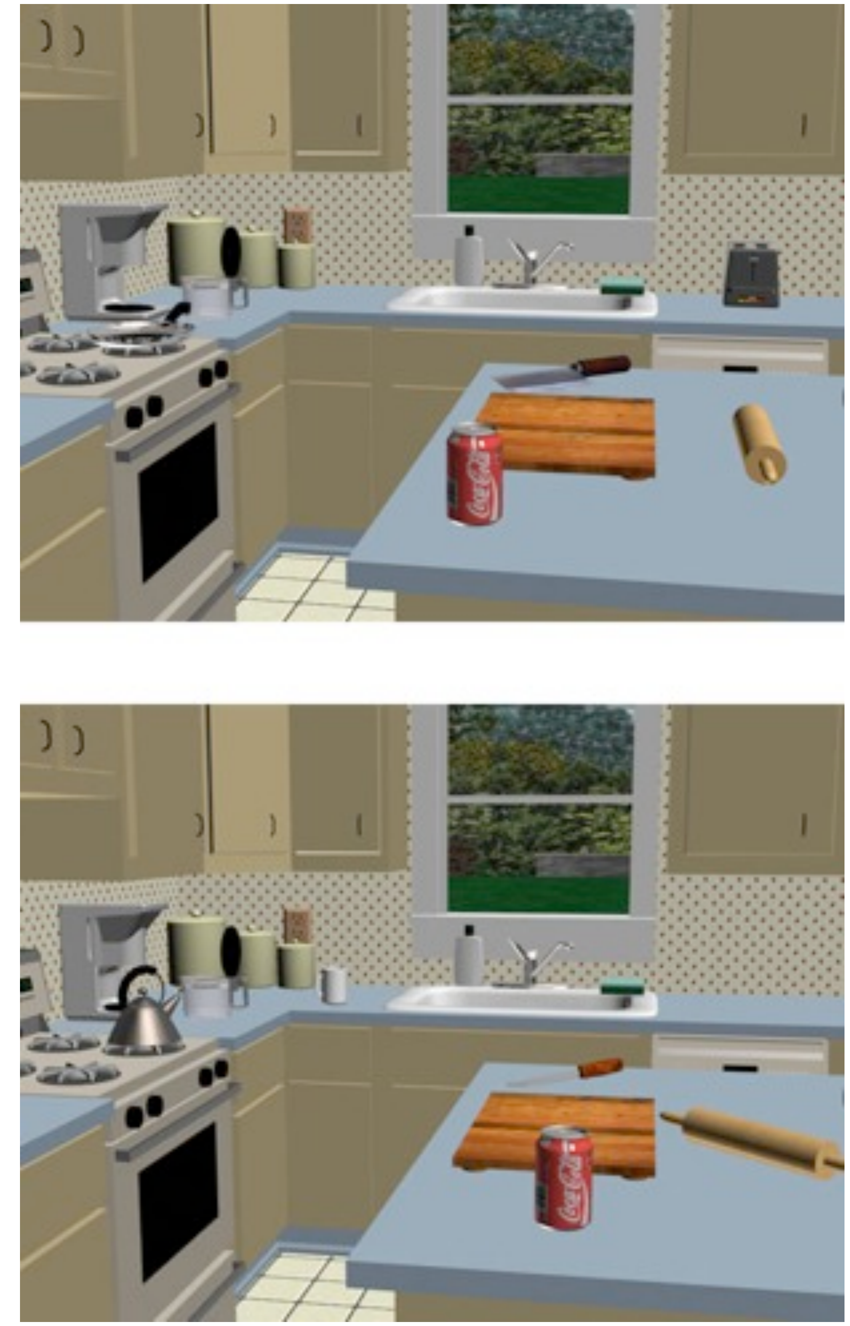
Brief summary

- Goal: comprehensive solutions to the problems of scene and object representation and behavioral sequence generation in cognitive autonomous robots.
- Seek solutions inspired by embodied human cognition and its development.
- Hypothesize that principles of neural dynamics, in particular, Dynamic Field Theory, together with principles of learning provide the appropriate language.

What?

- Scene representation: humans excel at fast analysis and memorization of objects and their poses in scene contexts



[Hollingworth]

What?

- Sequence generation: humans perform complex sequences of goal-oriented actions with ease (serial order)
- and quickly learn new sequences

- Our vision: cognitive robots that orient actions at objects, generate goal-oriented sequences of actions, interact with human users, and learn from experience

