Perception & Cognition: Two Foremost Ingredients toward Intelligent Robots

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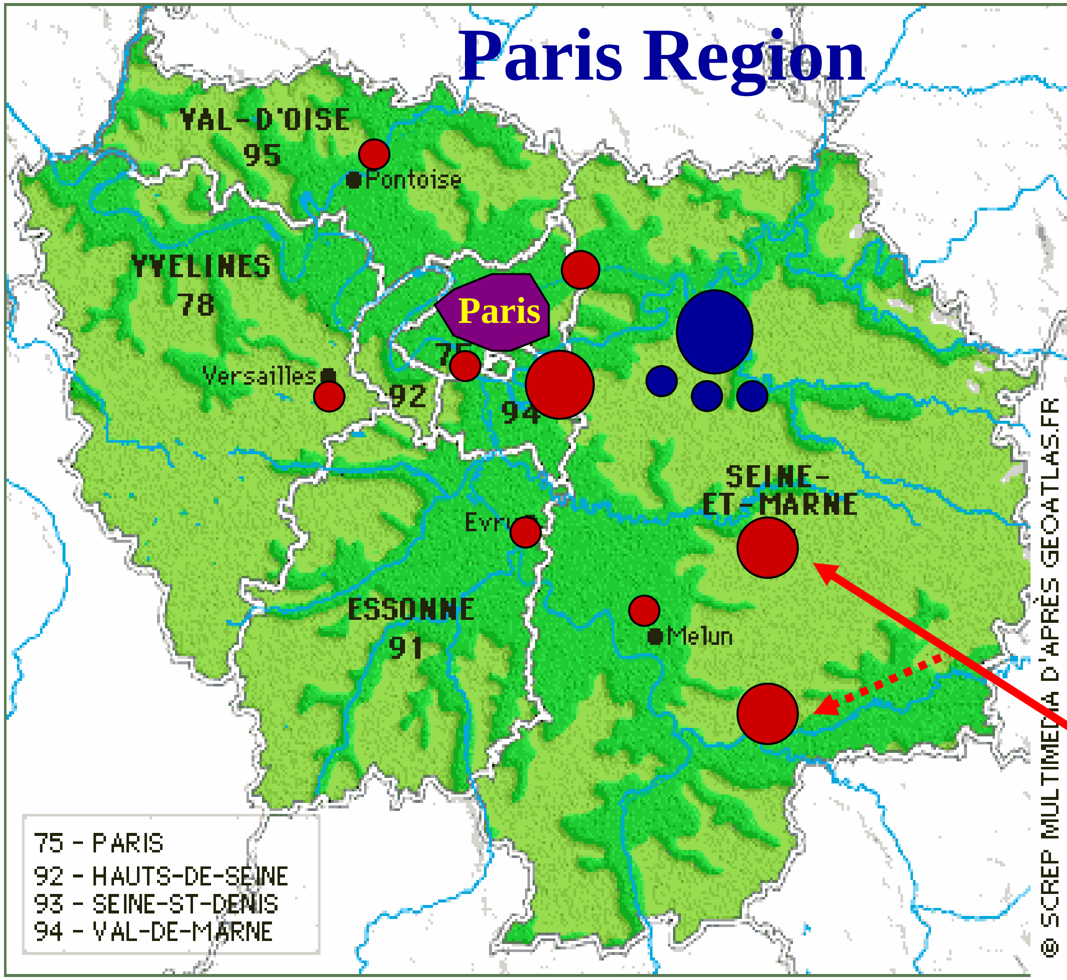

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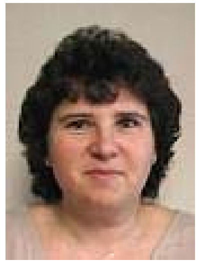




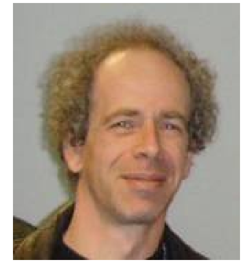

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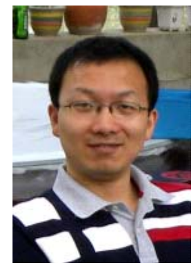


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IMS Team of LISSI Lab.

☞ **IMS team of LISSI (Intelligent Machines & Systems) works on exploitation of bio-inspired mechanisms in order to realize and implement « intelligent artificial systems »: application to Real-World problems.**

☞ **Privileged areas & applications are:**

❶ **complex information processing**

❷ **"industrial" & "Real-World" problems**

❸ **modeling & implantation of complex systems (Humanoid robots, Collective & Socials Systems, Self-Organizing Systems, etc…).**

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Introduction

The robots' (and machines') autonomy is one of primary challenges of the present decade.

Such robots have to be self-sufficient enough in order to be able to operate in cooperation with users who have no a-prior technical skills.

Among vital capabilities for such robot:

- ✓ **understanding its environment**
- ✓ **deciding (& modifying) actions regarding its environment**

Cognition

- ☞ **"Cognition": refers to the ability for the processing of information applying knowledge.**

- ☞ **In the field of computer science: often intends the artificial intellectual activities and processes relating the "machine awareness" realized knowledge-based "intelligent" artificial functions.**

However, "awareness" & "knowledge construction" require ability to perceive information from surrounding environment.

Cognition-Perception

Thus, "Cognition" and "Perception" remain inseparable ingredients toward autonomous machines (robots…)

Inspired from human's "early-ages cognitive skills" development:

