



# Overview of IM-CLeVeR work: 05/2010 → 04/2011

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CNR-ISTC-LOCEN, IM-CLeVeR



# Goals



- Furnish a **map** of the vast work of this year
- Highlight the **major achievements**
- Here, top-down approach:  
from CLEVER-B and CLEVER-K to detailed works
- Presentations, bottom-up:  
from Team's works to integrated work
- Collaborations



# CLEVER-B2 Bio-thread



- Goals, and set-up
  - Mechatronic board ([UCBM-WP3](#))
  - Target experiments with monkeys/children ([CNR\\_UCBM-WP3](#))
  - Experiments with joystick ([USFD-WP3](#))
- DMc ↔ SMc interface ([Demo](#))
- DMc (Decision Making component) ([Demo](#))
  - Overall architecture:
    - Sub-cortical models, cortical models, HRL ([CNR-WP6](#))
    - Hierarchical action models ([USFD-WP6](#))
    - Relevance of attention processes ([USFD Focussed W.;](#) [CNR-WP4](#), see D4.1)
  - Functioning, learning based on intrinsic motivations
    - Theory and models on intrinsic motivations ([CNR-WP5](#))
    - Theory and models of intrinsic motivations ([Barto-WP5](#))
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  - Mapping architecture and principles ([AU-WP6](#))
  - Mapping learning and staged development ([AU-WP6](#))
- Solution of all technical and coordination problems related to iCub Demonstrator
  - Simulated/real iCub ([CNR\\_AU-Demo](#))
  - Simulated/real mechatronic Board ([CNR\\_AU\\_UCBM-WP3](#))
  - Yarp, DMc ↔ SMc interface, working together! ([Demo](#))

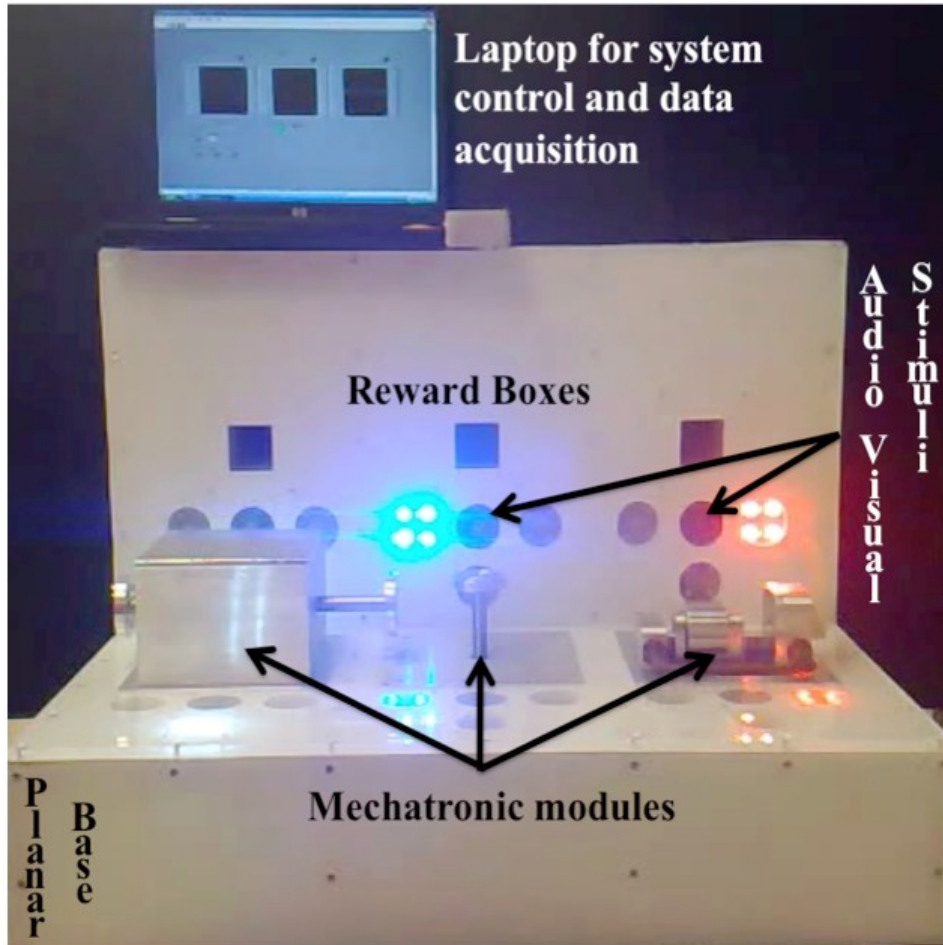


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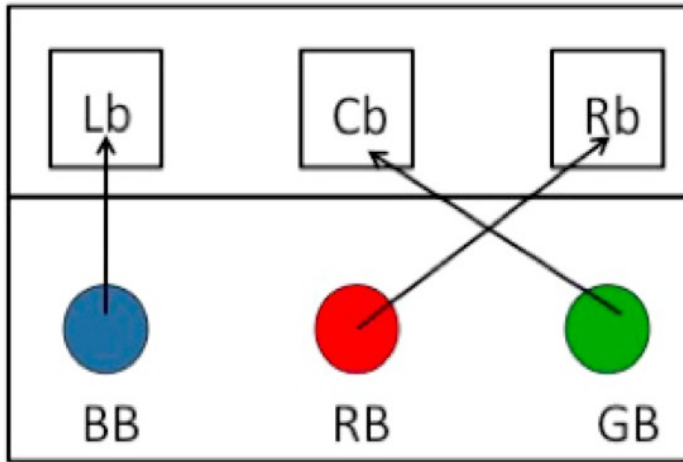


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# Mechatronic board (UCBM-WP3)



# Experiments monkeys/children (CNR-UCP\_UCBM-WP3)





# Joystick experiment (USFD-WP3)



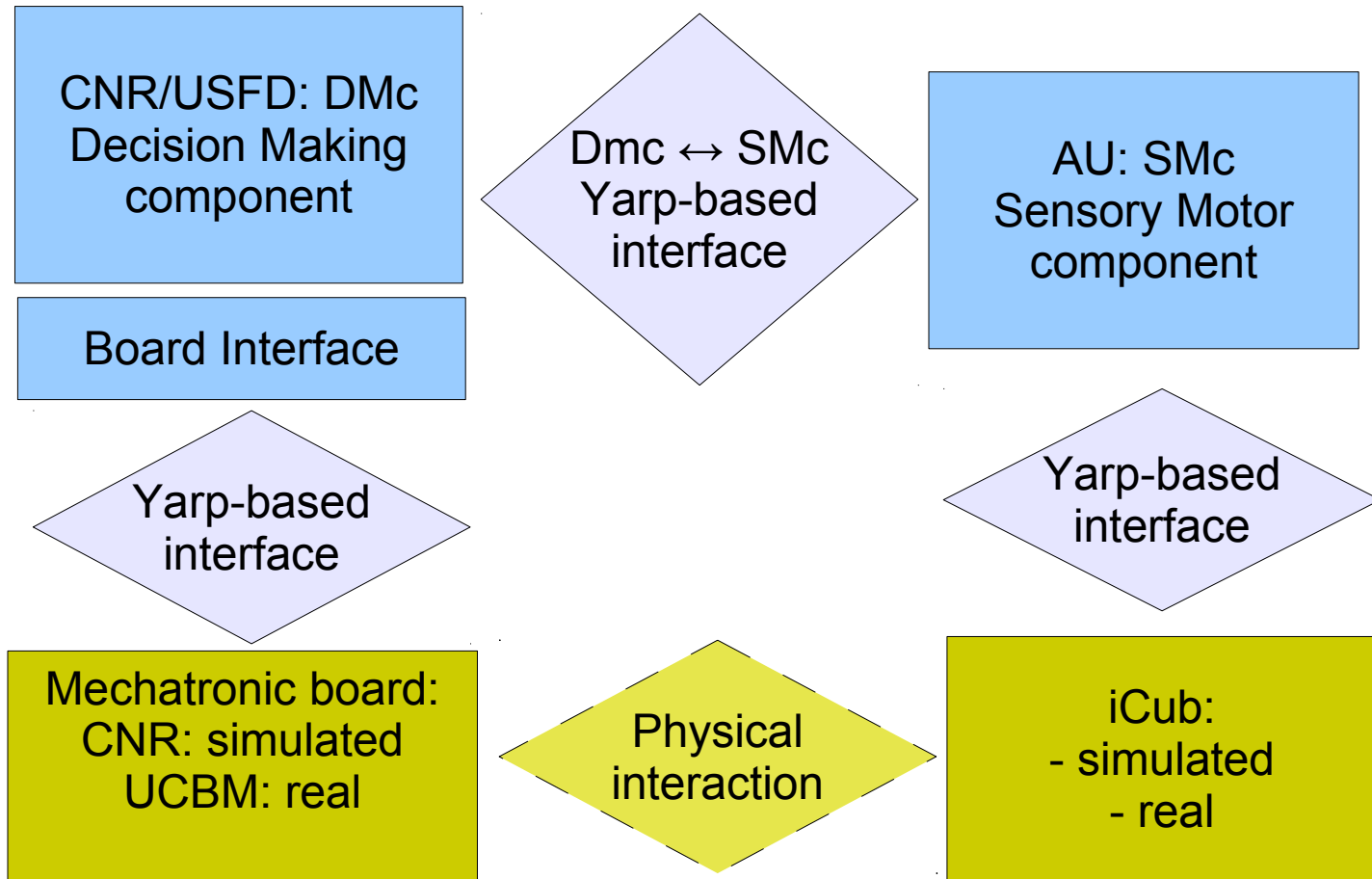


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# DMc ↔ SMc interface (AU\_CNR-Demo)