Two bottlenecks

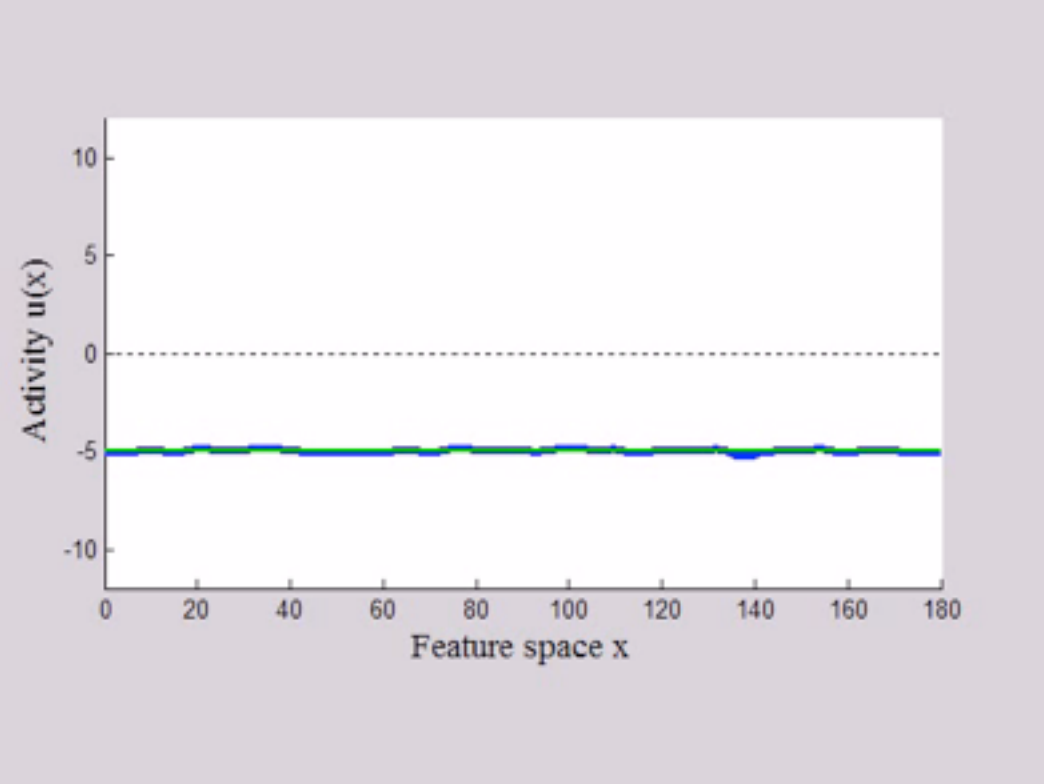
- (1) scene and object representation
  - segment the visual array into meaningful patches
  - enable visual exploration and keep track of objects in the environment
  - learn objects from a small number of views or even a single view
  - recognize objects when the view has changed and estimating object pose

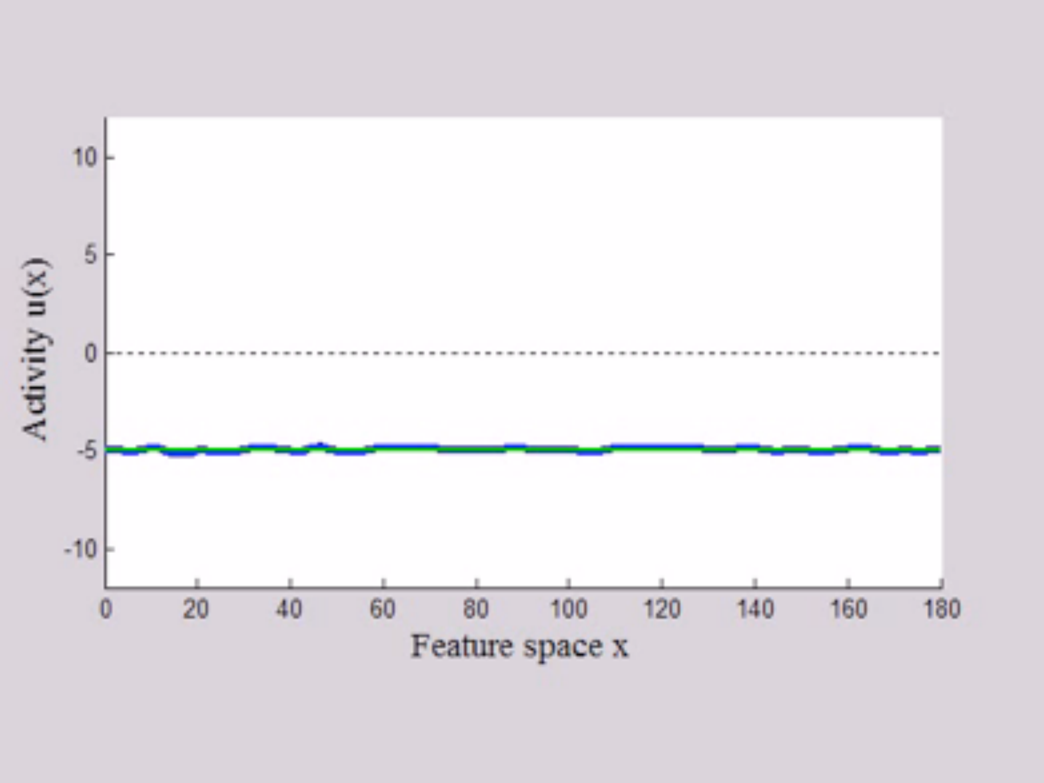
Two bottlenecks

- (2) sequence generation
  - autonomously initiate motor acts
  - terminate motor acts when an action’s intention has been achieved
  - organize sequences to both comply with behavioral constraints and to achieve goals
  - autonomously learn to achieve its tasks as environmental conditions vary

How? => neural dynamics

- dynamic fields: abstract from the discrete nature of individual neurons
- attractors enable linking to low-level sensory information
- perceptual and motor decisions, working memory, and other elementary forms of cognition emerge from dynamical instabilities
- learning is a natural property of neural dynamical systems
- framework for system integration in dynamic field architectures
- enables transfer from human cognition to cognitive robotics



