Expected Perception: an Experimental Application in Robotic Sensory-motor Coordination

Edoardo Datteri°, Giancarlo Teti*, Guglielmo Tamburrini°,
Cecilia Laschi*, Paolo Dario*, Eugenio Guglielmelli*

° Department of Philosophy, University of Pisa
Piazza Torricelli 3/a 56126 Pisa, Italy
e-mail: gugt@fls.unipi.it

* ARTS Lab, Scuola Superiore Sant'Anna
c/o Polo Sant'Anna Valdera, Via Rinaldo Piaggio, 34,
56025 Pontedera (Pisa), Italy
e-mail: cecilia@arts.sssup.it

Objectives

To propose and experimentally validate a novel scheme for sensory-motor coordination in robots, as a ground for overcoming difficulties in the current approaches for reactive agents.

To experimentally evaluate the helpfulness of 'Expected Perceptions' in action-oriented perceptual tasks.

Rationale

In reactive architectures [2], a crucial achievement of embodied AI [3,4], critical difficulties arise in view of the processing complexity of perceptual task in complex sensory modalities, like vision, or in the setting of highly dynamic environments.

Our work is grounded in the broad hypothesis that human perception and action are improved in speed and accuracy by expectation mechanisms, based on internal models of the environment and the agent.

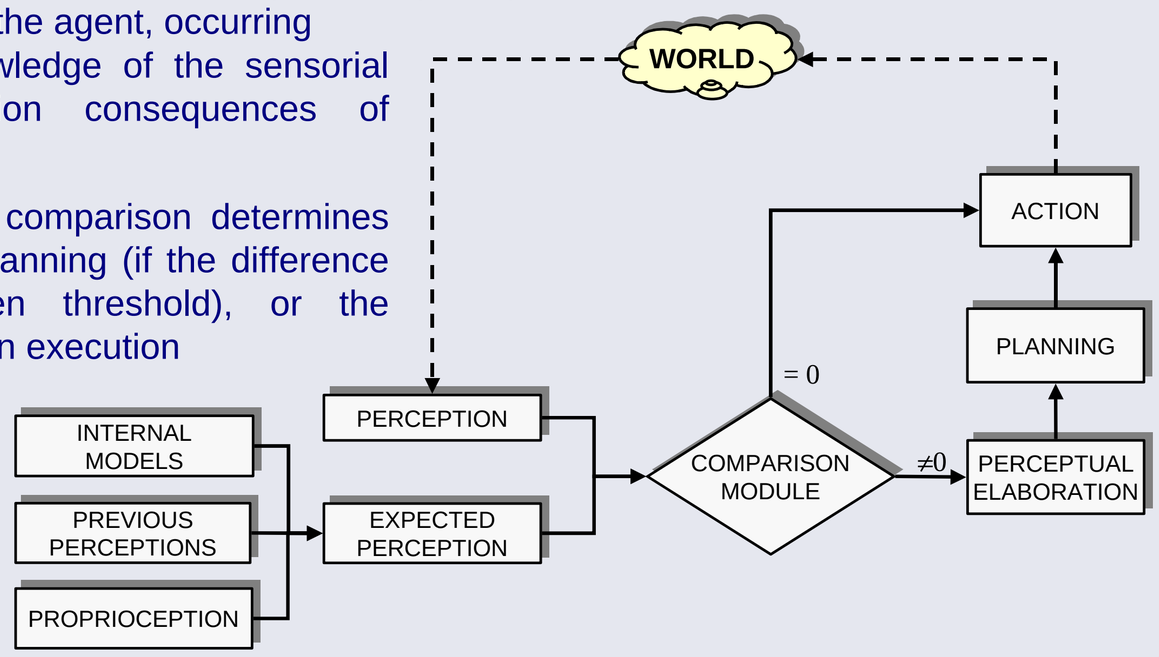
The Model

In the proposed approach, perception crucially involves comparison processes between incoming stimuli and *Expected Perceptions* (EPs). EPs are the basis for attention-driven and pre-interpretation mechanisms, that simplify perceptual elaboration. Action, on the other hand, is not construed as the result of continuous sensory-motor coordination, as in typical reactive architecture; it is basically viewed as a pre-planned execution, continuously monitored by comparisons between occurring and expected events (ultimately, EPs). Sensory data are more extensively processed for the purpose of action re-planning only when actual sensory detection conflicts with the current EP.

The EP-based scheme is functionally very close to some recent neurophysiological hypotheses on human sensory-motor coordination [1].