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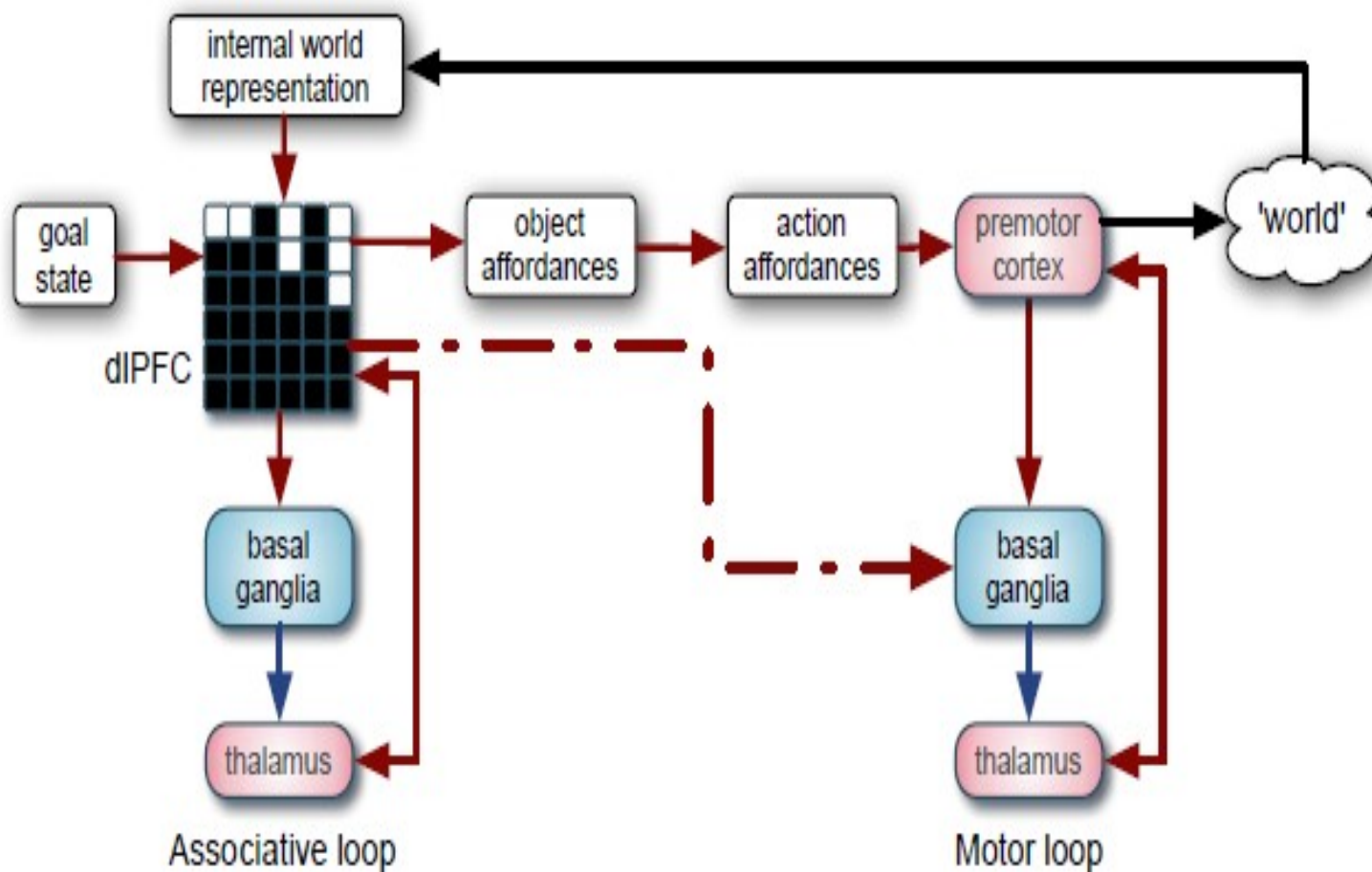
# DMC - Decision Making component (CNR\_AU\_USFD-WP7)



- Three striato-cortical loops
  - Control of arm movements (involving parietal/motor cortex)
  - Control of eye movements (involving parietal/prefront. cortex)
  - Selection of goals (involving prefrontal cortex)
- A dopamine learning signal generated when a salient event is detected in the environment by the superior colliculus
- Recall of goals by the prefrontal cortex in the test phase



# Precursor models: Hierarchical models (USFD-WP5 IM)

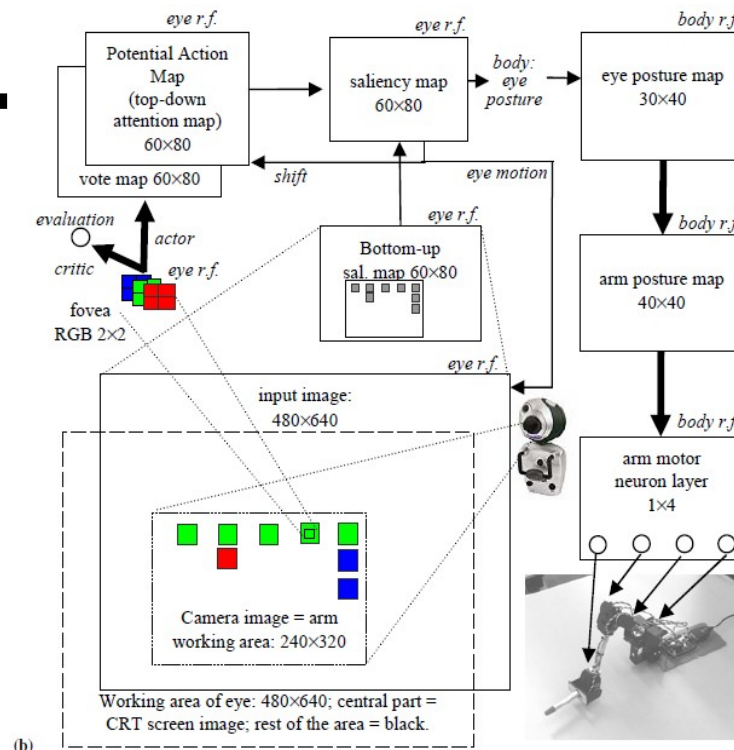


# Relevance of attention

(USFD-Focussed workshop;  
CNR-WP4)