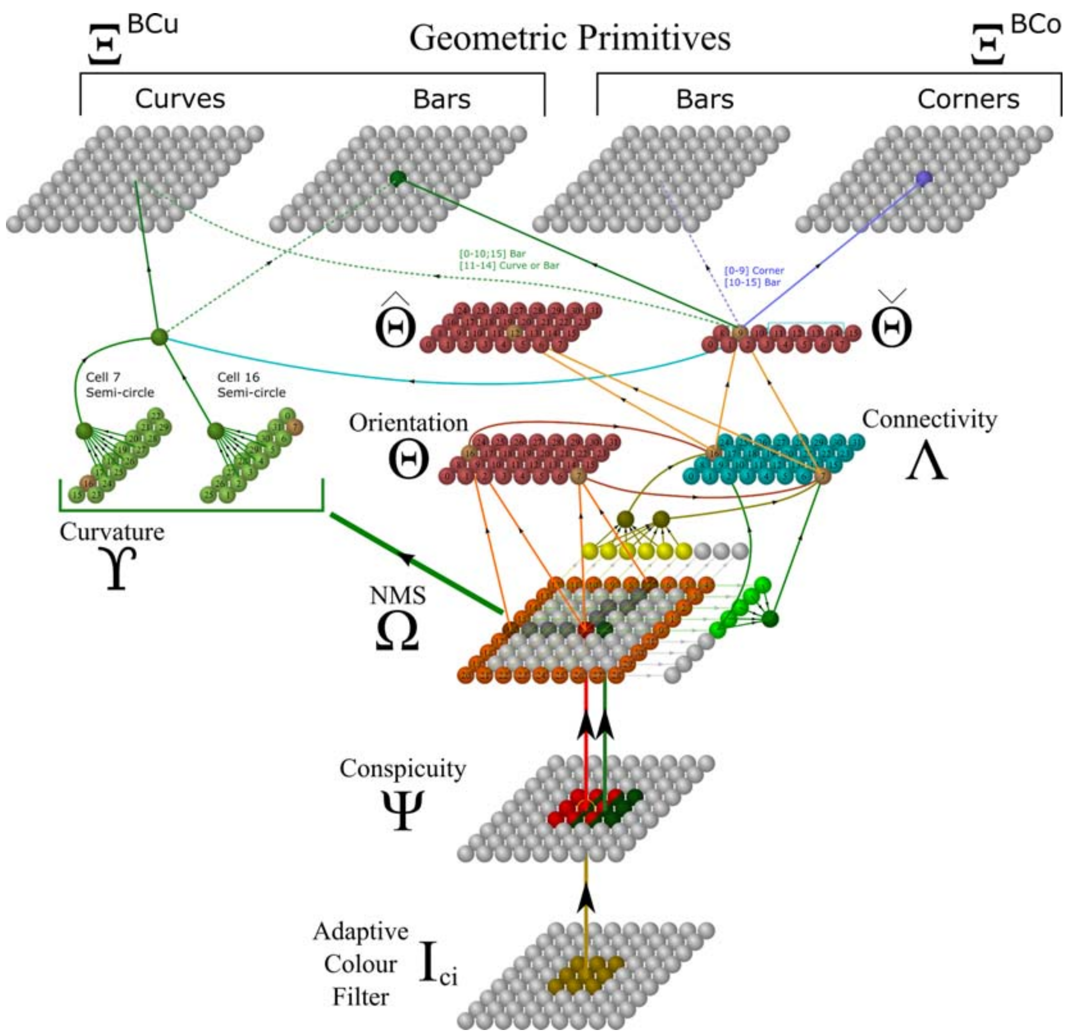


Who?

- RUB: Institut für Neuroinformatik
  - Gregor Schöner, Tobias Glasmachers, Christian Faubel, Oliver Lomp, Mathis Richter, Yulia Sandamirskaya, Stephan Zibner
- HIS: Cognition & Interaction Lab
  - Tom Ziemke, Robert Lowe, Boris Duran, Serge Thill
- UALG: Vision Lab of the Centro de Investigação Tecnológica do Algarve
  - Hans du Buf, Kasim Terzic, João Rodrigues
- IDSIA: Istituto Dalle Molle di Studi sull'Intelligenza Artificiale
  - Jürgen Schmidhuber, Matthew Luciw and Sohrob Kazerounian