Multi-layer cognitive "Perception-Motion" architecture for autonomous robots

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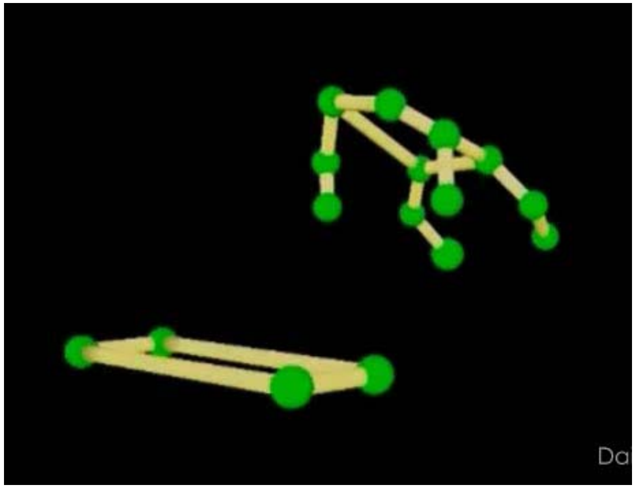
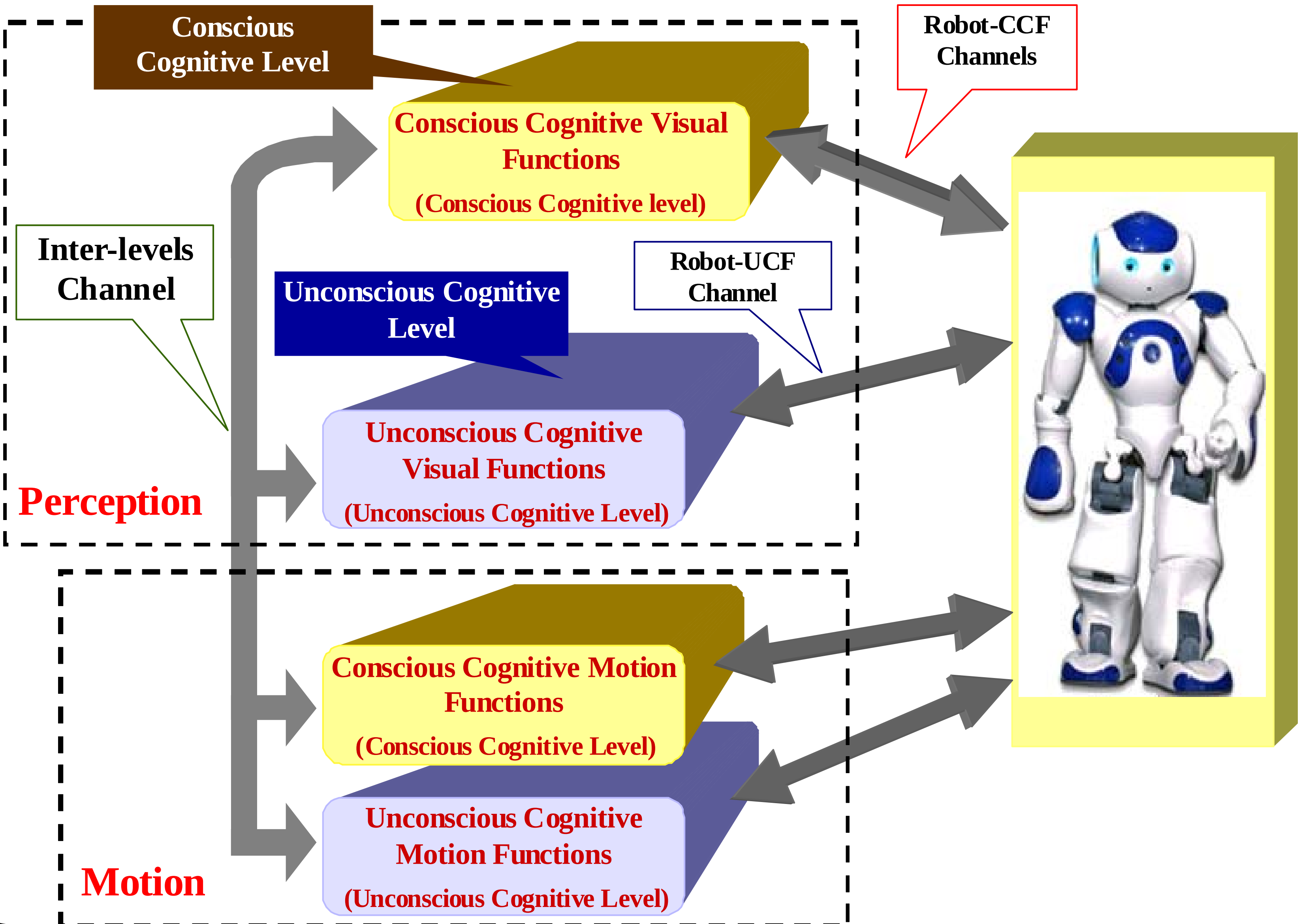
“Early-ages” Human’s Walking Skills Development

The “human’s walking” ability is not an automatic process but a cognitive development since the early ages.

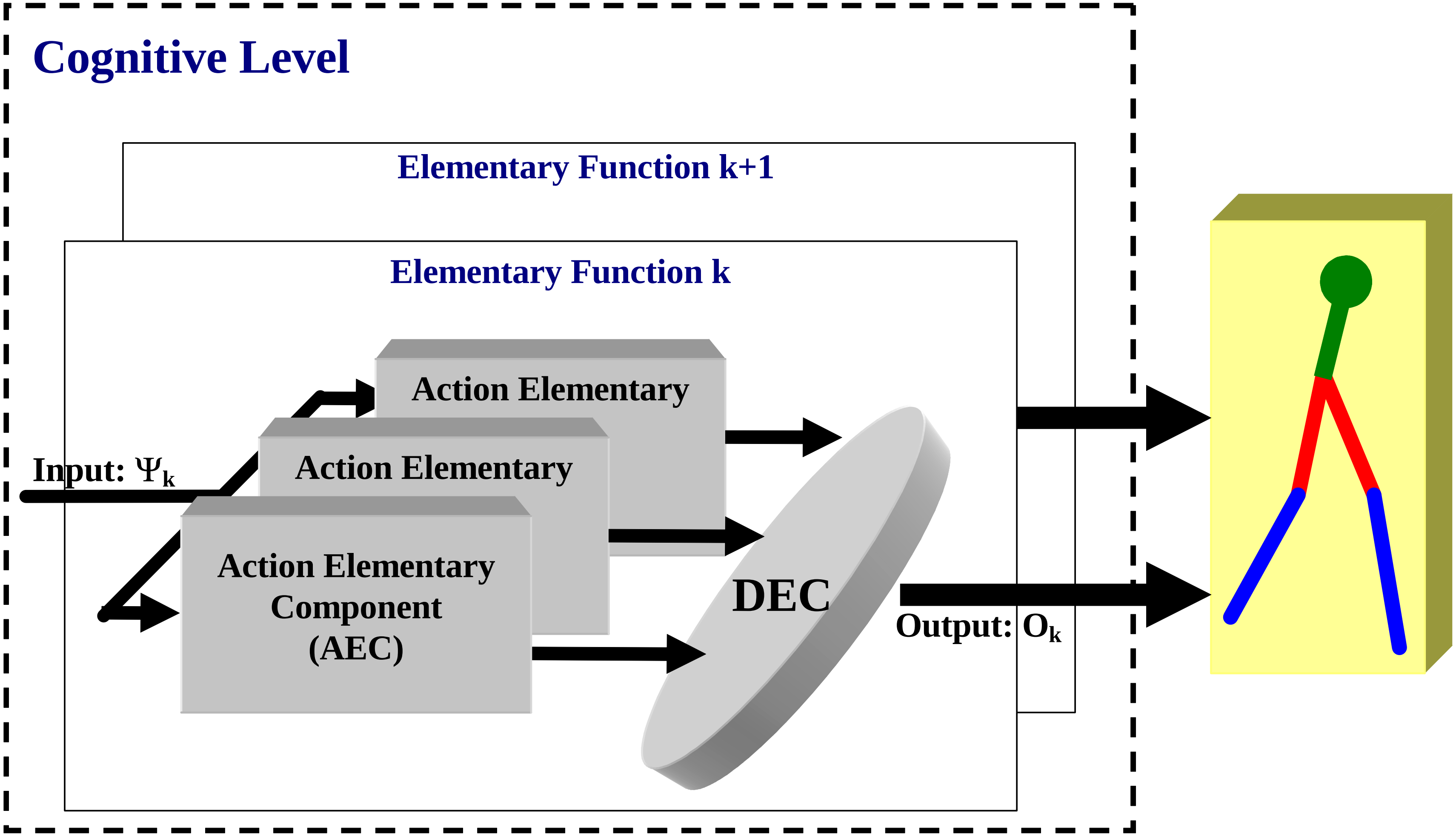
(Dr. Marianne Barbu-Roth : CNRS – Univ. Paris Descartes)