Attention is paramount for action

Focussed workshop on bio-constrained models at USFD



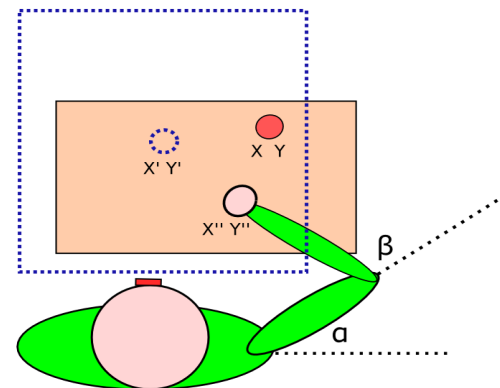
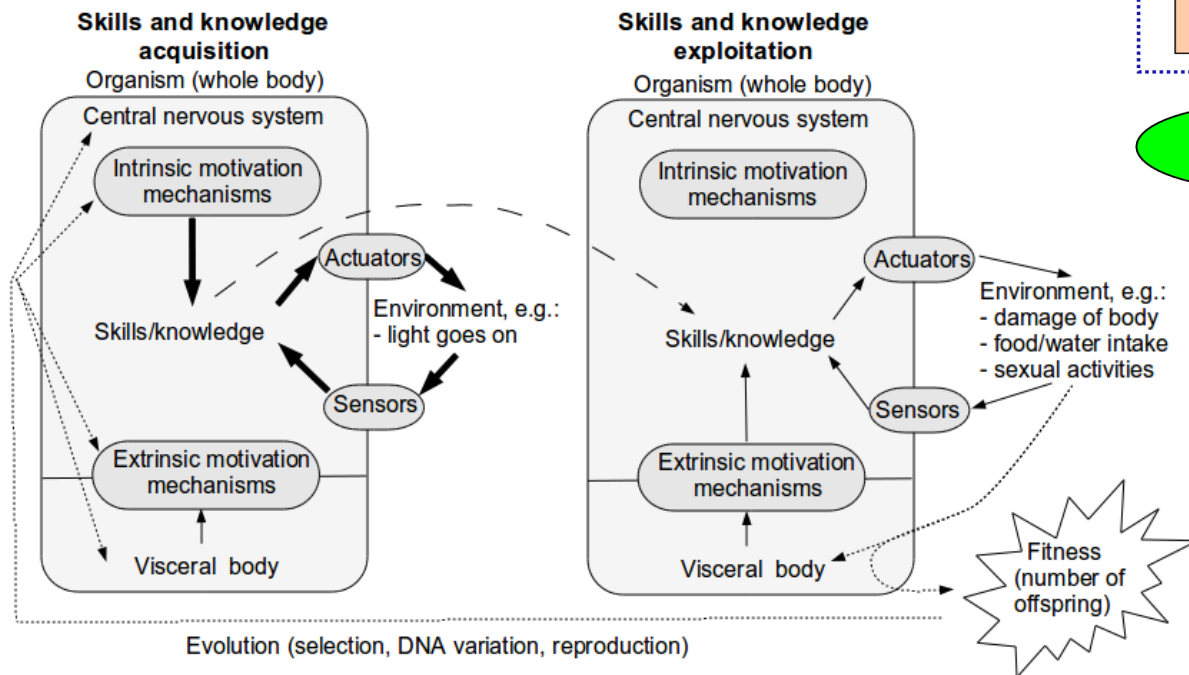


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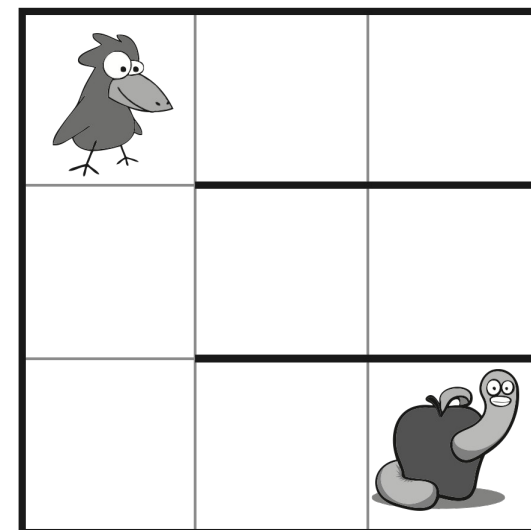
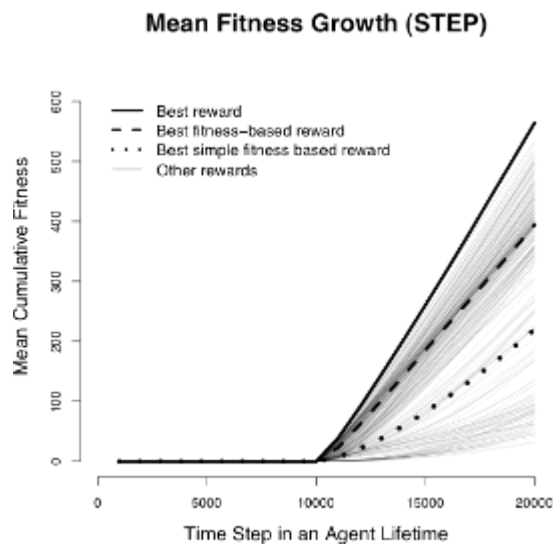
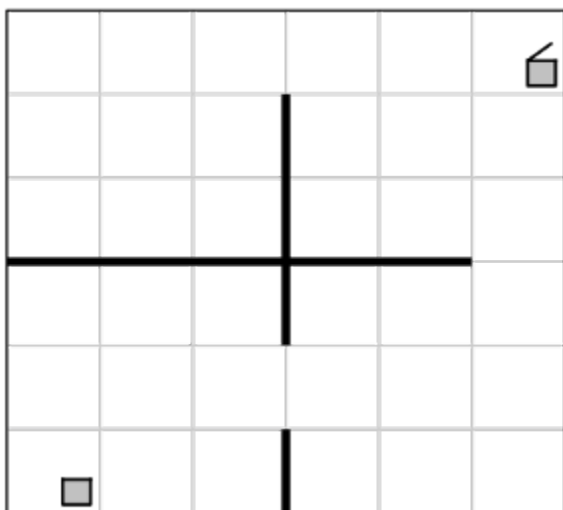


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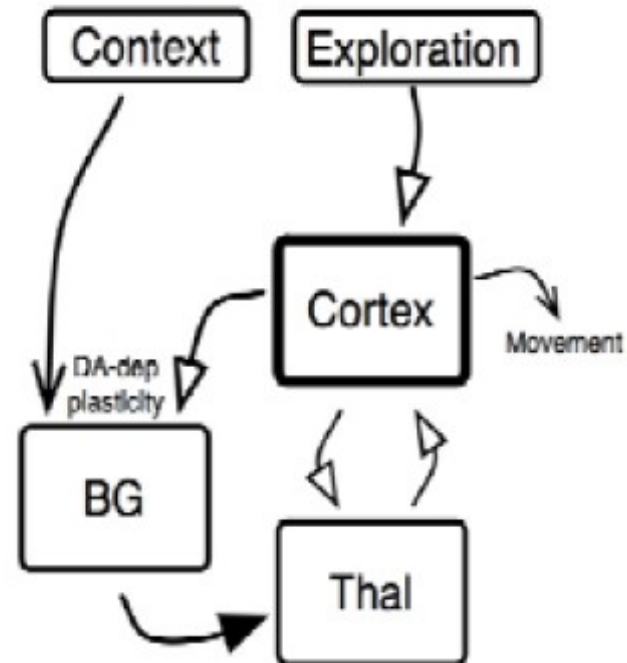
# Theory and mechanisms of intrinsic motivations (CNR-WP5)



# Theory and models of IM (Barto-WP5)



# Model of Joystick Experiment (USFD-WP5)



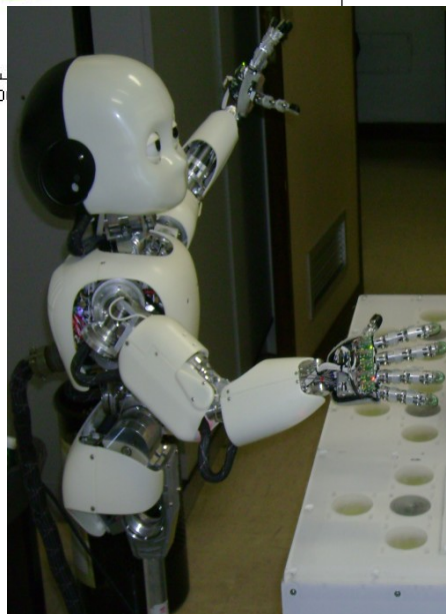
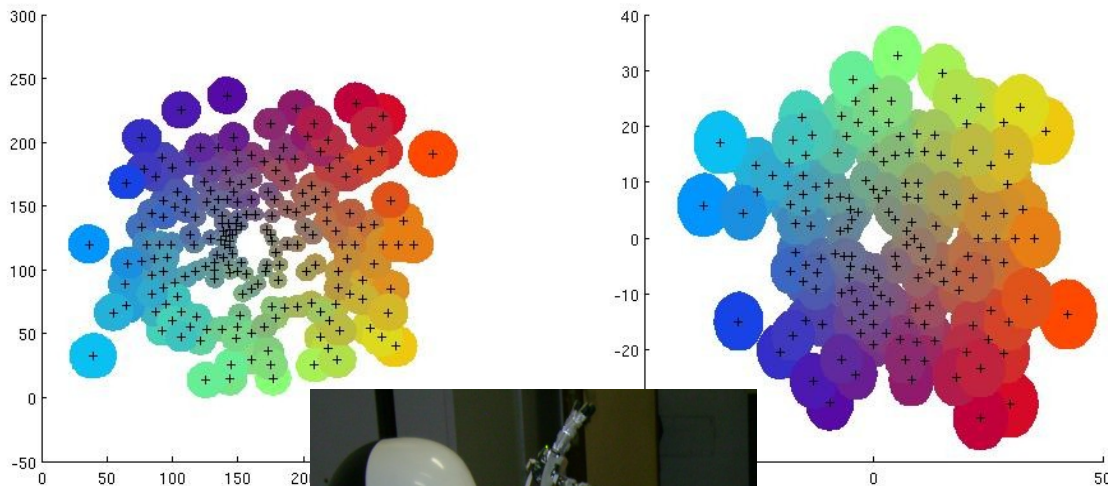


