Integrating Action and Language in Cognitive Robots: Experiments with Modeling Field Theory

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Recent research in interactive intelligent systems has focused on the investigation of the relationship between language and action (Cangelosi et al. 2005). The strict relationship between language and action has been demonstrated in various empirical and theoretical studies, such as psycholinguistic experiments (Glenberg & Kaschak, 2002), neuroscientific studies (Pulvermuller 2003) and computational models (Cangelosi & Parisi 2004; Wermter et al. 2003). In this paper we will present a new computational model on language and action based on the Modeling Field Theory algorithm. Modeling Field Theory (MFT: Perlovsky 2001) has been presented as an alternative method for overcoming the combinatorial complexity problem in the computational intelligent techniques. Perlovsky (2004; Fontanari & Perlovsky 2006) has recently proposed the use of MFT specifically to model the integration of linguistic and cognitive capabilities. By using concept-models with multiple sensorimotor modalities, a MFT system can integrate language-specific signals with other internal cognitive representations.

In new simulations we have applied a modified version of the MFT algorithm to classify and integrate multi-feature representations (Tikhanoff et al., submitted). We have applied the multi-dimensional MFT algorithm to the data on the classification of the posture of robots, as in an imitation task. We use data from a cognitive robotic model of symbol grounding (Cangelosi & Riga in press; Cangelosi et al. 2006). This model consists of two simulated agents (teacher and learner) embedded within a virtual simulated environment (Fig. 1). Each robot consists of two 3-segment arms attached to a torso. This is further connected to a base with four wheels. The robot has a total of 10 Degrees of Freedom: shoulder joint (2: one for left and one for right arm), upperarm joint (2), elbow joint (2), wheels (4).

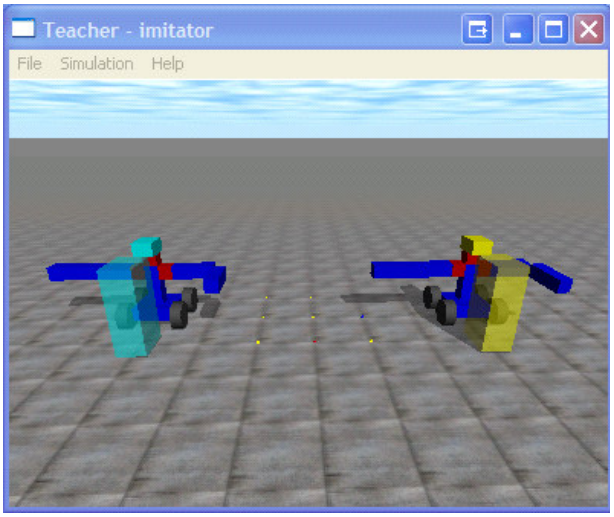

Fig. 1: Simulation setup with the two robots.

For our simulation, we have collected data on the posture of robots using 42 features. This consist of the 7 main data (X, Y, Z, and rotations of joints 1, 2, 3, and 4) for each of the 6 segments of the robot's arms (right shoulder, right upperarm, right elbow, left shoulder, left upperarm, left elbow). As training set we consider 5 postures: resting position with both arms open, left arm in front, right arm in front, both arms in front, and both arms down. In this simulation, all 42 features are present from timestep 0. Simulation results demonstrate the ability of the MFT algorithm to develop concept-models of action categories that can be used during communication.

Ongoing research is looking at the use of MFT for the acquisition of language in cognitive robotics. In particular we are currently looking at the use of multi-dimensional MFT to study the emergence of shared languages in a population of robots. Agents first develop an ability to categorize objects and actions by building concept-models of objects prototypes. Subsequently, they start to learn a lexicon to describe these objects/actions through a process of cultural learning. This is based on the acquisition of higher-order MFT concept-models.

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