Cognitive Perception-Motion Scheme

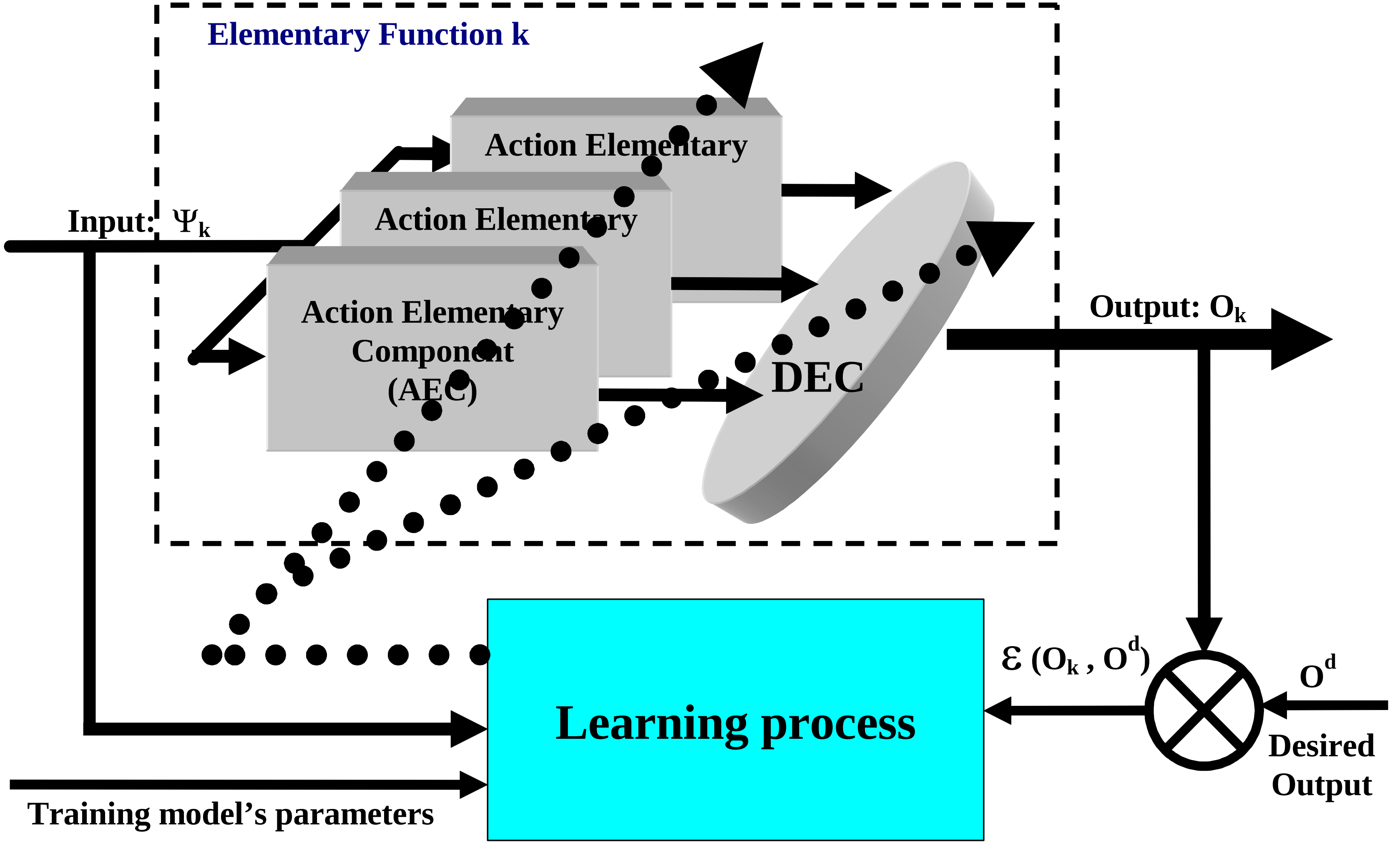


Cognitive level & Elementary Functions

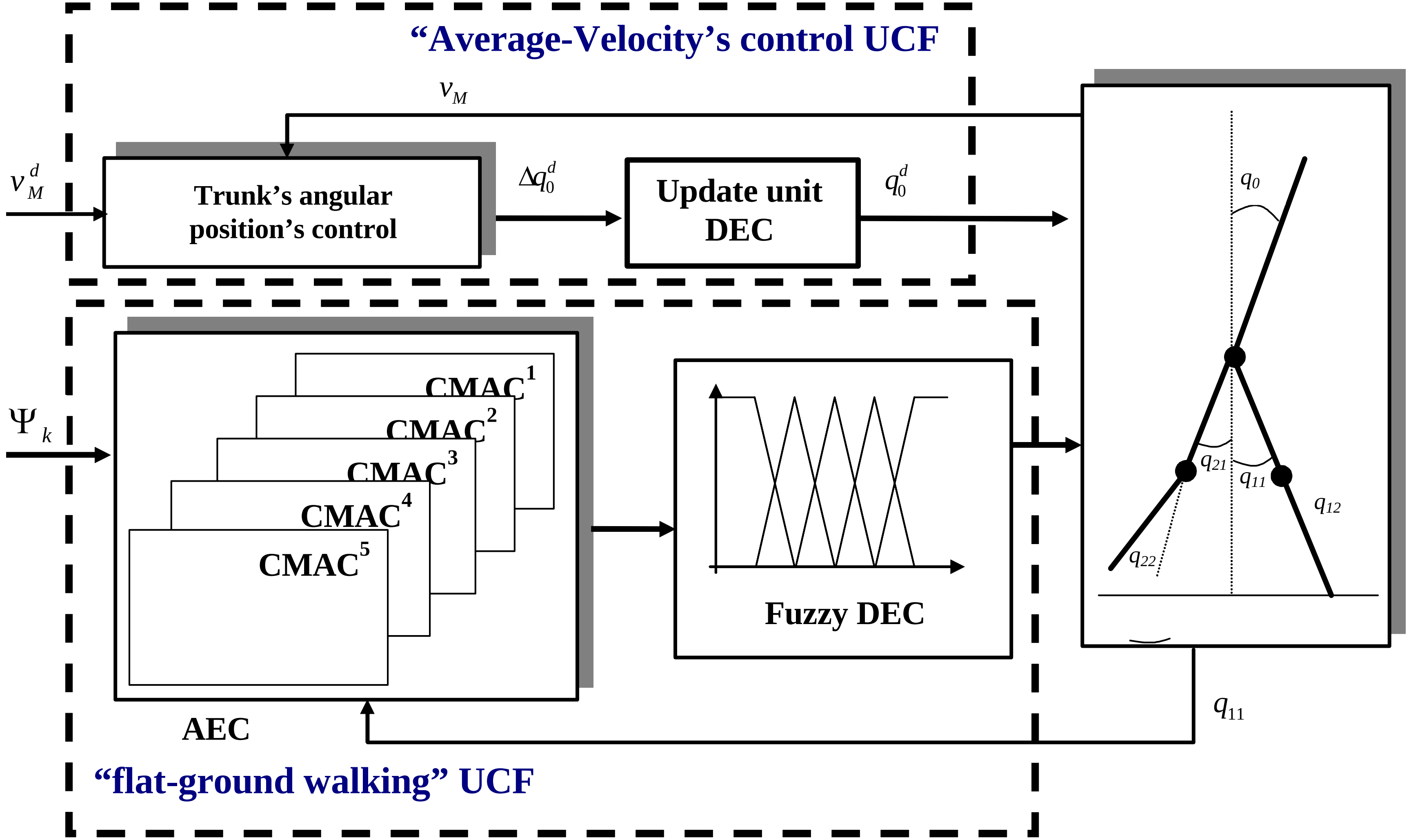


AEC: Action Elementary Component **DEC: Decision Elementary Component**

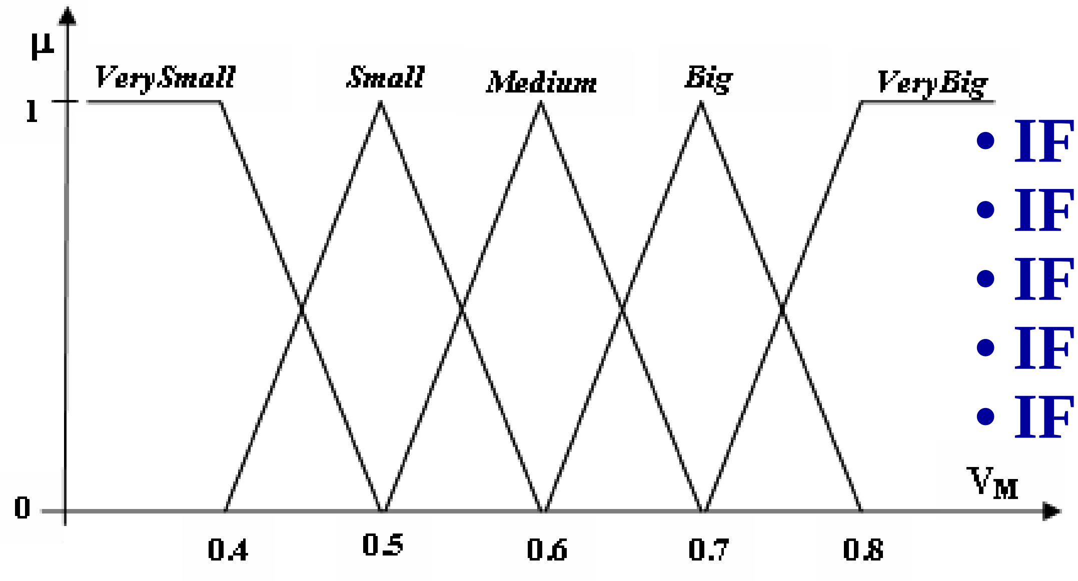
Cognitive level & Elementary Functions



Unconscious Cognitive Function Example