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# SMc: sensorimotor maps, staged development

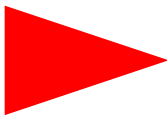




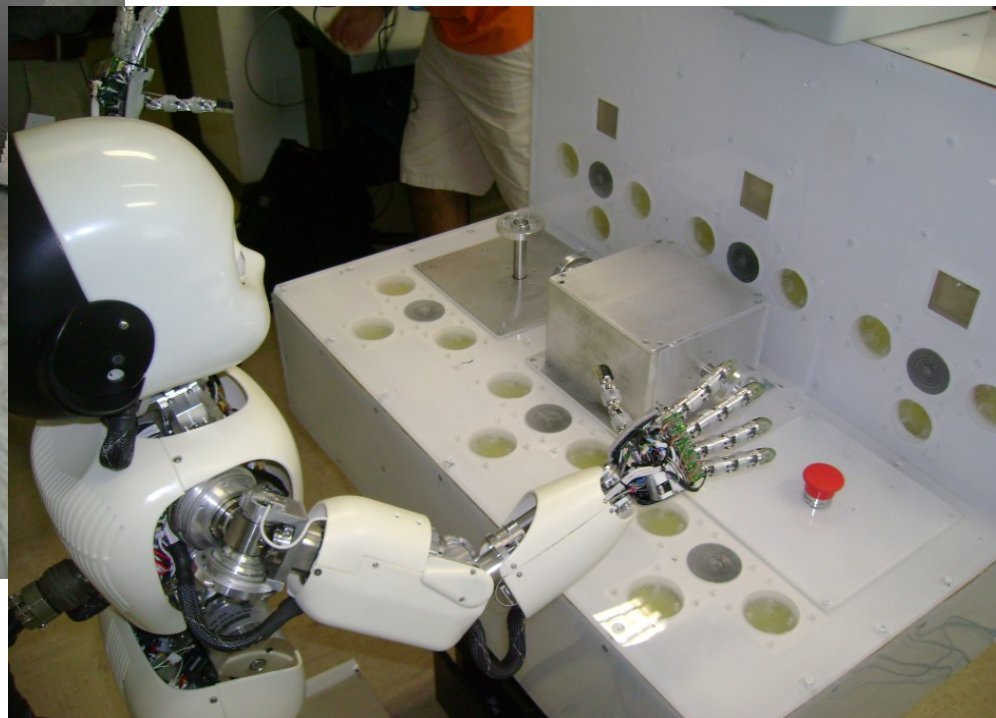
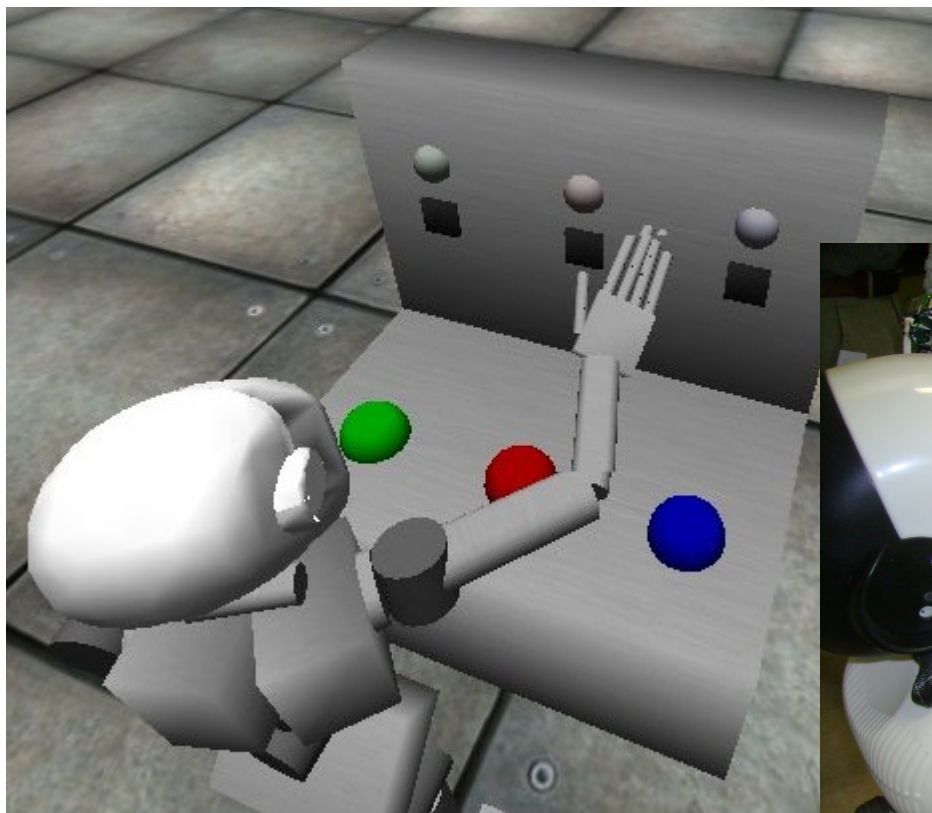
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# Simulated/Real iCub Simulated/Real Board, Yarp (CNR\_AU-Demo)



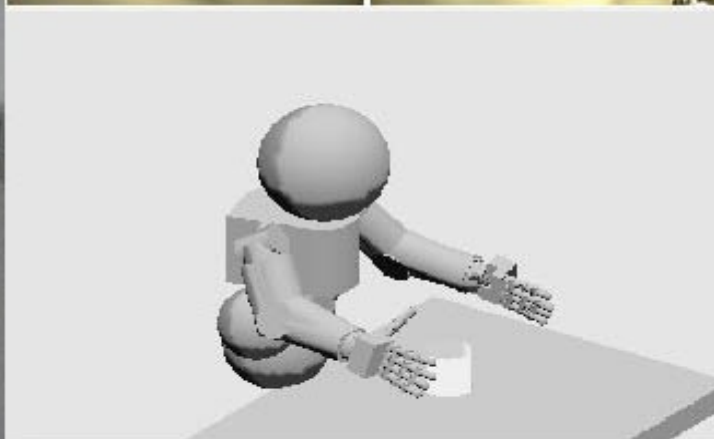
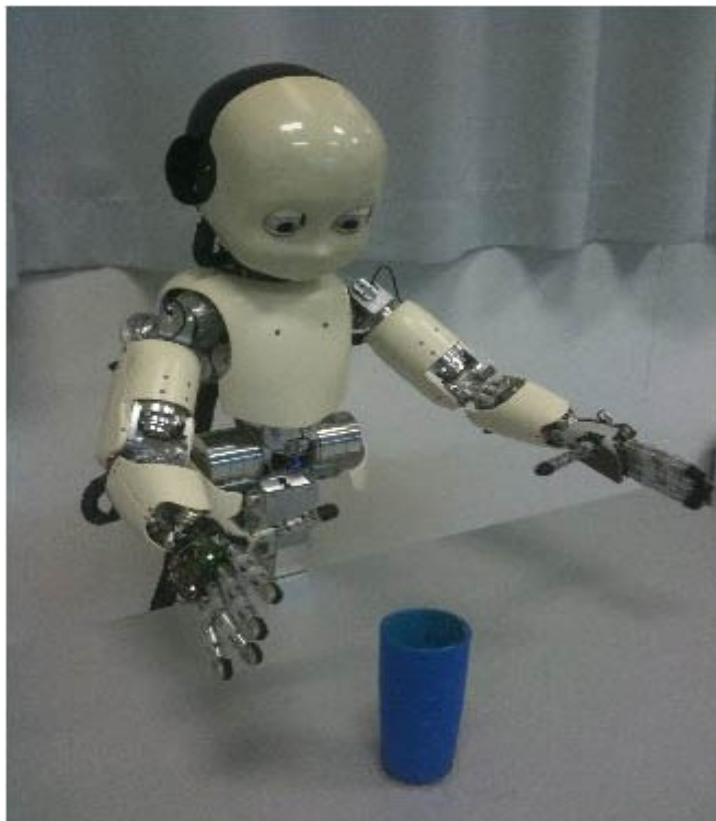


