Human-robot cooperative transport of soft materials: the draping of carbon fibre parts

Giorgio Nicola, Paolo Franceschi, Enrico Villagrossi

***Abstract*— Human-robot co-manipulation of large but lightweight elements made by soft materials is a challenging operation that presents several relevant industrial applications. This work discusses the approach for human-robot collaborative transport of flexible materials developed within the EU H2020 DrapeBot project. The DrapeBot project aims to develop a human-robot cooperative system capable of assisting an operator working on the carbon fibre draping process. The use of smart human-robot arbitration algorithms and the online tracking of material deformation enables a natural human-robot interaction.**

***Index Terms*— Human-robot interaction; Collaborative transport; Human-robot arbitration;**

I. Introduction

The human-robot co-manipulation of soft materials is becoming a relevant task from the industrial point of view, such as in aerospace, transport, and maritime industries. Compared to manipulating rigid materials, it introduces new challenges in modelling, perception, grasping, and control [1]. The European project DrapeBot[1] aims to develop a human-robot interaction technology capable of supporting one single human operator handling large carbon fibre parts during the draping task [2], which is performed by transporting the fabric onto the preform and adapting its shape.

II. Methods

This research investigates using a 3D camera to measure the deformation of soft materials (i.e., carbon fibre and fibreglass patches in the DrapeBot project) co-manipulated between humans and robots. The RGBD information, provided by the 3D camera, is processed through an AI algorithm to estimate the deformation of the material w.r.t. a deformation setpoint [3]. The material deformation estimation feeds a control algorithm able to arbitrate the role of the robot and the human. The control algorithm exploits the Differential Game Theory [4] to arbitrate the role of leader and follower between the human and the robot. For a given robot's nominal trajectory, the control algorithm allows nominal trajectory deformations based on the material deformation and the current position of the robot w.r.t. the nominal trajectory. The human-robot arbitrator dynamically assigns the leader role to the human or the robot based on their perceived interaction, providing a natural interaction and avoiding unwanted situations. The use of the vision sensor allows for measuring the soft material deformation. In contrast, a 6D force/torque sensor allows only the measurement of traction forces, while a vision system allows the preservation of the material from high forces exerted by the human, avoiding damage. The control architecture is described in Figure 1.

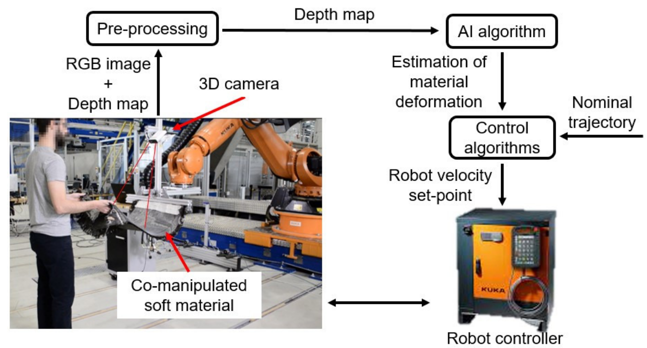

Fig. 1. Control architecture description.

III. Conclusions and Future Works

The research proposed a control architecture using a 3D camera to measure the deformation of soft materials and an arbitration algorithm able to change the leader's role in human-robot cooperative material transport. Future works will test the control architecture described above on a real industrial application.

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Giorgio Nicola *et al.* are with the Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing, National Research Council of Italy, Via A. Corti 12, 20133, Milan, Italy; *giorgio.nicola@stiima.cnr.it, https://orcid.org/0000-0001-8173-0707*

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