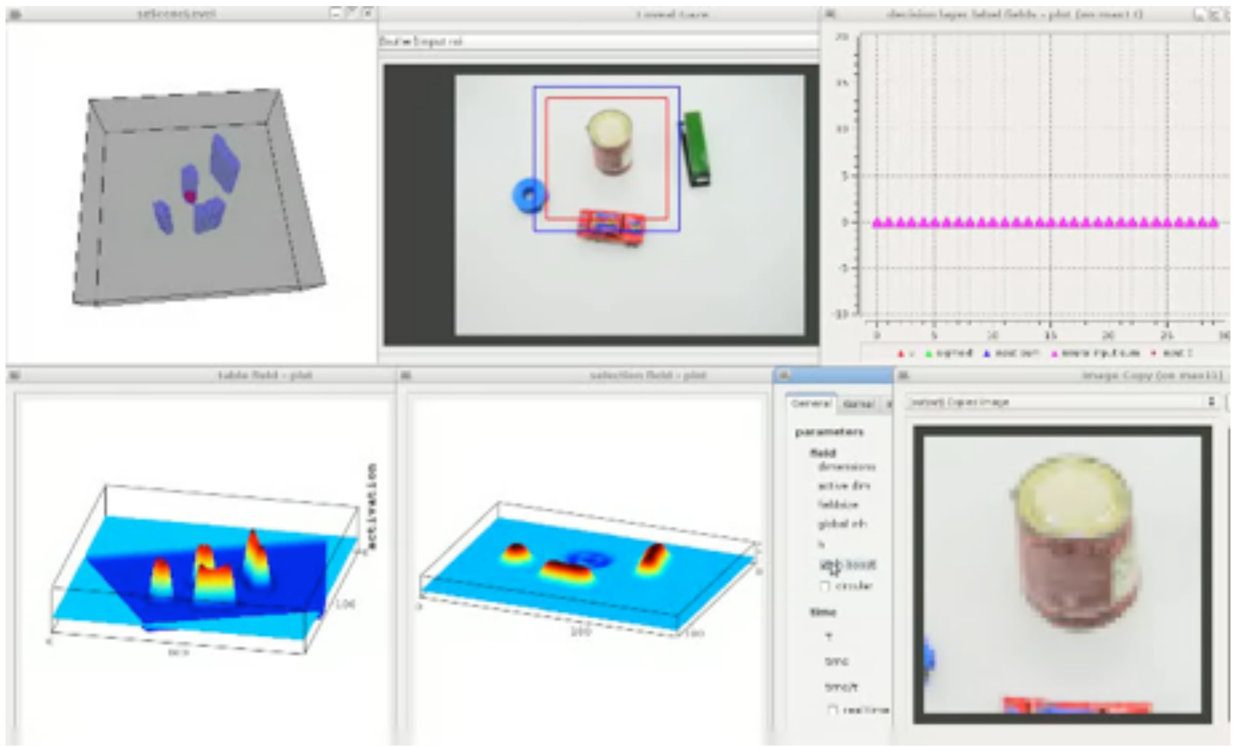
WP1: Dynamic scene representations

- Task 1.1 Develop a neural feed-forward system for local gist estimation
  - Martins, J.A., Rodrigues, J.M.F. and du Buf, J.M.H. (2012) Local object gist: meaningful shapes and spatial layout at a very early stage of visual processing. Accepted by Gestalt Theory.



WP1: Dynamic scene representations

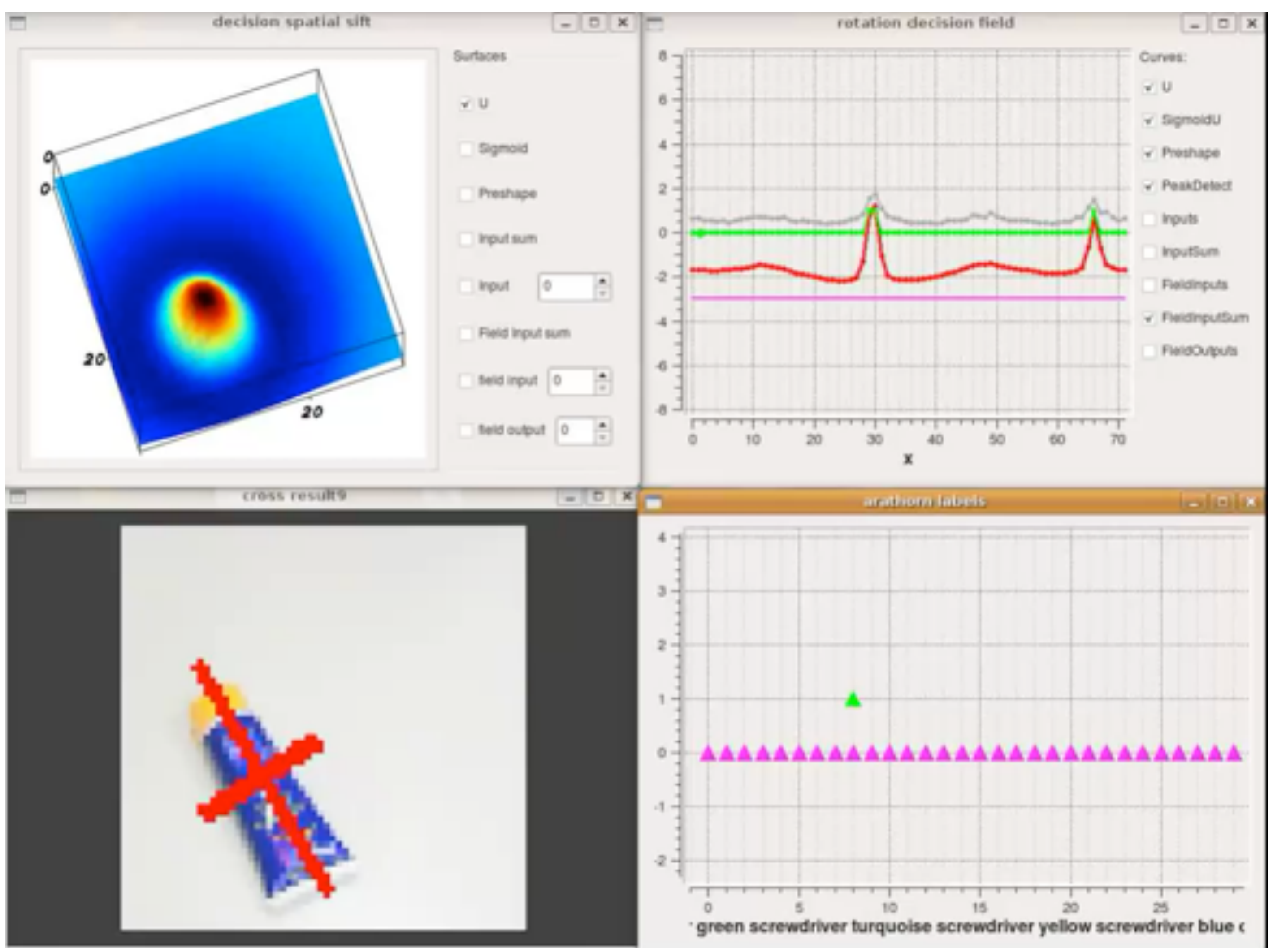
- Task 1.2 Develop an autonomous, active system of visual exploration, scene representation, and scene updating
  - Zibner, S. K. U., Faubel, C., Schöner, G.: Making a robotic scene representation accessible to feature and label queries. Proceedings of the First Joint IEEE International Conference on Development and Learning and on Epigentic Robotics, ICDL-EPIROB 2011, Frankfurt, Germany