# CLEVER-K2 ML-thread



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  - iCub Demonstrator ([IDSIA\\_UU\\_FIAS-Demo](#))

# Goals, tasks, set-up, Demo (IDSIA-WP7)



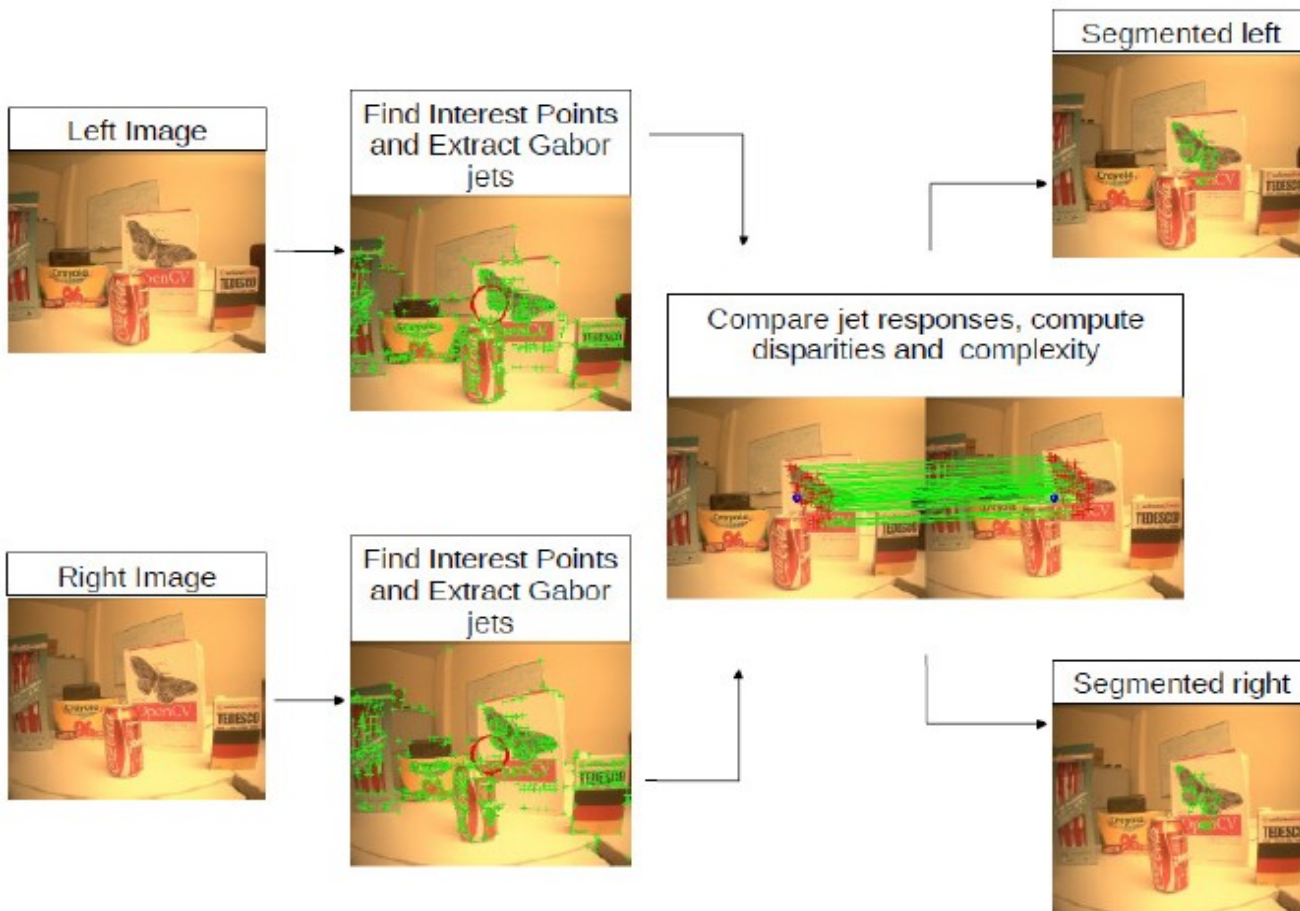


# CLEVER-K2 ML-thread

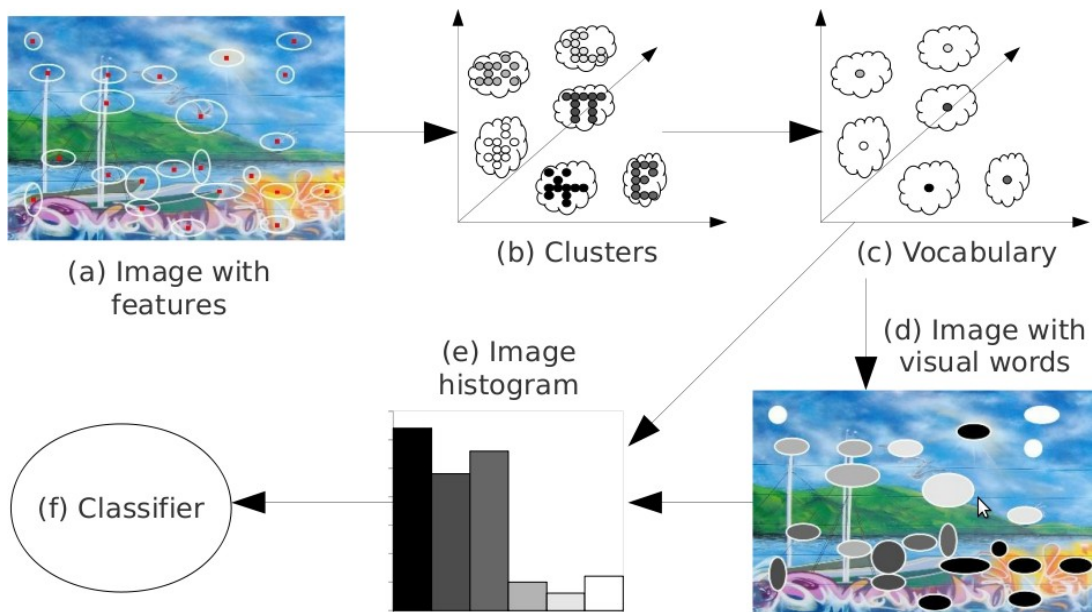
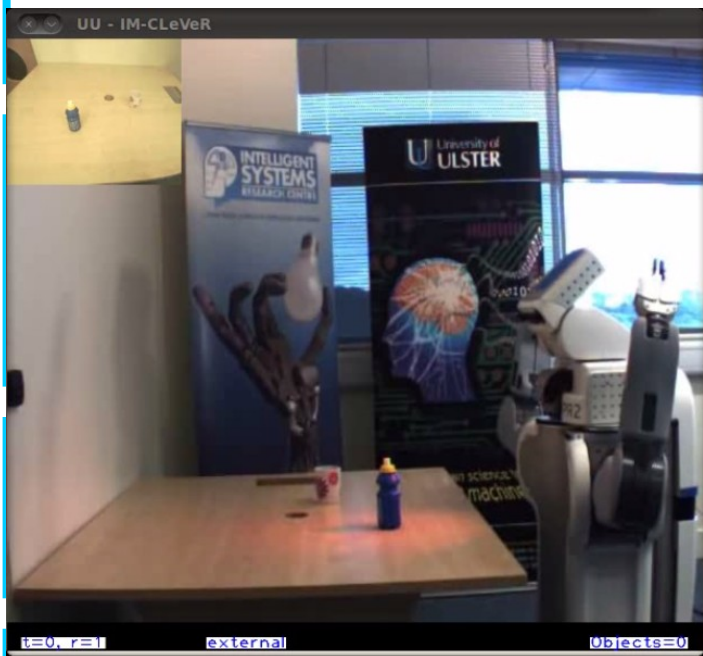