Unconscious Cognitive Function Example



- IF V_M is Very-Small THEN Y = o_1
- IF V_M is Small THEN Y = o_2
- IF V_M is Medium THEN Y = o_3
- IF V_M is Big THEN Y = o_4
- IF V_M is Very-Big THEN Y = o_5

	V_M (m/s)	q_0 (°)	q_{1j} (°)	q_{2j} (°)	L_{step} (m)
$CMAC^1$	**0.4**	**20**	**-7**	**3.5**	**0.23**
$CMAC^2$	**0.5**	**25**	**-10**	**3**	**0.28**
$CMAC^3$	**0.6**	**30**	**-15**	**2.5**	**0.31**
$CMAC^4$	**0.7**	**35**	**-20**	**8**	**0.36**
$CMAC^5$	**0.8**	**40**	**-25**	**8**	**0.40**

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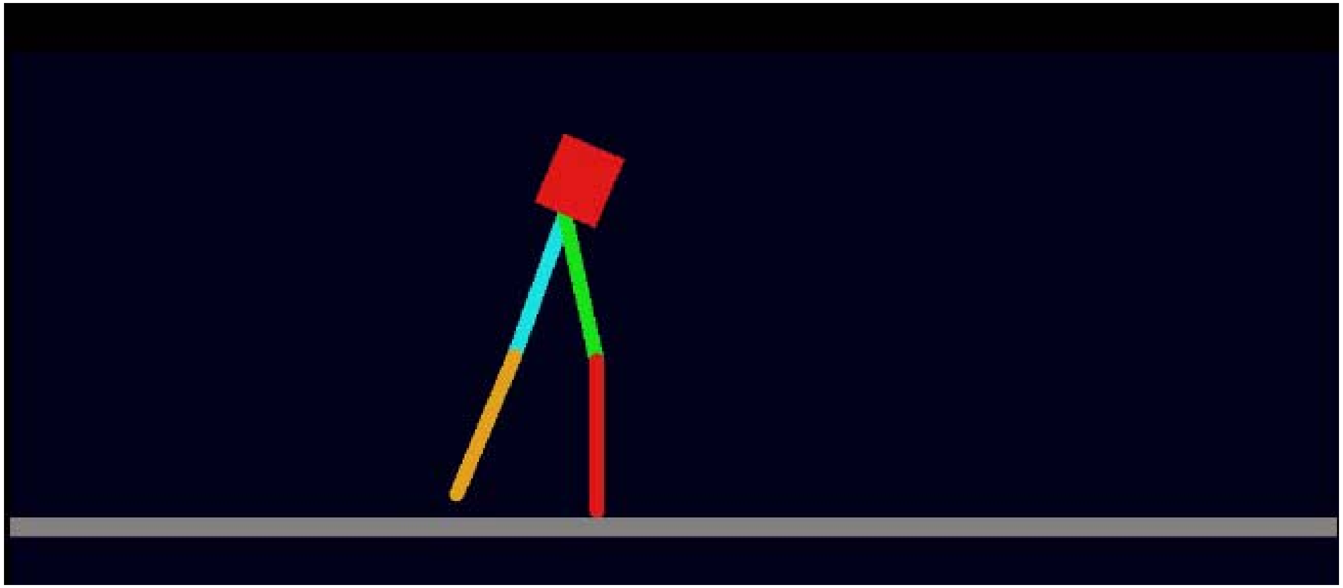
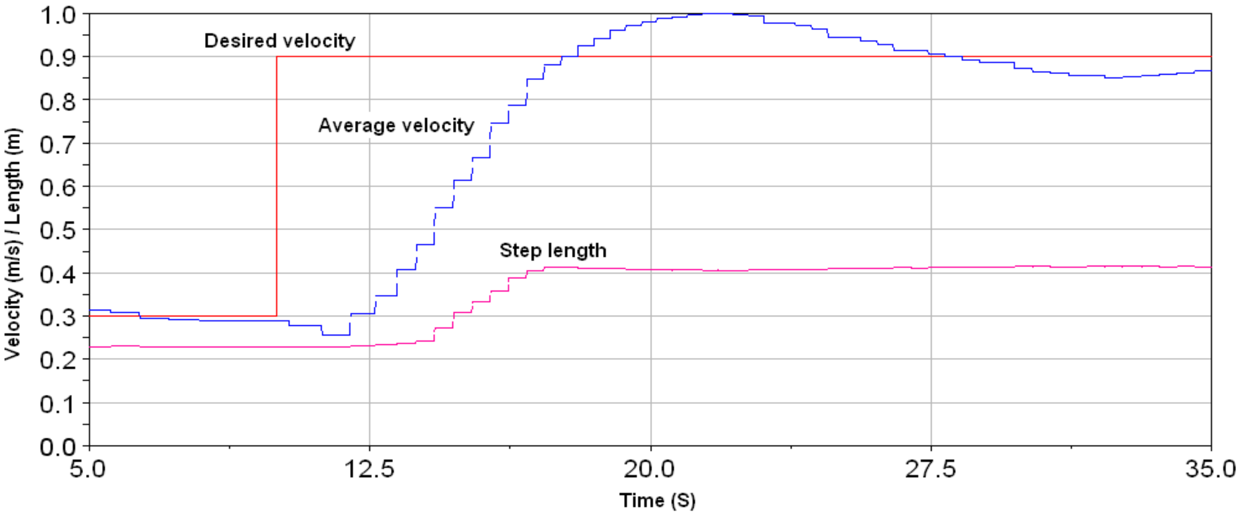
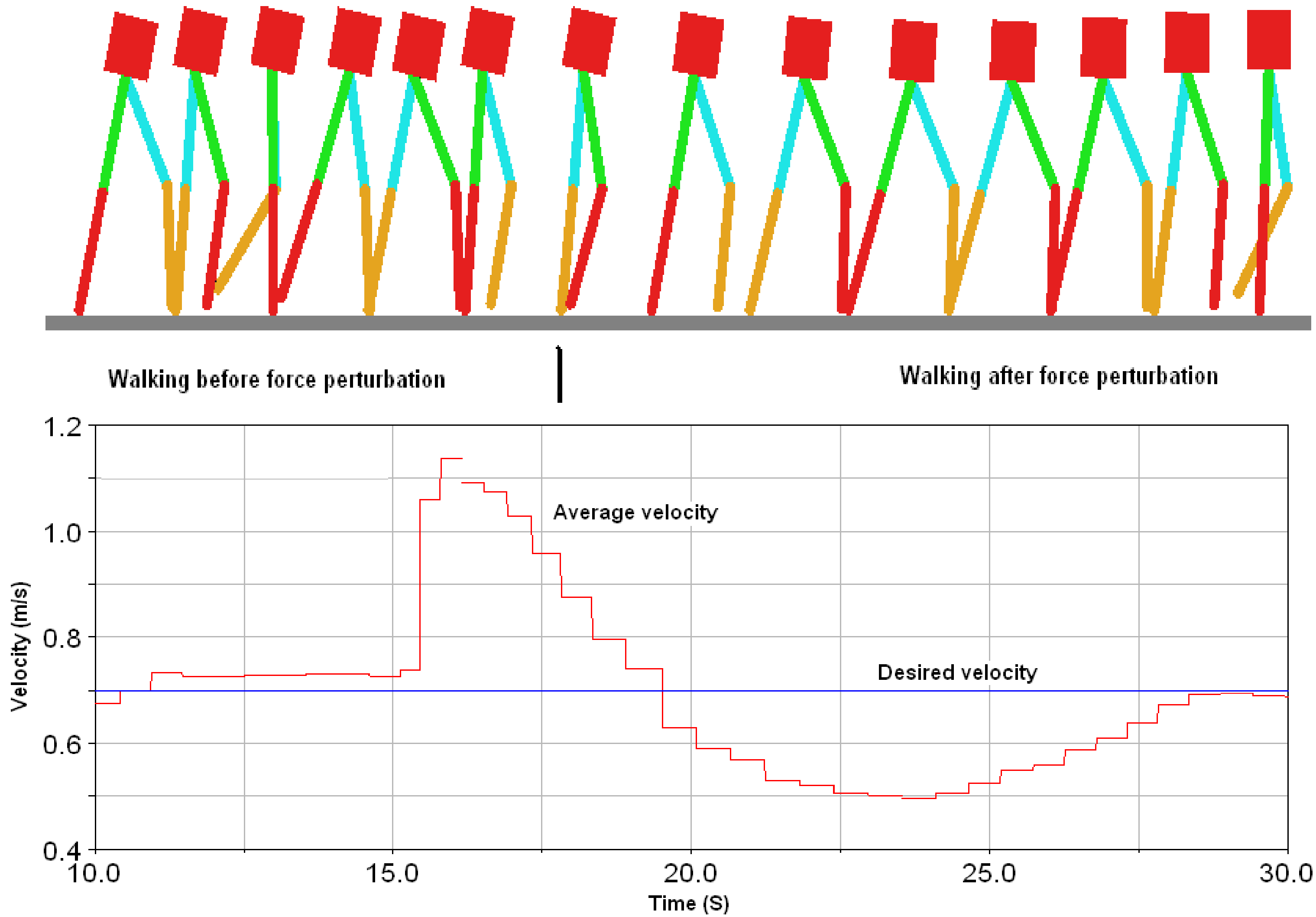
Unconscious Cognitive Function Example

