Imitation faculty based on a simple visuo-motor mapping towards interaction rule learning with a human partner

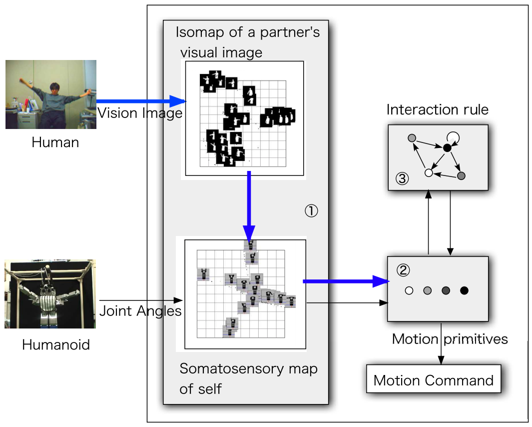
Masaki Ogino, Hideki Toichi, and Minoru Asada
Dept. of Adaptive Machine Systems, HANDAI Frontier Research Center,
Graduate School of Engineering, Osaka University
2-1, Yamadaoka, Suita, Osaka, Japan
{ogino, toichi}@er.ams.eng.osaka-u.ac.jp,
asada@er.ams.eng.osaka-u.ac.jp

Yuichiro Yoshikawa
Intelligent Robotics and
Communication Laboratories,
Advanced Telecommunications
Research Institute International,
2-2-2, Hikaridai, Seika, Kyoto, Japan
y-yoshi@atr.jp

Imitation has been regarded as one of the key technologies indispensable for communication since mirror neuron [1] made a big sensation not only in physiology but also in other disciplines such as cognitive science, and even robotics as well. Unlike a simple copy of human motion trajectories, imitation may include more important role of human motion recognition. That is, observing other's behavior may recall the self motion through the mirror system, and this might be considered as the key component of recognition, communication and even language acquisition [2]. It is an interesting question; in what point imitation faculty is effective for communication learning? if a robot can imitate normal motions of a human partner, is it easy to read mind of the partner for the robot? This paper is the first step to those questions.

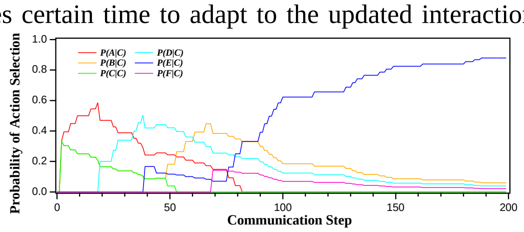
In this paper, we aim at building a human-robot communication system and propose an observation-to-motion mapping system as the first step towards the final goal, learning natural communication. This system enables a humanoid platform to imitate the observed human motion, that is, a mapping from observed human motion data to its own motor commands. To realize this capability, we suppose a human partner who kindly imitates the robot motion, and the system associates both data of the robot somatosensory information (the set of joint angles) and observed human motions imitated from the robot motions, each of which is self-organized onto two dimensional maps using the isometric feature mapping (ISOMAP) algorithm [3] for data reduction, respectively, beforehand. A neural network is utilized for this association based on which the humanoid can imitate human motions. This system is applied to interaction rule learning with a human partner who knows the rule and reacts to the humanoid action according to them. On the other hand, the humanoid does not know the rule at the beginning but gradually learns the rule by using its own reaction rule: to just imitate the observed human action if the corresponding reaction rule has not been learned, else to show a reaction to the human action according to the learned rules. Through these processes, the robot adaptively learns and updates the interaction rules with a human partner.

To validate the effectiveness of the proposed system, we examine whether the robot can acquire the interaction rule in the environment in which a human takes motions under



an artificial interaction rule. The interaction rule by which a human plays interactions changes at the 20th, 40th and 70th steps. In each step of them, new motions are added and the interaction rule is changed.

The figure below shows the temporal transition of the probability of motion selection when the robot observes the motion A. The graph shows that firstly the motion B is selected during the first 55 steps, then the motion D until the 85th step, and finally the probability for the motion C goes up highest. This corresponds to the interaction rule in each stage, although it takes certain time to adapt to the updated interaction rule.



References

[1] G. Rizzolatti and L. Craighero, The Mirror-Neuron System, *Annu. Rev. Neurosci*, 27, pp. 169–192, 2004.

[2] G. Rizzolatti and M. Arbib, Language within our grasp, *Trends in Neurosciences*, Vol 21, pp. 188, 1998.

[3] J. B. Tenenbaum, V. deSilva and J. C. Langford, A Global Geometric Framework for Nonlinear Dimensionality Reduction, Science, 290 (5500), pp. 2319–2322, 2000.