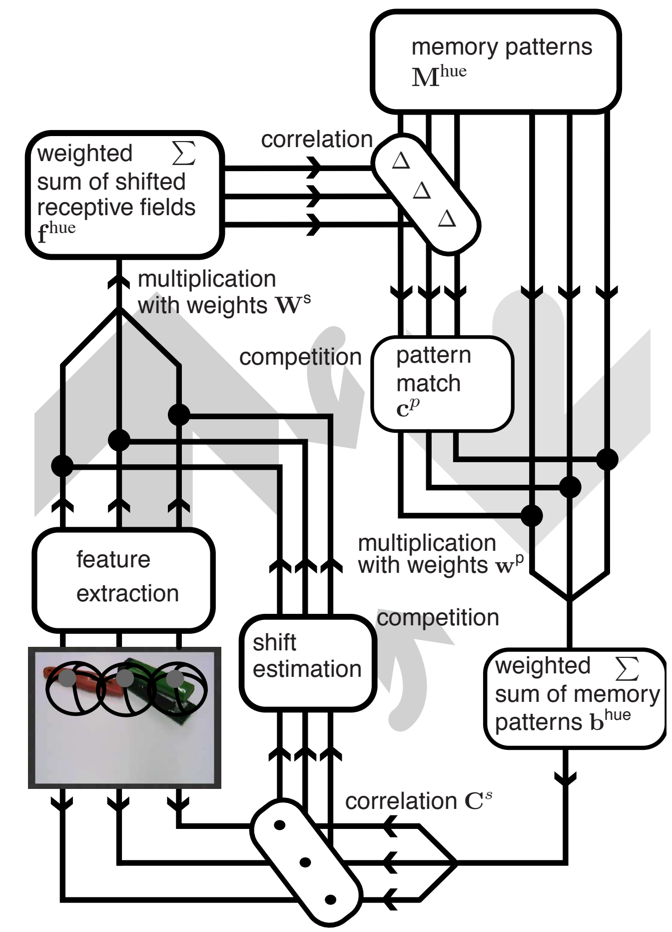


=> Poster
Zibner, Faubel, Schöner

WP2: Dynamic object representations

- Task 2.1 Develop a neural dynamic approach to object recognition that combines feature-based representations with pose estimation

