Embodied Approaches to Interpersonal Coordination: Infants, Adults, Robots, and Agents

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Workshop Background and Relevance

Humans interact with other humans. They do so frequently, in a wide variety of circumstances, to accomplish many different goals. This interpersonal interaction, especially in face-to-face circumstances, requires *coordination* (Clark, 1996). This involves many subtle behaviors, controlled carefully in the context of another person, from eye movements and gestures, to choice of words. The characteristics of the cognitive system that give way to this coordination have been a matter of debate recently in the cognitive sciences. Yet there remain many open questions about how the cognitive system functions in human interactions. How does interpersonal coordination emerge in the dyad? What behaviors are coordinated between persons, and in what manner? How can we model dyads and their interactions?

One challenge to advance our understanding of how human participants utilize social-cognitive cues in everyday communication is that the empirical evidence is based on macro-level behaviors in constrained unnatural contexts and tasks. To truly understand mechanisms of interpersonal coordination, however, we may need to focus on more micro-level behaviors as they unfold in real time, and in free flow interaction, for example, changes in eye gaze and shifts in body position as they are linked to objects, events, and actions of the social partner. Several new directions have pursued this microstructure of interpersonal interaction.

First, with advances in sensing and computing techniques, now we have the capabilities to process visual, audio and other sensory data collected from real-world interactions. This data-intensive approach provides a unique opportunity for new discoveries from various advanced data analysis techniques. These methods have leveraged visualization techniques to mine the temporal relationships between behaviors of two people (Yu et al. , 2009; see Fig. 1). This has shed light on the timing of interpersonal interaction, and how two individuals adapt to each other, both in infant-adult dyads (e.g., Smith et al., 2010; Yu & Smith, 2012; Nagai et al., 2012), and in two adults (Coco et al., 2012; Richardson & Dale, 2005).

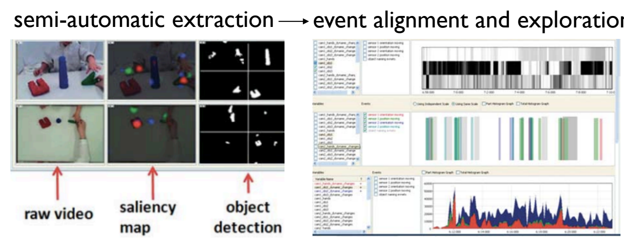

Figure 1: Visualization software for extracting, aligning and mining large multivariate time series of behaviors to uncover coordination (adapted from Yu et al., 2009).

Second, researchers in developmental robotics have investigated mechanisms of interpersonal coordination, to model and implement social systems. In developmental robotics, recent progress has been achieved in developing robots that elicit human scaffolding (Nagai, Nakatani, & Asada, 2010). This progress has been possible by implementing underlying processes that could be involved in the dynamic control of interpersonal coordination. For example, implementing a model of a mirror neuron system can help basic skills in robots like self-other discrimination, and can support more complex abilities, such as imitation (Nagai et al., 2011; see Fig. 2, left). By grounding high-level theories into robotic systems, we can address different aspects of how social-cognitive capabilities, such as gaze following and face preference, can be learned through sensorimotor interactions.

Third, research on virtual agents has developed new models of embodied human-agent interaction. This offers new ways to explore processes of interpersonal coordination. This has included, for example, the role of gesture and nonverbal behavior (Sadeghipour & Kopp, 2011), attentive speaking (Buschmeier & Kopp, 2011), and feedback (Kopp et al., 2008). Virtual embodied agents provide a foundation for testing theories of adult-adult interaction, and developing exciting social tools to support interpersonal coordination (see Fig. 2, right).

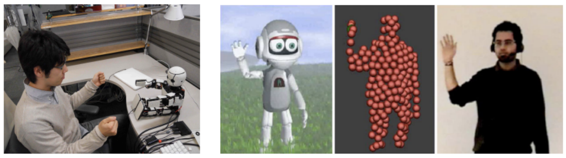

Figure 2. Left: Human-robot interaction; robot equipped with emergent mirror-neuron system (adapted from Nagai et al., 2011). Right: Human-agent interaction to explore models of gesture (adapted from Sadeghipour & Kopp, 2011).

Together these strands of research offer new insight into human social dynamics, and the means to implement and test theories in robotics and virtual agents. Bringing them together in one workshop is an opportunity to convey these new methods, and find shared interests and synergies among different approaches and different fields, These are the primary goals of the workshop.

Objective and Overview

The aim of this workshop is to introduce these approaches in an integrative fashion, and offer some basic demonstrations of relevant software, data analysis, and development.

Broad audience. Given the international and interdisciplinary composition of the workshop, we expect to attract broad interest from several domains, from cognitive and language development, to language processing and discourse; from human cognition to artificial intelligent systems; and from human babies, to adult, and to both physical social robots and virtual agents.

Activities. The organizers of the workshop will first offer a series of presentations on relevant research projects (see Schedule). These topics form a coherent collection of new approaches to interpersonal interaction, shown below in Table 1. Talks will include concrete details regarding data collection, system design, and so on; where appropriate, source code or software will be demonstrated and distributed to attendees (e.g., Coco & Dale's R toolbox for recurrence). The workshop organizers will together lead a discussion with the attendees on limitations, future directions, and so on.

Table 1: Thematic organization of workshop organizers covering domains of interpersonal coordination.

	infant	adult
human	Nagai, Yu	Kopp, Coco, Dale
robot / agent	Nagai, Yu	Kopp

Outcomes. Attendees will gain a basic understanding of human data analysis in the case of large-scale multivariate behavioral data mining (Yu et al., 2009, 2012), and the application of a particular technique referred to as cross recurrence analysis (Dale et al., 2011) which serves as a simple quantification over behavioral channels (R toolbox developed by Coco & Dale, in preparation). Nagai and Kopp will offer details of developing robotics and artificial agents.

Schedule

Duration	Topic (Speaker)
0-5 minutes	Introduction to the workshop (Dale)
40 minutes	Infant-caregiver coordination through software visualization (Yu)
40 minutes	Adult coordination and cross recurrence analysis (Dale & Coco)
5 minutes	Break
40 minutes	Social and developmental robotics and interpersonal interaction (Nagai)
40 minutes	Virtual social agents, human-agent interaction, and coordination (Kopp)
20 minutes	Discussion
Total:	~ 3 hours

Further Materials

The first author of the workshop will maintain a website to distribute publications and software for attendees.

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