Human-centric behaviour of redundant manipulators for ergonomic human-robot coexistence

Andrea Maria Zanchettin and Paolo Rocco

I. INTRODUCTION

Despite the benefits of robotic manipulators in industrial production, there are today several obstacles to obtain a more widespread use of such technology. Common industrial manipulators require closed-ended environments, with physical protection devices to separate them from human workers preventing a natural cooperation with human beings. The original contribution of this work to the field of human-robot interaction concerns the exploitation of the kinematic redundancy of next generation industrial manipulators, to achieve a natural-looking motion and to facilitate the acceptance of robots by humans co-workers in industrial environments.

II. KINEMATIC STUDY ON THE HUMAN ARM MOTION

In this work we conjecture that the most natural trajectories for a dual-arm redundant manipulator are those similar to human arm motions. An experimental campaign has thus been carried out to study the natural motion of the human arm and in particular to investigate how humans resolve the kinematic redundancy of their arm. Based on these experiments, a clear correlation has been found, during some pre-defined assembly-like motions, between the hand pose and the elbow swivel angle which was used to characterize the redundant DOF of the human arm. The existence of such relationship was first proven with statistical methods using a clustering approach and multivariate correlation statistics. Then, the correlation has been identified using a least-squares algorithm in a form suitable for easy application in the kinematic control of a robotic arm [3].

III. PHYSIOLOGICAL ASSESSMENT OF THE ACCEPTABILITY OF ROBOT TRAJECTORIES

The identified correlation has been exploited in the robotic controller to achieve a natural-looking motion for a 14-DOF prototype robot (ABB FRIDA, see [1]). Experiments on volunteers with collection of physiological data aimed at assessing the acceptability of robot trajectories through the quantification of the induced stress have been performed, see Fig. 2. The experiments have shown that the resulting motion was perceived more natural compared with other redundancy resolution criteria. The outcome of these experiments showed that the human-like redundancy resolution strategy can be adopted to effectively reduce the robot-induced stress in humans working side-by-side with robots: this conjecture which motivated this work was proven with a rigorous analysis of experimental data [2].

Fig. 1. Prototype robot FRIDA during a prescribed assembly-like motion assumes human-like postures

Fig. 2. One volunteer during the validation experiments

REFERENCES