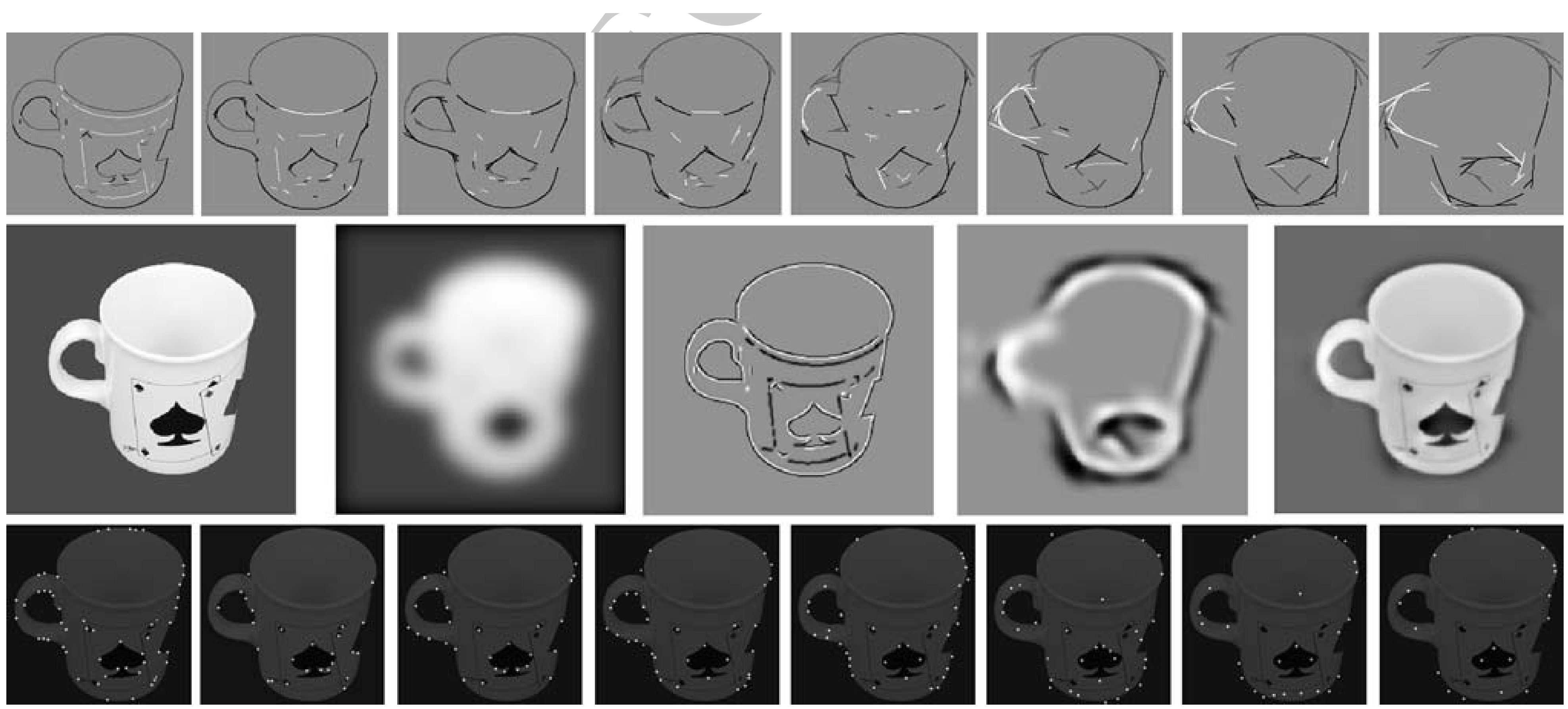




[Faubel, Schöner]

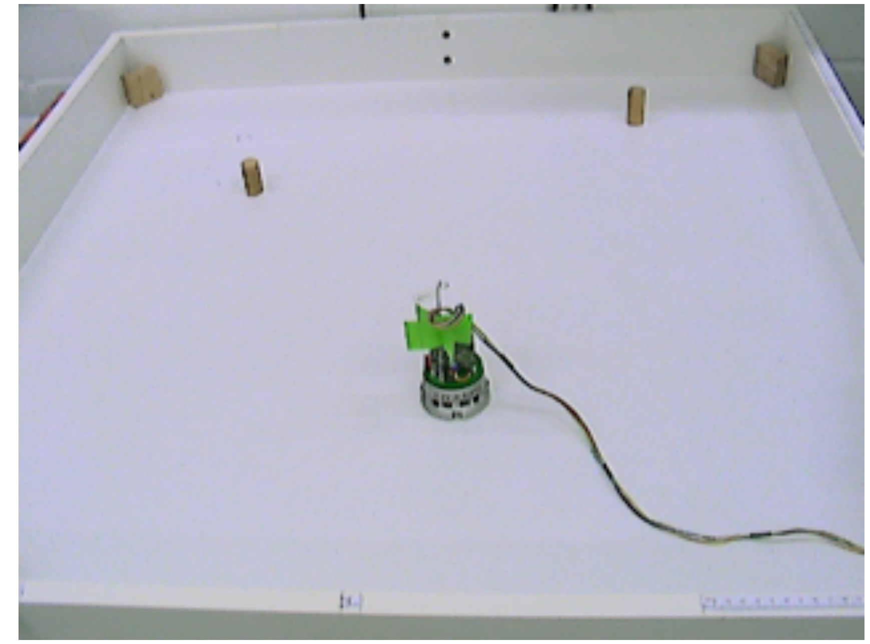
WP2: Dynamic object representations

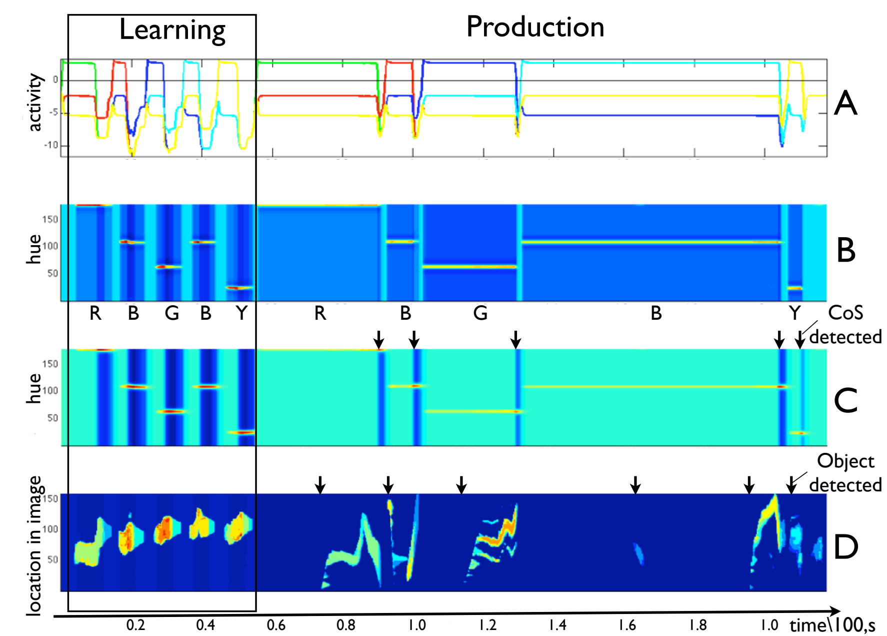
- Task 2.2 Develop a feature-based object recognition approach that is invariant under scale change
  - Rodrigues, J.M.F., Lam, R., du Buf, J.M.H. (2012) Cortical 3D face and object recognition using 2D projections. Accepted by Int. J. of Creative Interfaces & Computer Graphics.

