Imitation Behaviour Evaluation in Human Robot Interaction

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Abstract

In this paper, we present an experiment on imitation between a humanoid robot and a human subject. Contrary to many other experiments on imitation, it is not about imitation learning by the robot, but about the robot recognising when the human is imitating its behaviour. We show some first results of correlation measures for different experimental setups and discuss possible ways of representation of this data.

1. Introduction

The development of imitation behaviour as well as understanding imitation by others is a crucial milestone in child development. It helps to establish the self-other distinction and the own identity. Meltzoff and Gopnik (Meltzoff and Gopnick, 1993) argue that there exists an intermodal mapping between different sensory modalities such as motor actions and vision to make the recognition of imitation possible. In this paper, we investigate how imitation behaviour can be recognised and distinguished from other behaviour. In the next section, we present experiments between a human and a humanoid robot.

2. Experiments

The robot used in these experiments is the Infanoid robot (Kozima and Yano, 2001). This robot has been especially developed for studying social interaction, such as imitation behaviour. It is equipped with two arms and a head with several degrees of freedom as well as a colour camera. The objects used for visual recognition were two differently coloured pet bunny rabbits. We used visual data to detect the objects, and 12 different motor values to compare it with its own motions. Objects have been kept in the same hand during an experiment, movements and speeds were rather regular.

The movement patterns of the visual data can be seen in figure 2.

Three different kinds of experiments have been performed. In each experiment, the robot performs smooth random movements with both arms, while:

1. the human performs random movements with both arms.
2. the human tries to imitate the robot's movements with each arm.
3. the robot is holding the two coloured objects.

The following data has been used for the analysis:

Visual data: x_1, y_1, x_2, y_2, $\alpha_1, \alpha_2, d_1, d_2$, x'_1, y'_1, x'_2, y'_2, where (x, y) are the positions of each object on the image, (x', y') the movement vector of the object positions in time, and (α, d) the movement expressed in angle and distance.

Motor data: left arm: shoulder open, shoulder turn, elbow open, elbow turn, wrist open, wrist turn, right arm: shoulder open, shoulder turn, elbow open, elbow turn, wrist open, wrist turn

Figure 1: Setup for the imitation experiments between Infanoid and a human experimenter. In the left image, the human subject holds the two coloured object in each hand, trying to imitate the robot that is performing random arm movements. In the center image, the robot is displayed holding the two coloured objects by itself, also performing random arm movements. The right image shows the objects as seen by the robot.

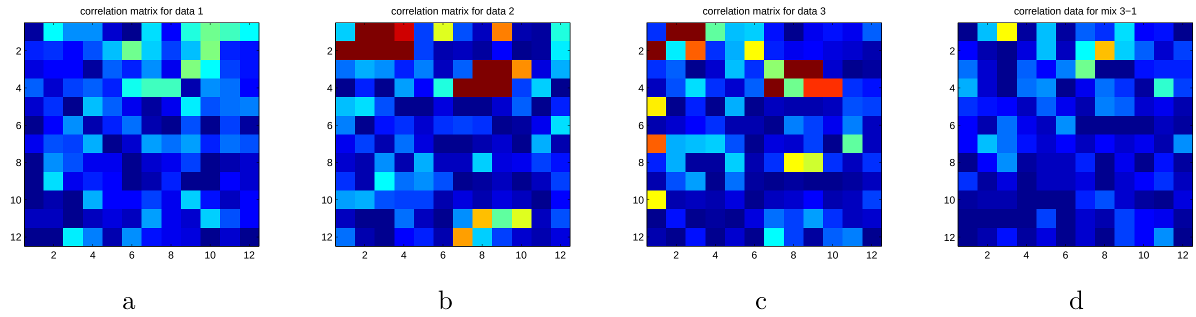

Figure 3: Correlation matrices between motor and visual data during four different experiments. The rows represent the visual data, the columns the motor data. a) Robot-Human experiment, random movements of both human and robot. b) Human tries to imitate Robot. c) Robot holds the objects by itself. d) Control experiment with motor data from (a) and visual data from (c).

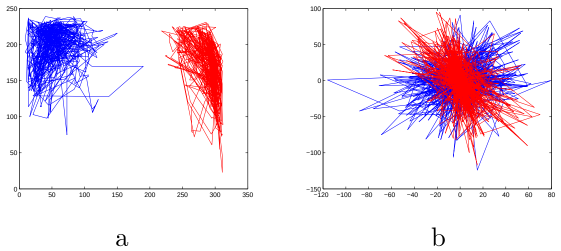

Figure 2: a) The visual data (traces of the positions in 2D space of object 1 and 2 over time) during one of the experiments is shown seen from the robot's perspective. b) Derivative in time of the same data.

3. Results

In figure 3, the correlation matrices between visual and motor data for the different experimental setups are shown. One can clearly see the correlation between each object and each arm of the robot in the case where the robot is holding the objects itself (figure 3c). The high correlation on the left upper side (first two rows) presents the object position and the left arm motor data, the high correlation on the right upper side (row 3 and 4) presents the object position and the right arm motor data. There is little correlation between the other visual data such as angle and velocity of the objects and the motor data. This is similar for the case where the robot is being imitated (figure 3b), showing a clear correlation between the visual data for the objects position and the left and right motor data.

In the other setups, there is little correlation, one being the control experiment performed with the robot and the human, and the other control experiment realised by swapping the visual data between experiments. As a result, the robot could use the presence of this correlation to find out whether it is imitated by someone if the correlation is not caused by itself.

In further experiments, we will investigate, whether using these data, an interpersonal map as introduced by Hafner and Kaplan (Hafner and Kaplan, 2005) can be created. Since the types of sensors of the human and the robot are different in contrast to the original experiments with AIBOs, this might not be feasible. The main difference in our Infanoid experiments is, that the imitation is based on the online visual data seen by the imitated robot.

References

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