Towards a Biologically Inspired Semantic Segmentation of Goal Oriented Actions

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Introduction

It has been shown the existence of a population of neurons, *mirror neurons*, in the macaque's F5 motor area which are "active" during both the execution of a *Goal Oriented Action* (GOA) and the observation of the same action executed by another individual (Rizzolatti G., Luppino G, 2001). A *GOA* denotes a series of prehension movements that relate body parts of the subject to a three-dimensional object. In our work we focus on *action understanding* as functional interpretation of mirror neurons. We suppose that action understanding can be subdivided into two subsequent stages: a *structural description* of the observed action and an interpretation stage. We also suppose that mirror activity is involved in both recognizing the structural description of a GOA and associating this description with the *correct sequence of motor commands*. Accordingly, in a previous paper, we have proposed a visuo-motor control model (MEP) (Prevete R. et al. 2005) based on the assumption that mirror neurons take part in an *expected perception* mechanism (Datteri E. et al. 2003) which verifies whether the *actual visual input* matches a *predicted visual input* computed on the basis of a motor command sequence. In this work we focus on the basic hypothesis underlying the proposed model as well as on some implementation issues.

Observer Independence

From neurophysiologic data it appears that the activity of several cortical areas is independent/tolerant of the location of the observed target-object relative to the observer (Rizzolatti G., Luppino G, 2001). These findings seem to support the hypothesis, implicitly assumed in MEP, that: (**i**) an agent *A* observing himself to perform a GOA, or observing an agent *B* to carry out the same GOA, computes a sequence *s* of *N*-dimensional GOA visual feature vectors *v* in an observer independent/tolerant internal representation.

Observed GO-Action Structural Description

Let's call V and S the sets composed of all instances of *v* and *s*, respectively. We assume that: (**ii**) V is composed of a collection of equivalence classes $VC_1, VC_2, \ldots, VC_M$. Thus (ii) corresponds to assuming that it exists a dictionary of tokens such that every observed GOA is composed of tokens belonging to it, i.e., it is possible to segment each *s* in a unique sequence of V's equivalence classes.

Let's now define the following equivalence relation: $\forall s_1, s_2 \in S$ $s_1 = s_2$ iff it is possible to associate to both s_1 and s_2 the same subset of sequences of V's equivalence classes (Fig. 1).

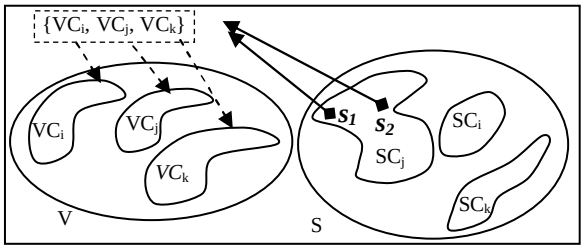

Figure 1

We now make this basic assumption: (**iii**) Each SC_i class corresponds to a set of *semantically* related GOA.

We prove that, under hypothesis (ii) and (iii), the computation of an expected perception becomes the selection of one of VC's equivalence classes. Moreover, the matching between the expected perception and the subsequent actual perception becomes a classification problem.

Implementation issues

According to what stated in (i), we are implementing an observer independent/tolerant measure of some relevant hand-object features (Oztop E., Arbib M.A. 2002) based on Poggio's recognition system (Giese M A, Poggio T 2003). Starting from this measure, we intend to fulfil and test the plausibility of the hypothesis (ii) and (iii) in an experimental setting. Preliminary results are encouraging.

References

Datteri, E., Teti, G., Laschi, C., Tamburrini, G., Dario, P., Guglielmelli, E. (2003). Expected perception in robots: a biologically driven perception-action scheme. *Proceedings of ICAR 2003, Coimbra, Port.*,(pp. 1405-10).

Giese M A, Poggio T. (2003). Neural mechanisms for the recognition of biological movements and action. *Nature Reviews Neuroscience, 4*, 179-192.

Oztop E., Arbib M.A. (2002). Schema design and implementation of the grasp-related mirror neuron system. *Biol. Cybern., 87*, 116-140.

Prevete, R., Santoro, R. and Mariotti, F. (2005). A Biologically Inspired Visuo-Motor Control Model based on a Deflationary Interpretation of Mirror Neurons. *Proceedings of CogSci2005, Stresa, Italy*, (pp.1779-84).

Rizzolatti G., Luppino G. (2001). The cortical motor system. *Neuron, 31*, 889-901.