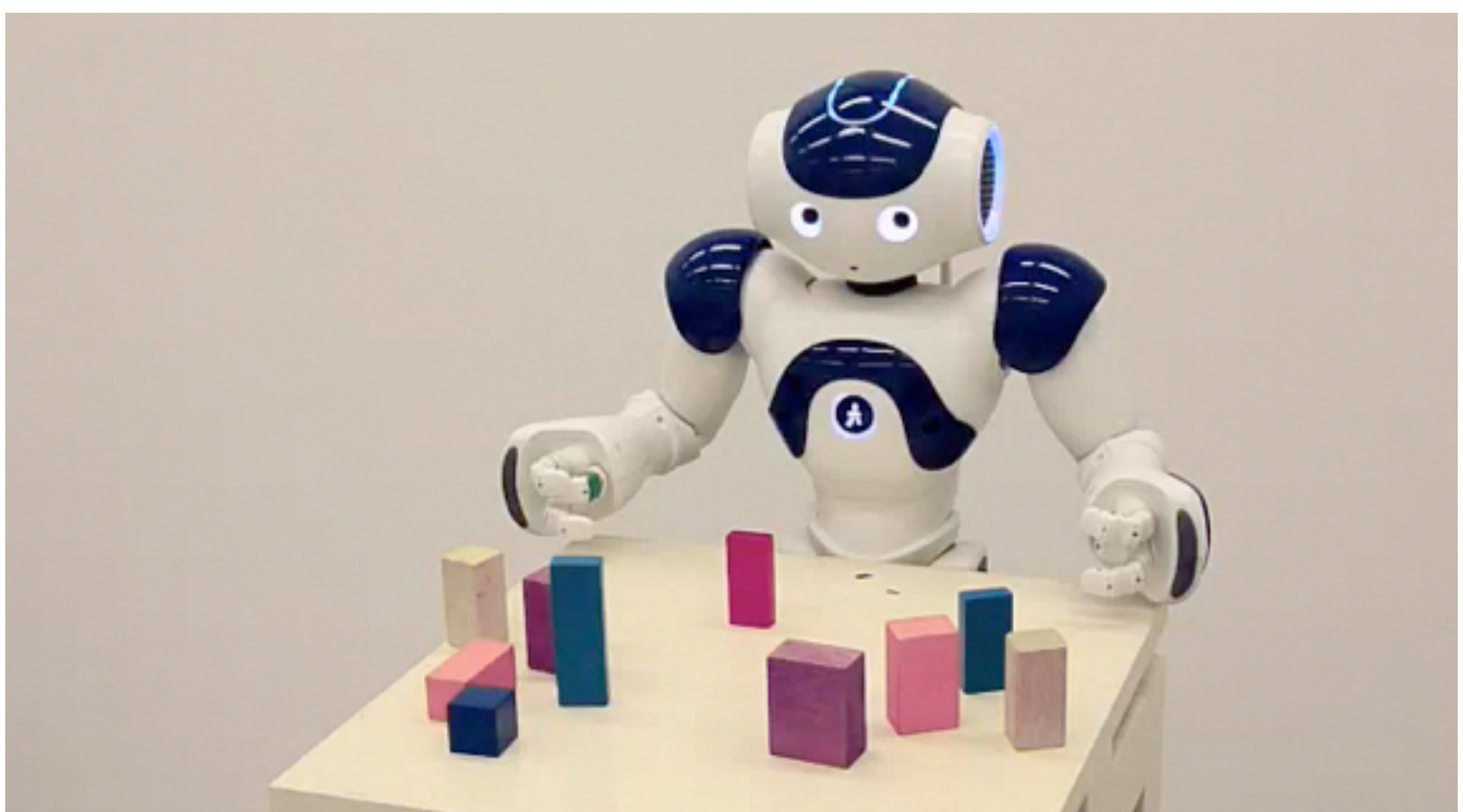


WP3: Organizing sequential behavior

- Task 3.1 Develop a neural dynamic architecture for serially ordered behavioral sequences
- Task 3.2 Expand this architecture to include the organization of behavior to accomodate intrinsic constraints







