Prediction of Intention: from gesture to whole-Body movement

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I. Introduction

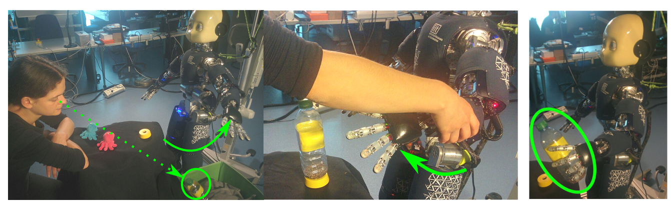
In the future humanoid robots will be able to help humans in their daily tasks. Unfortunately, we are still far away to produce this kind of robots. Among the several challenges that robots face to act in the real world, there is the problem of understanding their environment and their human partners. Robots need to be able to predict what is going to happen and what is their user's will, to be able to anticipate their actions and plan those they have to perform. About the environment understanding, a lot of methods have been created and are still improved from advanced kinematics and dynamics computations (haptic perception) to artificial intelligence programs (often with visual perception). Here, we focus on the robot's ability to predict the user intention and to act accordingly. The main intuition is for the robot to learn distributions over some demonstrated trajectories to be able to recognize and continue movements from initial observations.

II. 1^{st} Appplication: Intention prediction during Human robot physical interaction

In this presentation, we will first present a software that allows a humanoid robot to predict the continuation of a movement initiated by a human partner from kinematics guidance. This software allows the robot to perform the arm movement expected by its user given early observations of it. We performed a set of experiments where the user initiates a movement with the robot left arm, then the robot recognizes which movement has been initiated (in a set of learned movement) and it predicts the continuation of the movement with its duration. From this prediction, it performs the movement and the corresponding task that are dropping objects in different beans. This application was presented in [1] together with the description of an open-source software.

III. 2^{nd} Appplication: Intention prediction using multimodalities

Then, we will present an improvement of our method that allows the robot to predict the movement to perform from different modalities, as presented in Fig 1. In this software, the movement expected by the user can be understood by initiating the robot's arm movement using physical interaction; presenting the movement to perform using a head gesture; or using both modalities. Thus, this second software improves the first one by allowing the user to choose either to guide the robot with physical guidance (which is useful when the robot has to predict a specific orientation of the arm during its movement) ; with a head movement (which is useful when the user doesn't like to touch robots or when the beginning of the movement is ambiguous) ; or both modalities to improve the recognition performance. We perform different experiments that compare the quality of the prediction according to the modality used to guide the robot (visual/physical guidance only or both). In a first experiment, the robot has first learned two movements that have the same initial and final positions but with a different movement shape (the first is a "bell movement", the second a line movement). The second experiment concerns two movements that finish at two different position goal. For these experiments, the robot first learns the movements. We presented this application in [2].



(a) Visual Guidance. (b) Physical Guidance.

Fig. 1: The humanoid robot iCub a) recognizes the intended movement primitive using the partner's directional gaze; b) predicts the movement to perform using the partner's physical guidance at the beginning of the movement.

IV. Method used to learn trajectory distributions

To perform these two experiments, our robot learns distributions other movement primitives, using a method called *Probablistic Movement Primitives* [3] was adapted to our application. This method has been implemented in Matlab, and the software is open-source. This method will be introduced in this presentation with a short comparison with usual methods (such as Dynamic Movement Primitives).

V. Current study: to predict whole-body movement of a human

The two studies presented above are limited to the robot's arm movements and action prediction. The last challenge that is currently explored is about allowing the robot to adapt its behavior to its user's whole-body movement. To do so, the robot has to predict the continuation of this whole-body movement. In this case, the data dimension of the movement is bigger. Because of this bigger data dimension, the computation time of the movement inference will be too long if we use the same method than previously. Thus, we propose a method where the robot will predict the continuation of the user's movement in a latent space (*e.g.* in a reduced dimension). To do so, the method combines an autoencoder to reduce the data dimension of the movement and to reconstruct it and the Probabilistic Movement Primitive method to predict in the latent space the continuation of the movement.

Experiments have been realized with the iCub [4] humanoid robot and we use the Geomagic driver [5] to guide the robot in simulation; the user's head orientation of the second experiment has been measured using Intraface [6] and the user's whole-body movements of the third experiment have been measured using the Xsens [7].

VI. Conclusion

With this three experiments, the robot will be able to understand the user's intention and his/her movement and to predict either the continuation of the user movement given initial observations, from small to whole-body scale.

References

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