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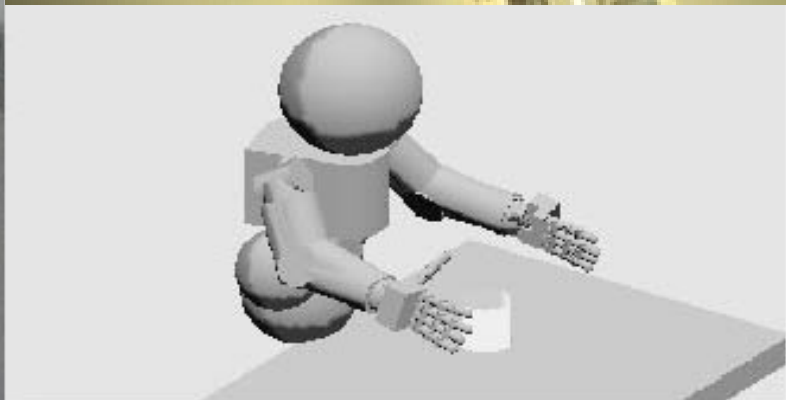
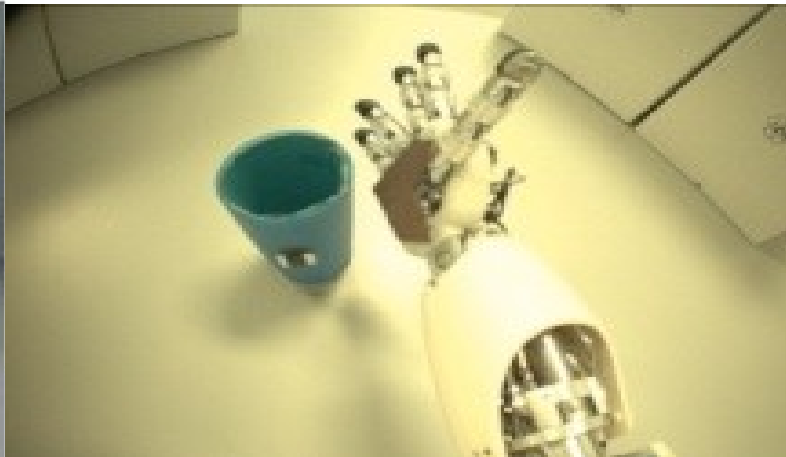
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# Object recognition (UU-WP4)



# Object identification and slow features (IDSIA-WP4)





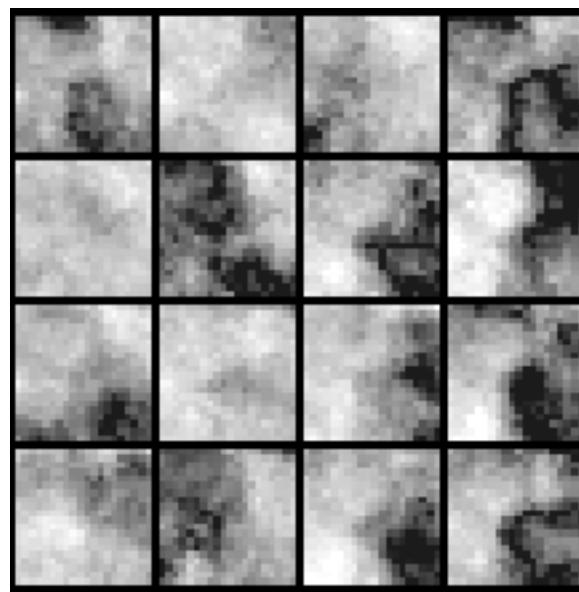
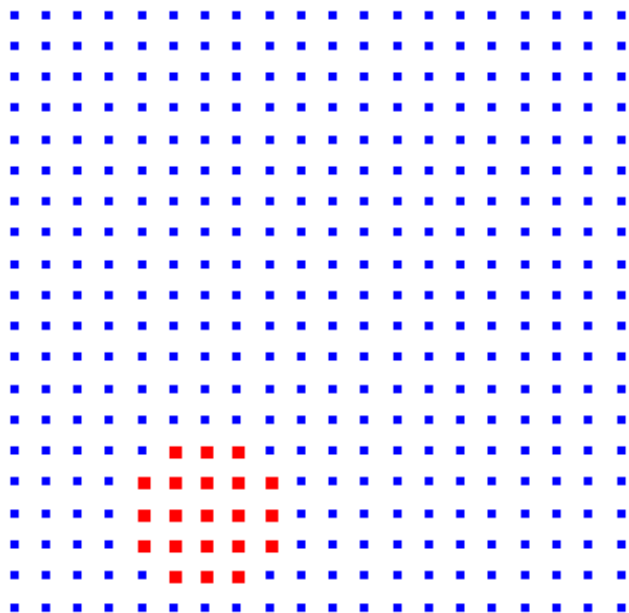
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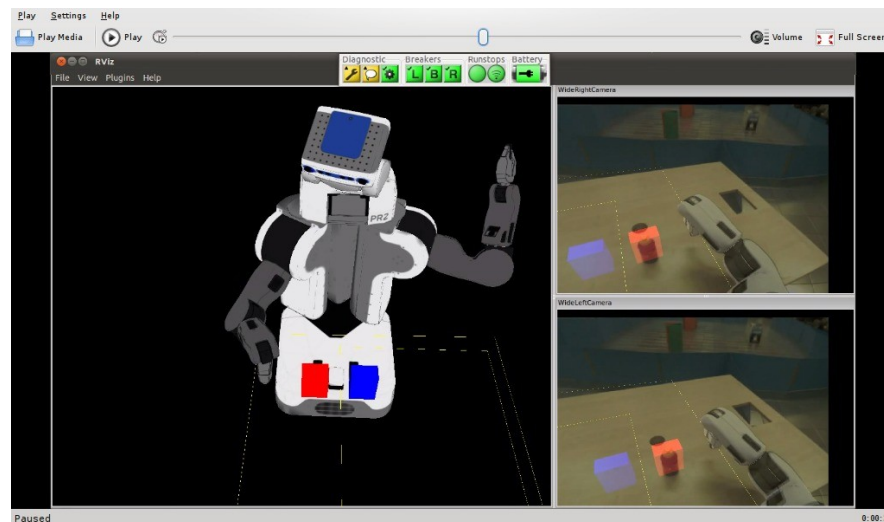
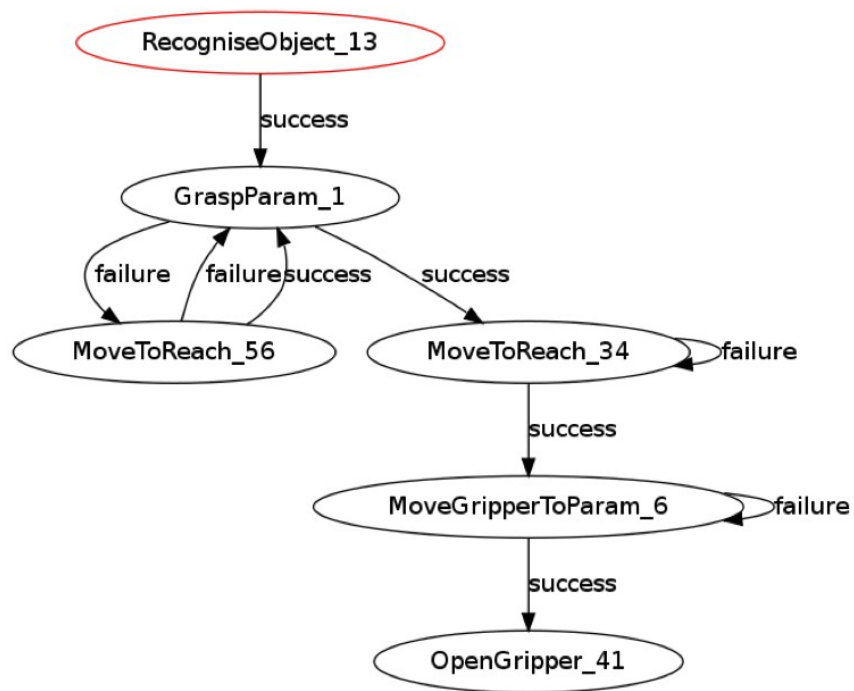
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# Hierarchical architectures (IDSIA-WP6)