=> Poster: Richter, Sandamirskaya, Schöner

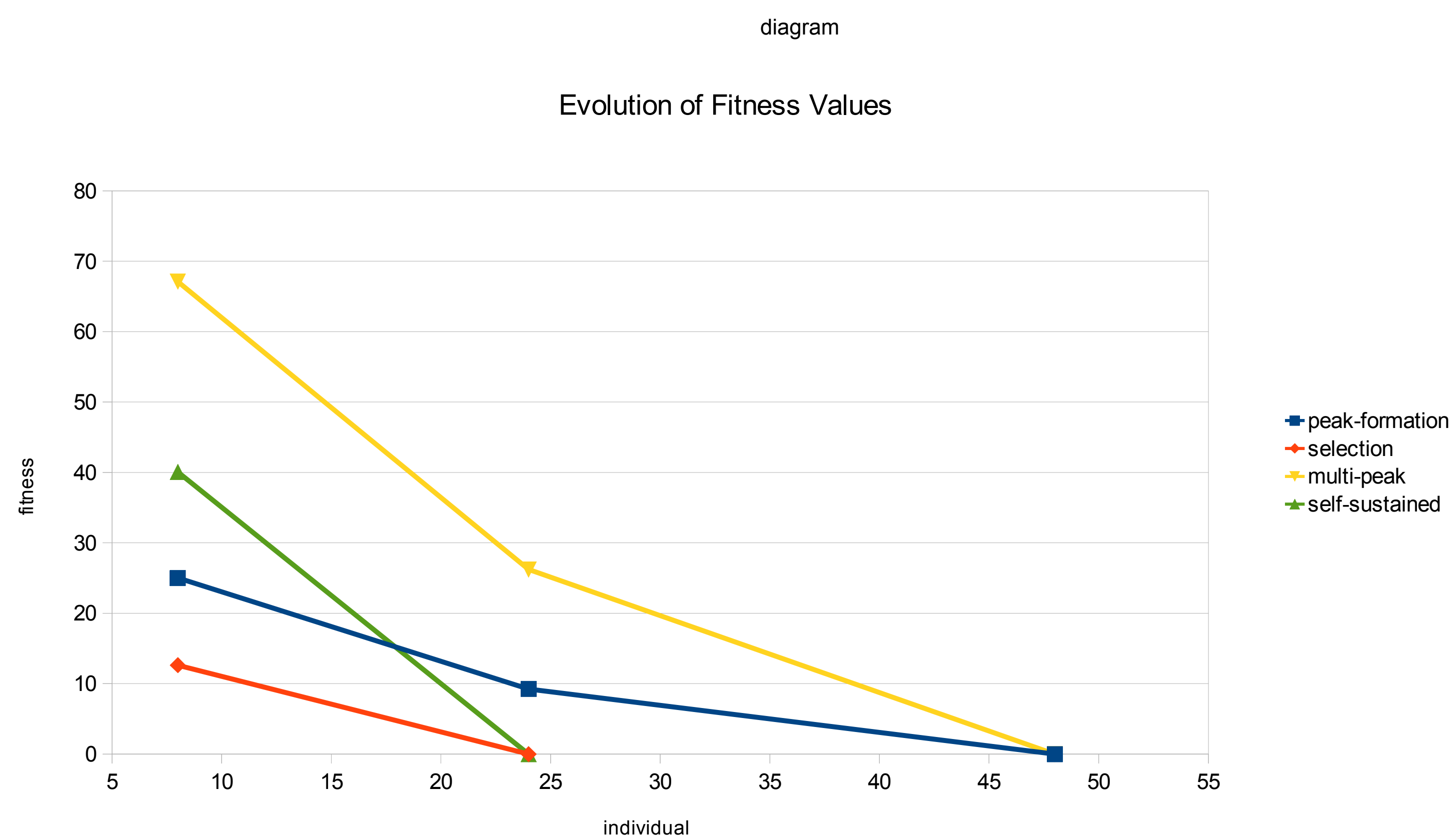
WP4: Learning principles for organization of sequential behavior

- Task 4.1 Develop an approach toward learning the condition of satisfaction of elementary actions
- => movie
  - Incremental learning a low-dimensional encoding of high-dimensional inputs (images) in a discrete time dynamics: Matthew Luciw and Sohrob Kazerounian: Incremental Slow Feature Analysis: Adaptive and Episodic Learning from High-Dimensional Input Streams (under review)

WP4: Learning principles for organization of sequential behavior

- Task 4.5 Develop a method to optimize parametric control of Dynamic Fields

red: field
yellow: sigmoided field
blue: input
green: resting level



[Glasmachers, Lomp]

WP5: Implementation and integration

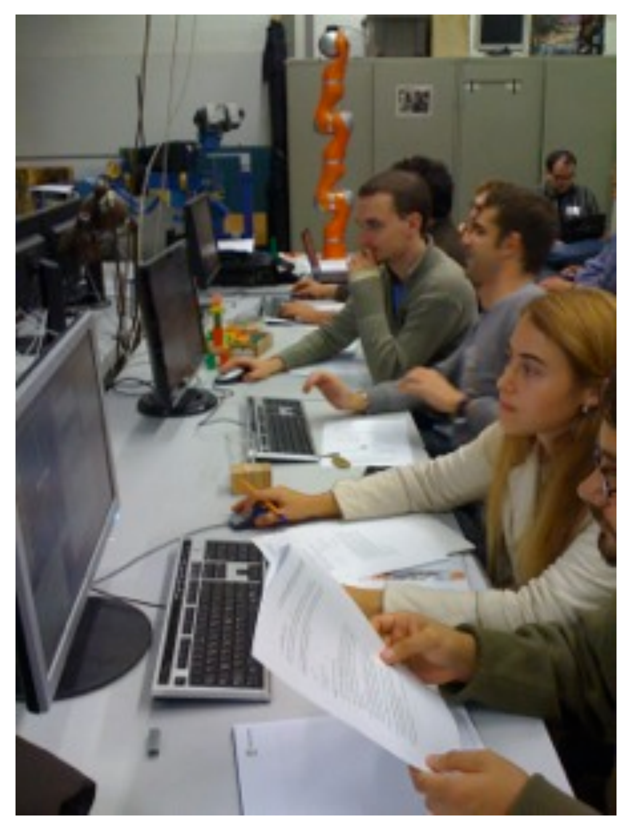
- Task 5.1 Developing standards/ software framework
  - released CEDAR (Cognitive Embodied Dynamic ARchitectures), a software framework to graphically assemble and simulate Dynamic Field models: www.cedar.ini.rub.de

[Lomp, Zibner, Richter]

Outreach

- Fall school in Guimarães, Portugal in September 2011
  - Neural Dynamics Approaches to Cognitive Robotics
  - co-funded by the EU Cognition II Network
  - http://www.robotics-school.org/






we are at month 11… … expect more in the near future…