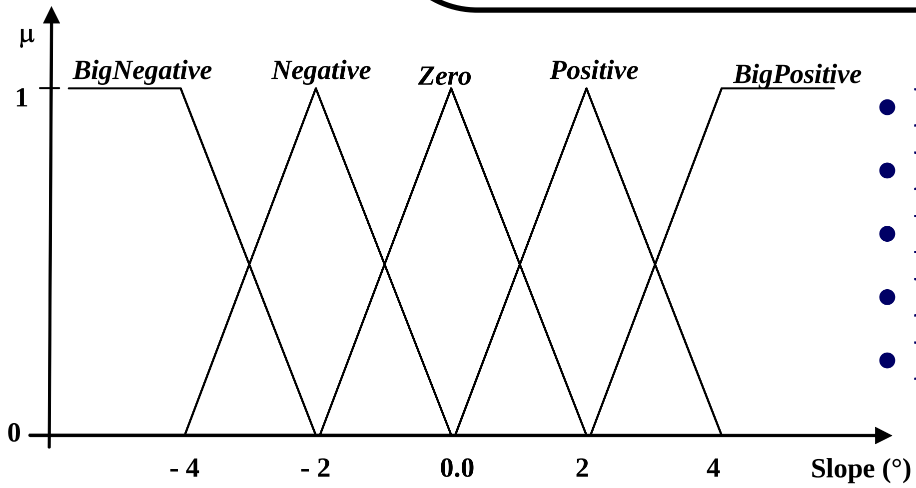




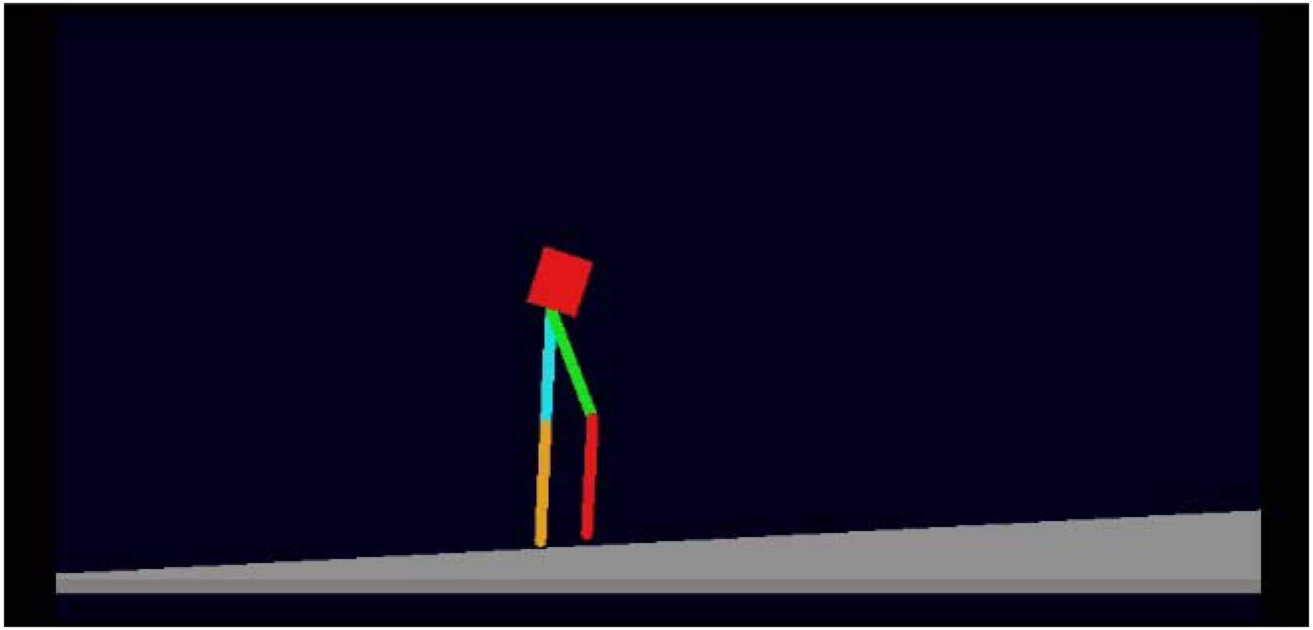
Emergent Behavior



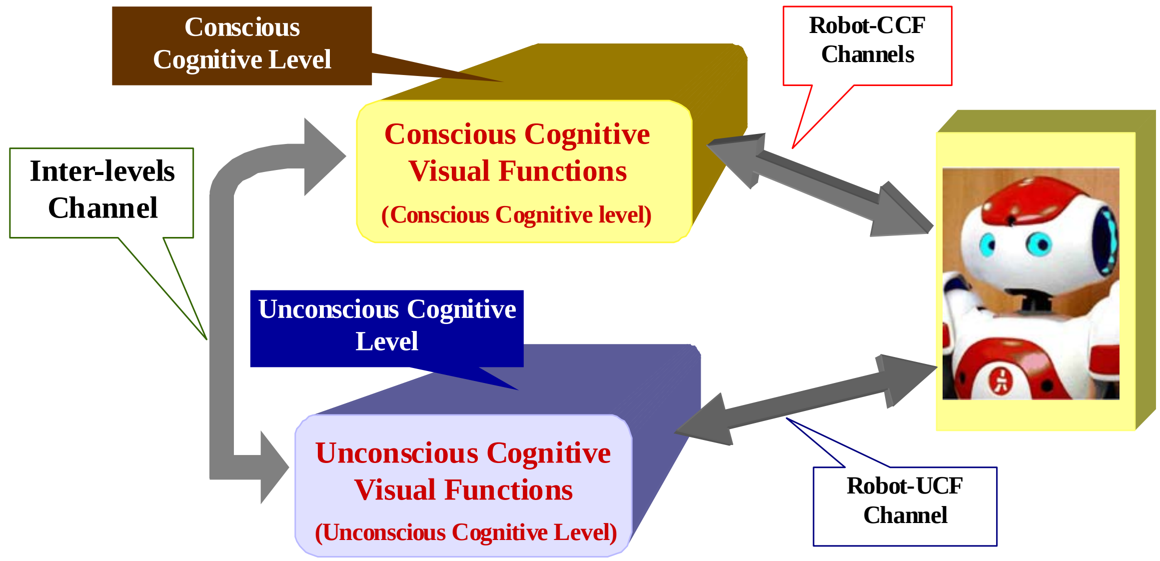
Generalization: Same structure

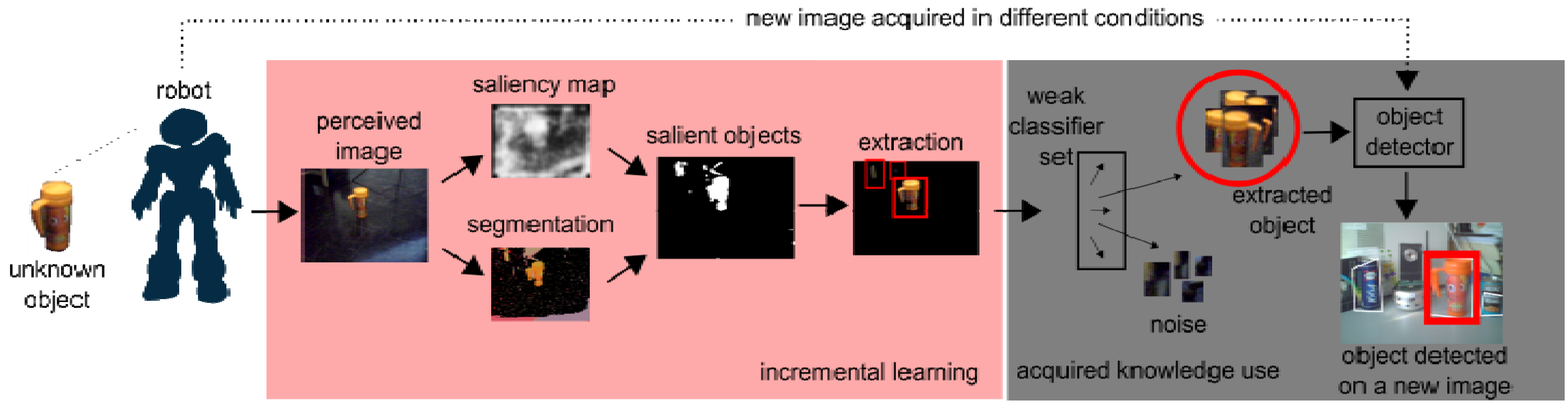


- IF Slope is Big-Negative THEN Y = o_1
- IF Slope is Small-Negative THEN Y = o_2
- IF Slope is Zero THEN Y = o_3
- IF Slope is Small-Positive THEN Y = o_4
- IF Slope is Big-Positive THEN Y = o_5



Perception (Vision) Scheme





Unconscious **Conscious**

Salient objects detection

Let $I(x, y)_{\mu}$ **be the image &** $I_{\omega hc}(x, y)$ **be the Gaussian blurred image**

We define "Luminance Saliency" as:

$$S_{Y}(x, y) = \left\| I_{\mu Y} - I_{\omega hc\, Y}(x, y) \right\|$$

We define "Chromatic Saliency" as:

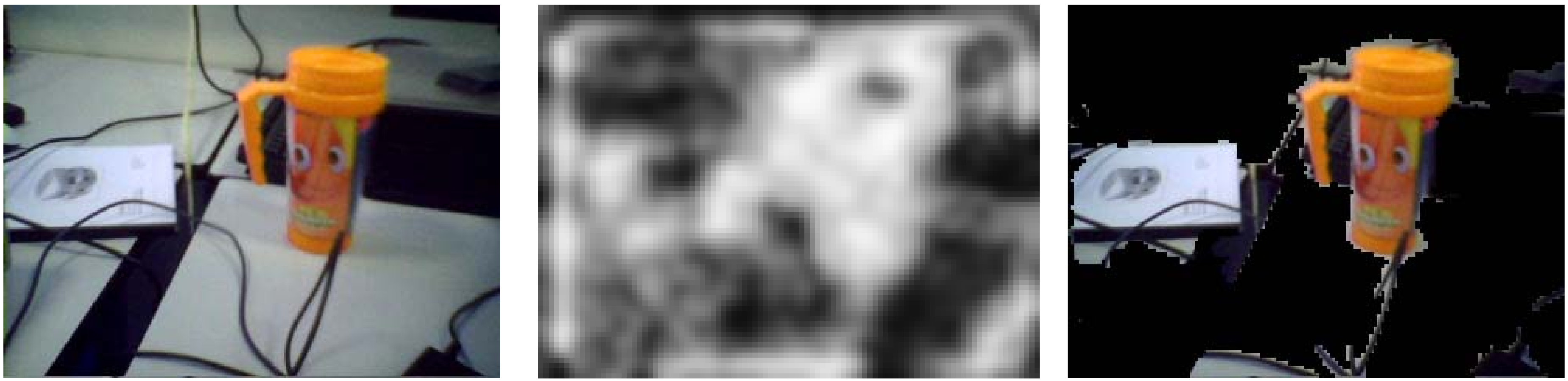
$$S_{CC}(x, y) = \left\| I_{\mu CC} - I_{\omega hc\, CC}(x, y) \right\|$$

in YCrCb color space: "Y" for Y channel and "CC" for Cr & Cb channels.