# Hierarchical representation of data and skills (UU-WP6)





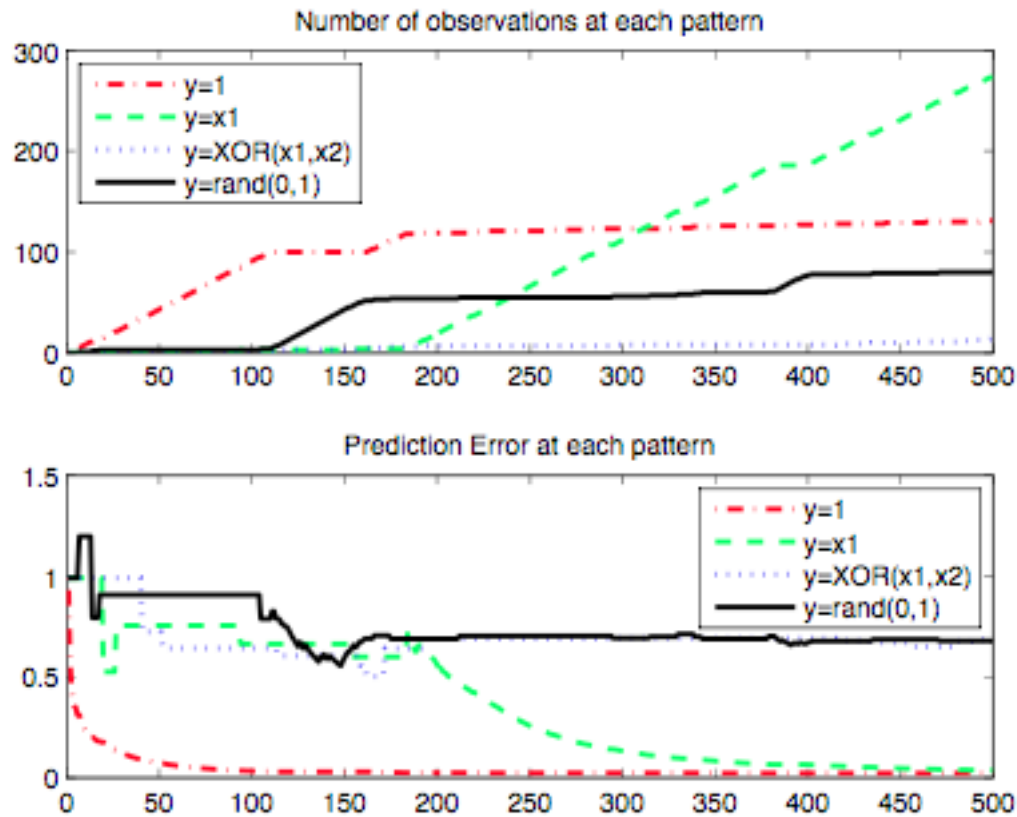
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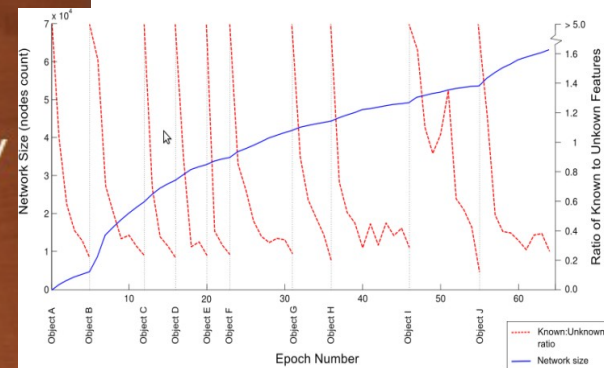
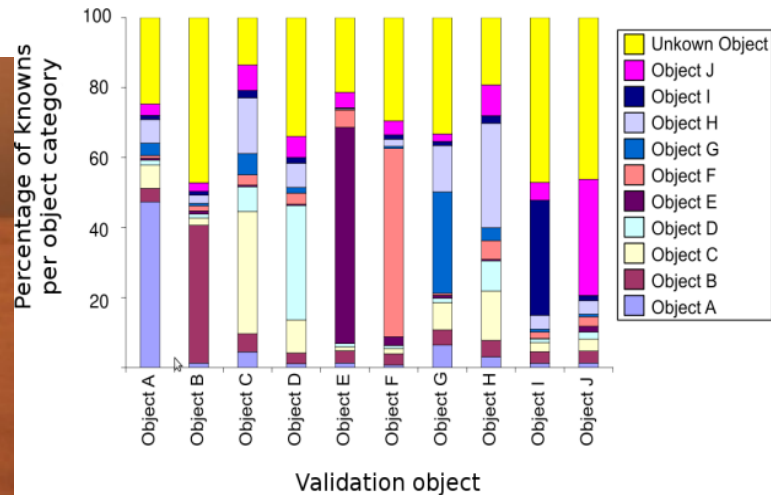
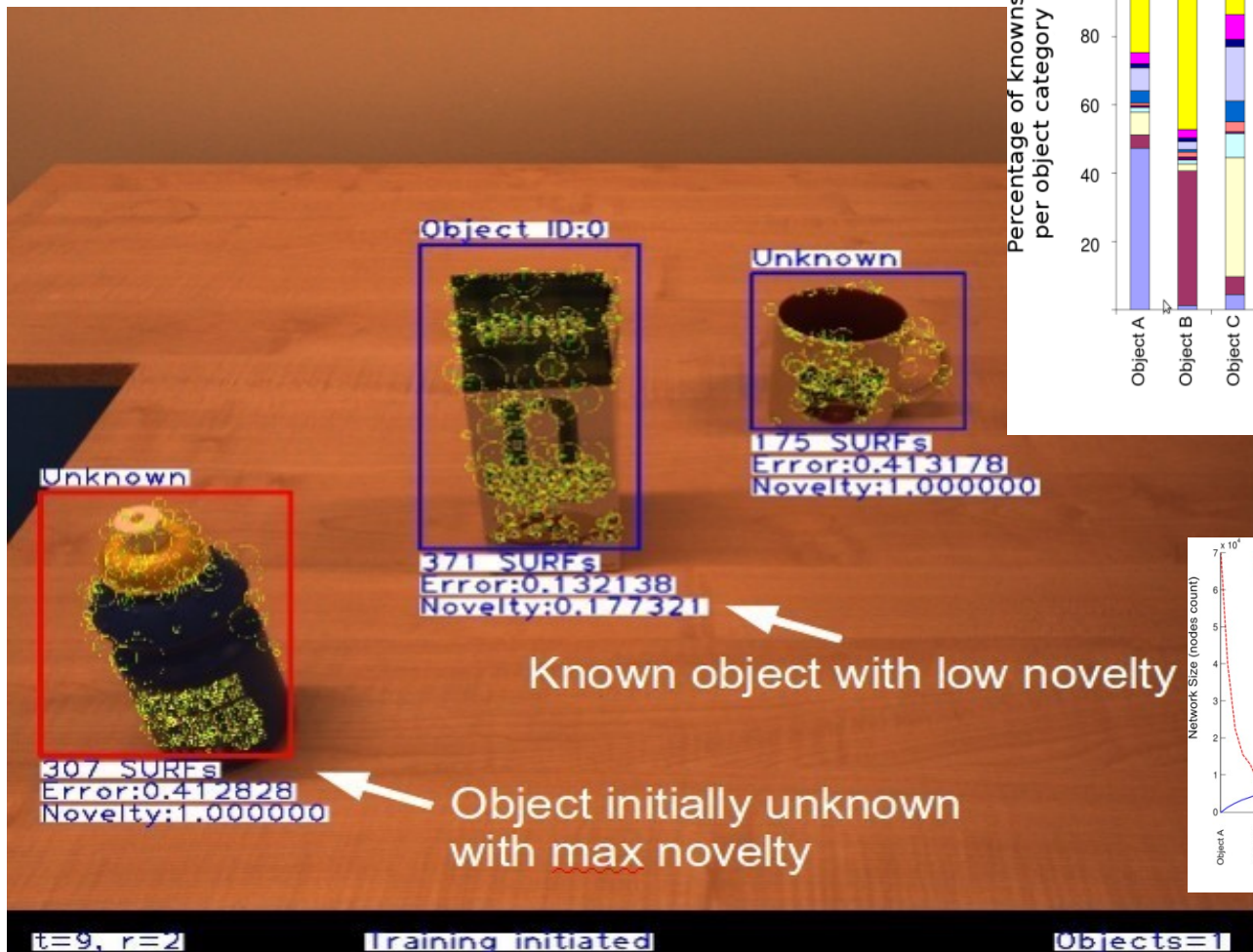
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# Compression-based IM (IDSIA-WP5)

