Improving the fluency of the robot to human handovers using a human inspired feed-forward release controller*

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Abstract—With the aim to increase the comfort and the perceived fluency of the human robot interaction during object handover, we propose a two parameter feed-forward controller with human-like dynamics for robotic hands able to release objects and tools.

I. INTRODUCTION

The most basic collaborative motor task between humans is probably the object handover, in which an object is passed between two agents: the passer and the receiver. Object handover is fundamental for a wide range of functional or social activities in which humans help each other sharing the same goal and a common plan of execution. Behavioral studies in humans have highlighted how during object handover, the passer and the receiver regulate their grip forces in complementary fashion in order to accomplish a successful transfer [1][2]. The initial contact with the receiver is largely controlled in a feed-forward manner by the passer who produces a stereotypic movement defined using visual cues describing the partner’s movements [3], as well as on the experience/practice of the passer. After contact the passer grip force decreases following a characteristic profile within a certain time window [2]. Such behavior anticipates the likely action of the receiver in taking the object based on previous experience of the handover action.

II. MATERIALS AND METHODS

We propose an automatic release controller mimicking feedforward behavior with an internal model of successful object reception by the human partner. Assuming the human satisfies the predictions of the internal model, the grip force profile exerted by the robotic hand follows a stereotypical and time-based trajectory similar to the grip force curves reported in [2]. The controller proposed, tuned with different pairs of parameters is compared with an object transfer between two humans. The quality of the interactions is rated by eight subjects (age 25-36 years old) by means of a questionnaire. The experimental set-up consisted of a robotic hand, a three-axial force sensor in the wrist, a PC equipped with a data acquisition board and a test-object instrumented with sensors. The robotic hand was a left-handed version of the IH2 Azzurra Hand (Prensilia Srl, Italy). The robotic hand includes force sensors able to measure the grip force (F_G) and the interaction forces at wrist level (F_I). The feedforward release controller proposed in this paper is characterized by two parameters: a) the threshold on the modulus of the wrist force (F_W) that detects the beginning of the handover (and triggers the control algorithm), and b) the release time (t_r), i.e. the time required to decrease the grip force down to zero from an initial grip force F_G0. We tested the influence of the proposed feed-forward release controller parameters (F_W and t_r) on the quality of handover perceived by human receivers. Each participant was instructed to stand, eyes open, at a marked position in front of the robot hand or human passer and to reach, grip and receive the test-object using a tridigital precision grip with his dominant hand.

Figure 1. Experimental set-up

III. RESULTS

Control strategies with a lower F_W to trigger the release are generally preferred, even if t end (i.e. the time between the initial contact and the full object release) is comparable. This points out that the initial phase of the handover (immediately after the object contact) is crucial for the subjective impression of the robot behavior’s quality and a perceived latency in the control after this event is generally not acceptable.

REFERENCES