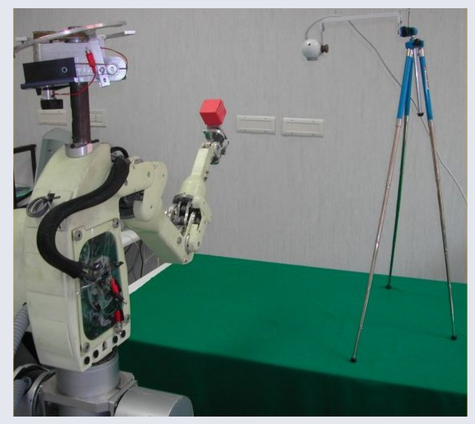
The flowchart of the proposed system is as follows:

- action is first planned
- incoming sensory stimuli (perceptions) are continuously compared to EPs during execution of planned action
- EPs are generated on the basis of previous perceptions, internal models of the environment and the agent, occurring events, and knowledge of the sensorial and proprioception consequences of agent's actions
- the result of the comparison determines the need for re-planning (if the difference exceeds a given threshold), or the prosecution of plan execution
- in the latter case no additional computations are required for the generation of the action



Experimental validation

The proposed EP-based scheme has been implemented as a visuomotor control system for the 8 d.o.f. Dexter robotic arm, in a positioning task, i.e. pushing an object along a straight trajectory.



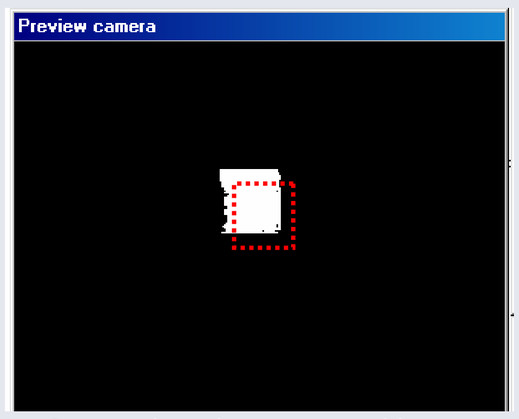
The experimental scenario

A red cube was mounted on the end effector of the arm, so as to be easily detectable by a vision system consisting in a RGB camera.

In the experimental trials the arm movement followed a free-obstacle pre-planned trajectory laying on a plane parallel to the image plane.

Comparisons between EP images and real images, thresholded on the object colour, were performed every two seconds. EP images are built based on the expected geometric position of the percept, calculated on the basis of the internal model of the arm movement. Comparison consists of calculating differences between EP-images and real images expressed as pixel distance of the two percepts.

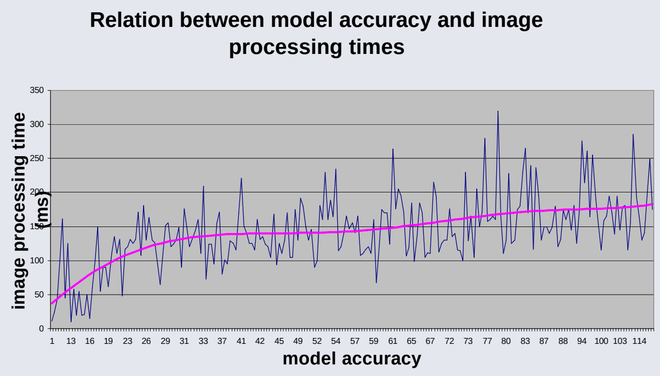
The plan execution was stopped only when the difference was higher than a predefined threshold, occurring in the case of unexpected events, deviating the object from its trajectory

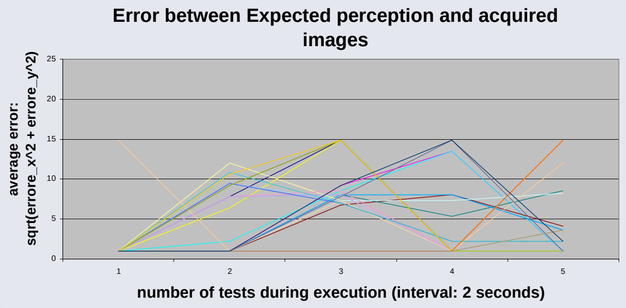


Comparison between real image, thresholded on the object colour, and a EP image (red dotted box)

Results

Experimental results with different prediction models showed that complete image processing is, in general, computationally more expensive than the proposed EP-based image processing. Moreover, computational costs decrease with the accuracy of the prediction model.





These results suggest that an EP-based scheme can be fruitfully adopted to develop sensory-motor reactive systems endowed with complex sensor modalities and inhabiting partially structured environments.

References

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