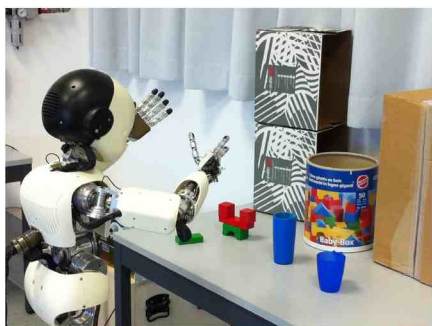


# Novelty detection (UU-WP5)

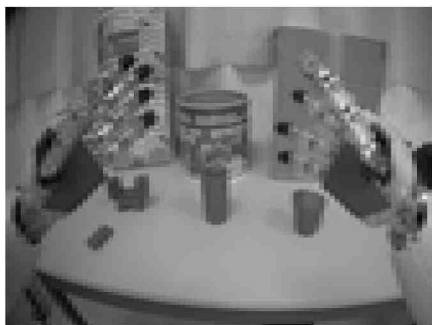


# HW/SW infrastructure, Virtual skin (IDSIA-WP7)

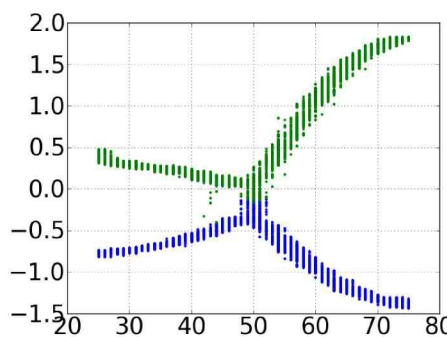
● → Left Arm      ● → Right Arm



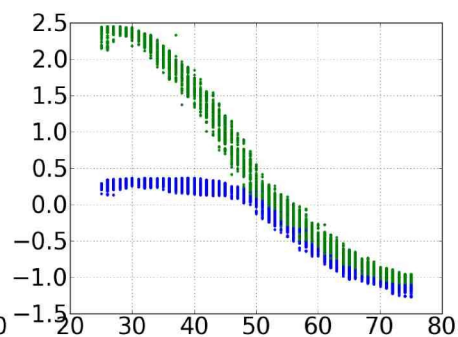
(a)



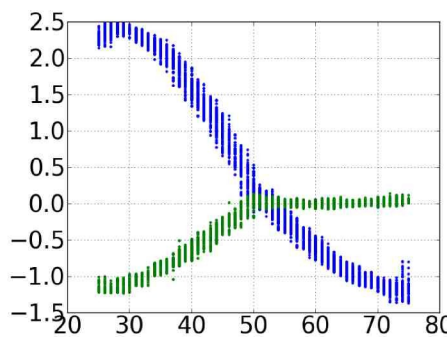
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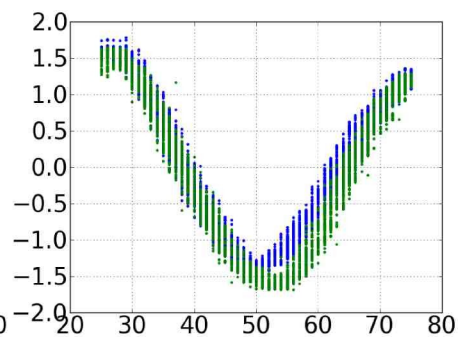
(c)



(d)



(e)



(f)

Arm Position →

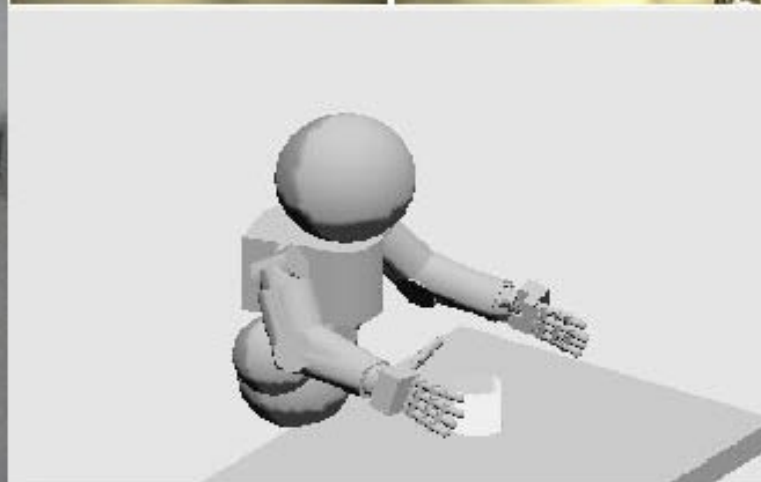
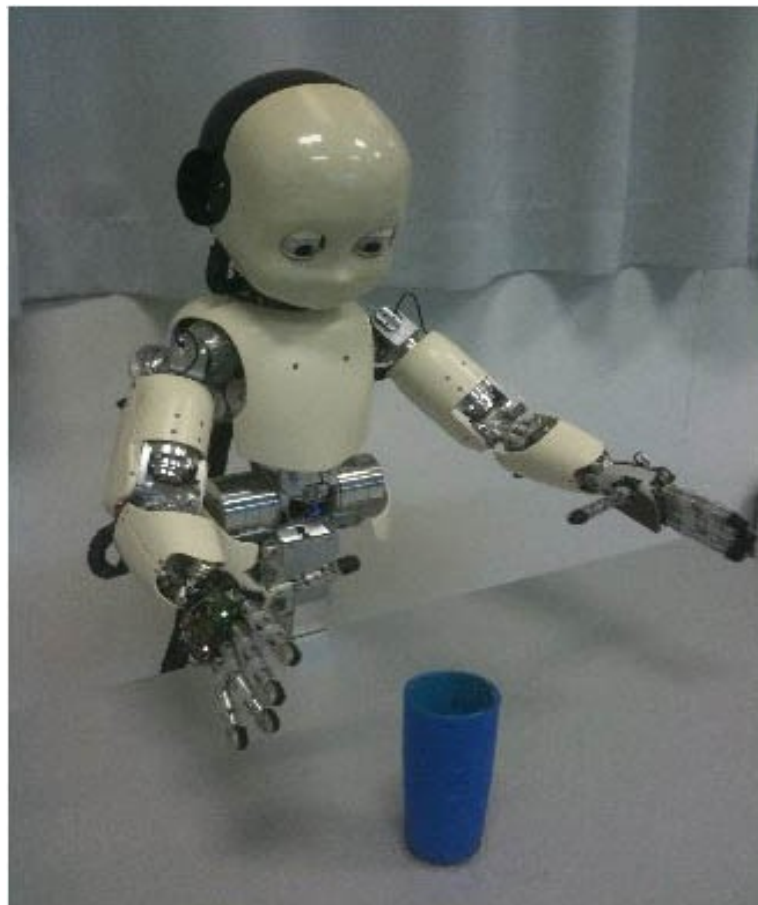


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# iCub demonstrator (IDSIA-WP7)





# Main collaborations

- 1) CNR-USFD: CLEVER-B2 (1 common pub.)
- 2) CNR-UCBM: HRL, motor control (2 common pub.)
- 3) CNR-UCBM: Board, monkeys experiment (visits/meetings)
- 4) CNR-Barto: HRL (visit)
- 5) AU-USFD: “iCub joystick model” (close internet interactions)
- 6) AU-UCBM: Development (1 common publication)
- 7) AU-UU: Saccade learning driven by novelty detection (visits)
- 8) IDSIA-UU: CLEVER-K2 (visits)
- 9) IDSIA-UU: object visual processing (visits)
- 10) IDSIA-FIAS: visual processing (visits)
- 11) IDSIA-FIAS: Reinforcement learning (visits)
- 12) FIAS-UCBM: object visual processing (common student)

**... and 5 Focussed workshops!**



# Research went beyond the state of the art



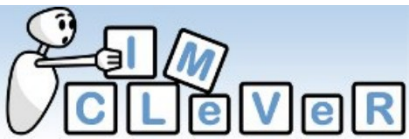
Journal publications: **25**

Internat. conferences/workshops with referees: **70**

Edited books: **2**



# ...and now WP3: Abstraction



# Bio-thread $\leftrightarrow$ ML-thread: cross-fertilisation

- 1) Theory on intrinsic motivations (CNR\_USFD  $\leftrightarrow$  Barto\_UU\_IDSIA)
- 2) Bio-constrained models of IM (CNR\_USFD  $\leftrightarrow$  IDSIA)
- 3) Bio- and ML-models of hierarchical behaviour (CNR  $\leftrightarrow$  IDSIA)
- 4) Novelty detection for staged development (AU  $\leftrightarrow$  UU)
- 5) LCAS Framework for hierarchical skill building driven by novelty (UU  $\leftrightarrow$  AU)
- 6) Visual processing, vergence control (FIAS  $\leftrightarrow$  IDSIA)



# Main evaluators' concerns: replies



(Here few highlights: see Periodic Project Report for others)

- All asked to ensure cross-fertilisation and collaboration
  - Several collaborations
  - We implemented 5 focussed workshops
- Share IDSIA knowledge:
  - Various visits from various labs
- Convergence on IM and HA concepts:
  - Various focussed workshops; common books
  - Common view is emerging:
    - (a) Agreement is enough to work
    - (b) This is itself an important aim of our research



# Main evaluators' concerns: replies



- Empirical experiments are informing modelling:
  - CLEVER-B2: several inputs from experiments
  - Joystick experiment: key inputs from experiments
- UU change of Team leader:
  - 2 common reports (UU, IDSIA, CNR)
  - UU visits to IDSIA, collaboration on CLEVER-K2
  - Much work from UU! E.g., on computer vision