Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 126 (2014) 82 – 91
Procedia
Social and Behavioral Sciences

ICTTP 2014

Synchrony detection as a reinforcement signal for learning: Application to human robot interaction

Caroline Grand, Ghilès Mostafaoui*, Syed Khursheed Hasnain, Philippe Gaussier

Neurocybernetic team, ETIS, Site de St Martin I, 2, avenue Adolphe Chauvin 95302 Cergy-Pontoise, France

Abstract

The present study is aiming to build a synchrony-based attentional mechanism allowing to initiate and to maintain human robot interactions. Moreover, we question the importance of synchrony detection for learning and gaining new competences through the interaction. We previously proposed a synchrony-based neural model capable of giving the robot minimal abilities to select a human partner and to focus its visual attention on this preferred interactant. Here, we extend this model by using synchrony detection as a reinforcement signal for learning (during the interaction) the human partner appearance (shape) in the context of an autonomous mobile robot.

Keywords: Synchrony; Intuitive human robot interaction; Focus of attention; Partner selection; Dynamical systems; Neural networks

1. Introduction

Being able to perceive, detect, track, and recognize others movements is a crucial ability in human social interactions. From a biological point of view, it is well known that this human capacity to perceive others biological motion is incredibly robust. The exact nature of the characteristic permitting us to easily detect biological motion and to focus our attention on the pertinent salient regions of the visual field are not clearly defined. Neurobiological and psychological data acknowledged two pathways for biological motion detection: kinematics and shape. Nerveless, the exact role and importance of these two pathways, named dorsal (for kinematics) and ventral (for shape) in the brain, stay unclear (Lange & Lappe, 2007).

* Corresponding author. Tel.: +33 1 34 25 65 91; fax: +33 1 34 25 28 39.
E-mail address: ghiles.mostafaoui@ensea.fr

doi:10.1016/j.sbspro.2014.02.322

For bio-inspired Human Robot Interaction (HRI), this question is obviously as important as difficult. What are the pertinent visual characteristics (kinematics and shape) to extract from the camera images? How to use the extracted visual features to initiate and sustain the interaction? How to focus the robot visual attention on the human partner? Numerous studies were conducted and many solutions were proposed to tackle these challenging issues.

In the field of bio-inspired HRI the applicability of these possible solutions is dependent on two main conditions. The first and most obvious one is to maintain a real time interaction between the robot and the human implying the use of algorithms having low cost computational time and not memory resource demanding, especially in the case of interactions with mobile robots. The second condition is more related to biological aspects. In fact, for bio-inspired approaches, the used algorithms must have plausible neural models. Moreover, the adopted solutions must be, as far as possible, in accordance with neurobiological and psychological data on human visual perception and human-human interaction.

Regarding shape recognition, tremendous published works for people detection, recognition, and tracking can be found in classical computer vision literature. One can classify them using different taxonomies (see Aggarwal & Cai, 1999; Gavrila, 1999; Moeslund & Granum, 2001). A simple way to differentiate these numerous studies is to consider the use (or not) of explicit models of the human shape. In fact, for people detection and tracking on image sequences, a first possibility is to define explicit 2D or 3D models of the human shape to segment and track (in the successive images) the different body parts of the human in the visual field (2D silhouette, Davis, Harwood, & Haritaoglu, 1998; 2D articulated model, Cham & Rehg, 1999; 3D models, Rehg & Kanade, 1994; etc.). Another possibility is to avoid using “a priori” explicit knowledge on human shape and to adopt a bottom up approach to construct models for people recognition by combining different low-level image characteristics (contours, Goldenberg, Kimmel, Rivlin, & Rudzsky, 2002; points of interest, Gabriel, Hayet, Piater, & Verly, 2005; blobs, Fablet & Black, 2002; etc.). In practice, the efficiency of all these promising methods is highly dependent on the application and the experimental conditions (outdoor/indoor, real-time/offline, fixed camera/moving camera etc.). Moreover, most of these algorithms are highly computational time demanding and have no plausible neural model.

Additionally, the remarkable human capacity to perceive biological motion seems to appear at early stages of infant development. In fact, psychological studies point out the neonates’ capacities to imitate simple facial gestures (Meltzoff & Moore, 1977). Considering the very basic visual perception abilities of the newborns we may question the reason of this early emergence (or presence) in human development, of a competence for human motion perception. It was demonstrated that this particular sensibility to biological motion is strongly related to our motor controllers. Viviani and Stucchi (1992) showed the coupling between motor and perceptual processes while perceiving doted points moving with trajectories respecting the two third power low which is one of the most known kinematic characteristic of biological motion. More recent studies point out a strong link between perceiving motion and executing actions, the experimental results demonstrate that: *"motor learning has a direct and highly selective influence on visual action recognition that is not mediated by visual learning"* (Casile & Giese, 2004).

This resonance between producing actions and perceiving others movements was also highlighted by the importance of synchrony during human social interactions. In fact, studies on development psychology acknowledged synchrony as a prime requirement for interaction between a mother and her infant. An infant stops interacting with its mother when she stops synchronizing with it (Nadel et al., 1999). Infants synchronize their legs motion with adult speech (Candon & Sanders, 1974). In addition, synchrony detection mechanism in young infants plays a pervasive role in learning and cognitive development (word learning, Gogate & Bahrick, 1998; object interaction skills, Watson 1972; self-awareness and control, Gergely & Watson, 1999; learning related to self, Rochat & Striano, 2000; etc.)

An interesting fact is that studies on interpersonal motor coordination point out unintentional synchronizations among people. Issartel, Marin, and Cadopi (2007) studied interpersonal motor-coordination between two participants when they were instructed not to coordinate their movements. The results showed that participants could not avoid unintentional coordination with each other. This reflects that when visual information is shared between two people in an interpersonal situation, they coordinate (unintentionally) with each other.

Keeping in view the importance of synchrony in social interaction, it has also been widely studied and used in robotics. Andry, Blanchard, and Gaussier (2007) proposed synchrony as an internal reward for learning. Prepin and Gaussier (2009) also used the level of synchrony as a reinforcement signal for learning. Blanchard and Canamero