Salient objects detection

Final Saliency: Neighborhood

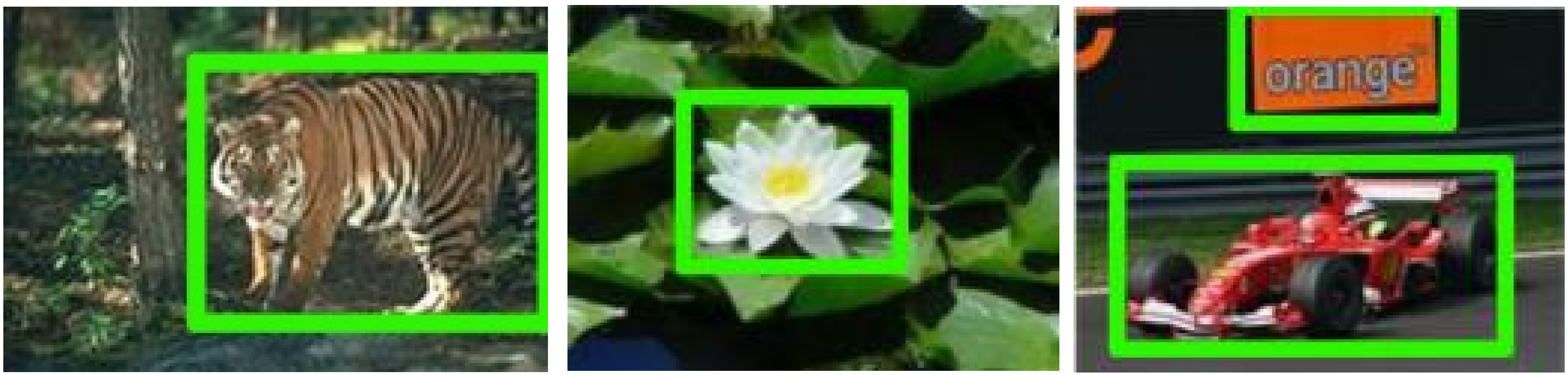
$$S_{final}(x,y) = f\left(S_Y\ ,\ S_{CC}\ ,\ \text{Neighbours-pixels}\right)$$



Original image (left), Salient map example (middle), salient objects (right)

Salient Objects' Finding

Original image (left), Salient region detection (middle), segmentation (right)



Examples of salient objects' detection

Learning & Knowledge Construction

Acquire image

Extract fragments by salient object detector

For each fragment F

  If (F is classified into one group) **Then**

    populate the group by F

  If (F is classified into multiple groups) **Then**

    populate by F the closest group by Euclidian distance of features

  If (F is not classified to any group) **Then**

    create a new group and place F inside

Select the most populated group G

Use fragments from G as learning samples for object detection algorithm

Classifier

A combination of 4 classifiers: $\{w_1, w_2, w_3, w_4\}$

Each classifying a fragment "F" as "belonging" or "not belonging" to a certain class

Area w_1: separates "too different" areas.

Aspect w_2: separates fragments with "too different" aspects.

Chromaticity w_3: separates fragments with "too different" chromaticity.

Texture w_4: separates fragments with "too different" textures.

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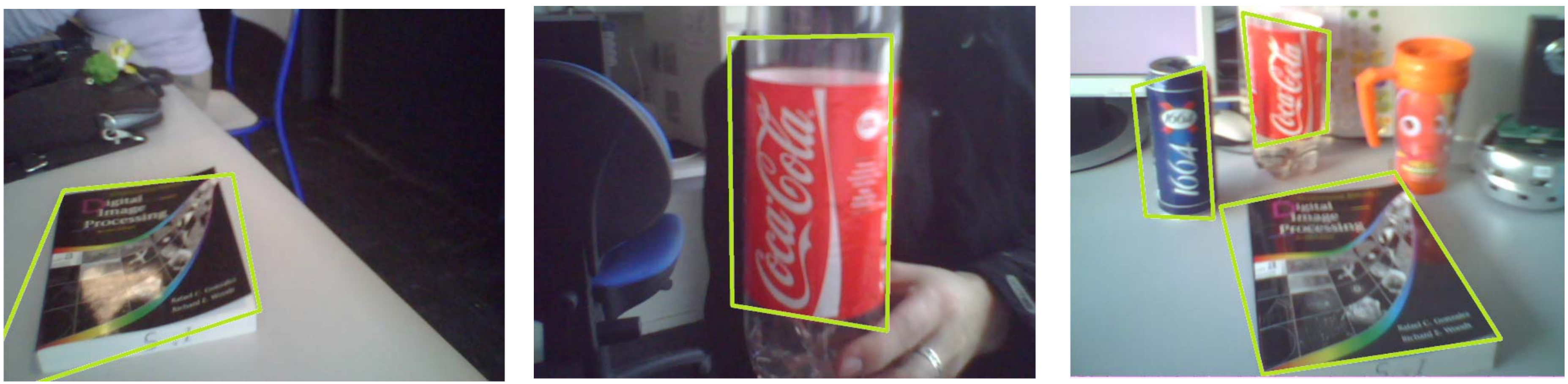
Some Results

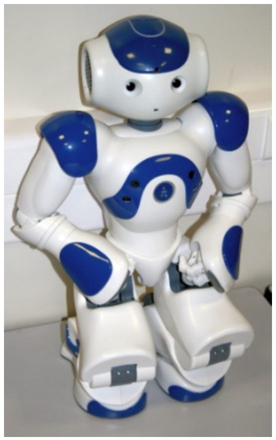
Table 1. Percentage of correct detections of object over testing image set using Viola-Jones detection framework.

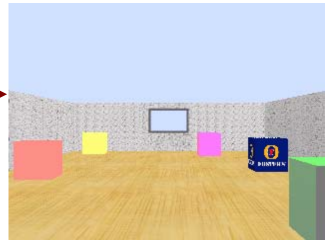
Viola-Jones	apple	beer	coke	khepera	mouse	mug	pda	shoe
% of correctly detected instances	98.0	88.2	77.3	60.0	76.0	89.1	80.0	81.8

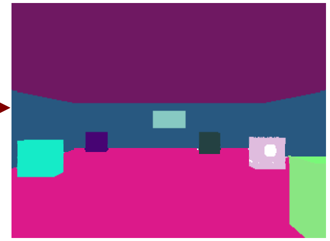


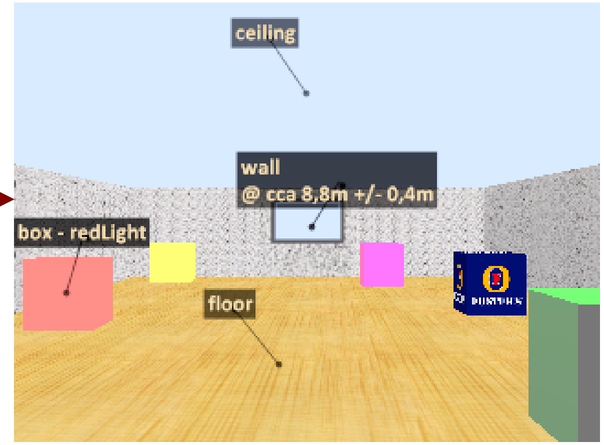
Examples of objects' detection in current environment.

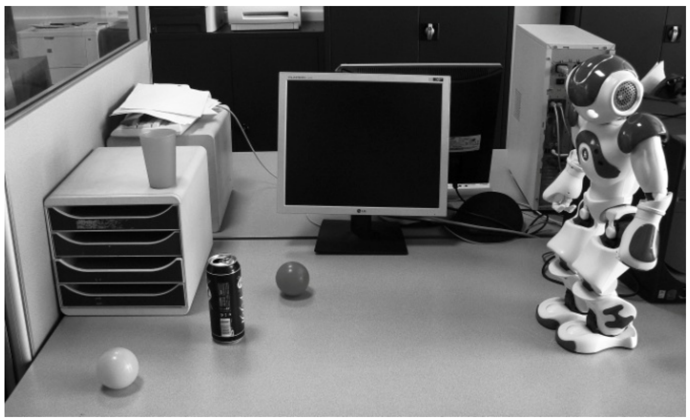
Conscious Cognitive Function Example

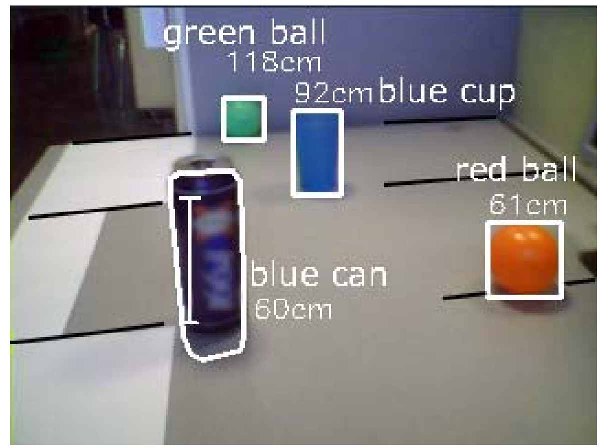












Examples of objects' detection in current environment.

Conscious Cognitive Function Example

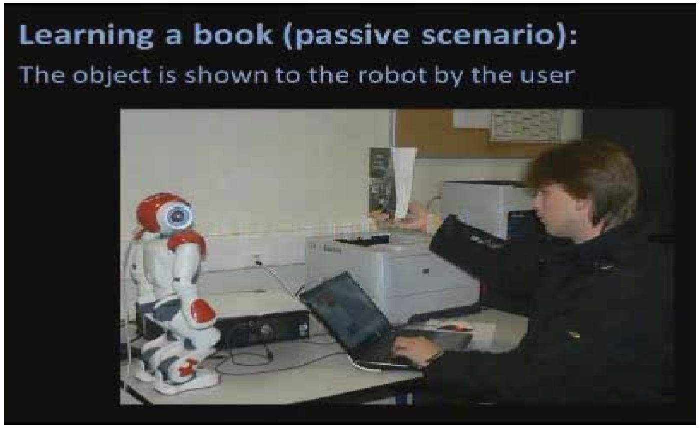
Implementation on NAO Robot

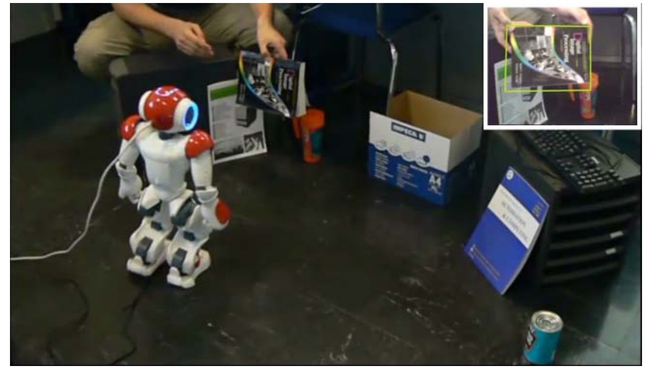
The process

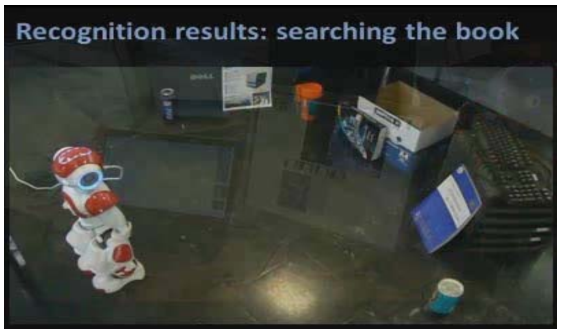
1) get an image from Nao's camera
2) find the desired object on it using image processing algorithms
3) approximate its distance and position with respect to Nao with some human inspired algorithms
4) fetch the object

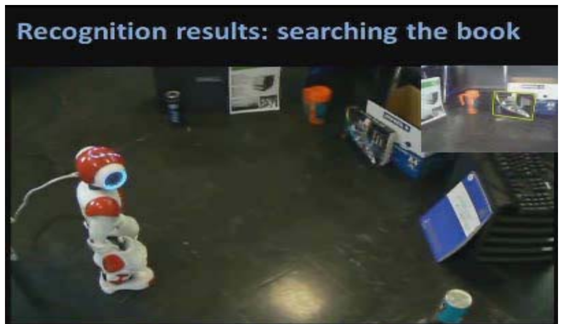
NB: Nao uses its voice synthetiser to inform us about its actions ...

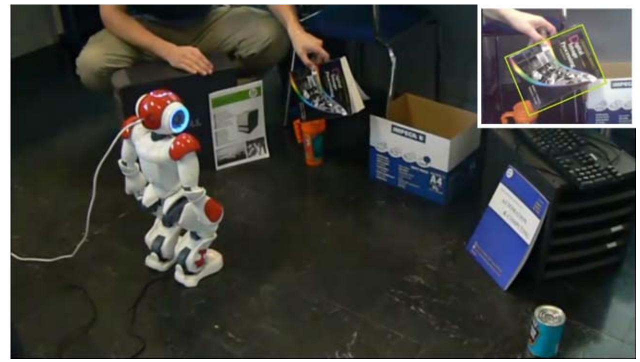
Implementation on NAO Robot

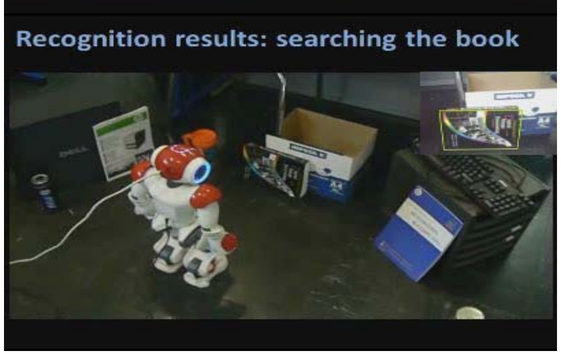


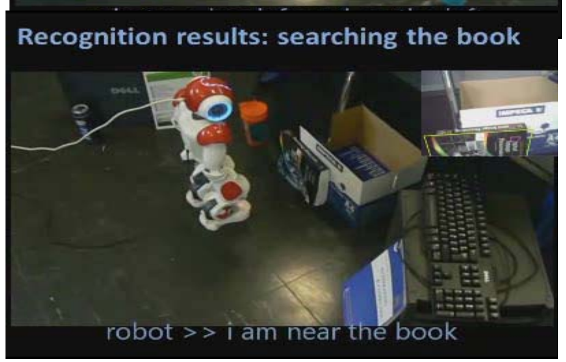












Final Words

Machine intelligence Architecture based on :

"Cognition-Perception" duality

- obtained results show viability of the proposed architecture

- obtained results show also the pertinence of the used methods

Probably a promising aspect is related to "Emergent behaviour": part of "intelligent skill"

Final Words

However, today, the most important is of course:

Your Opinion

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Thank you for your attention