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HUMAN ROBOT INTERACTION ANALYSIS DURING ROBOTIC COMANIPULATION OF MEDICAL INSTRUMENTS

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Background: Robots are nowadays present in numerous medical scenarios, such as laparoscopy, orthopedic procedures or functional rehabilitation. Specially challenging are those systems where both the robot and the user simultaneously hold a medical instrument, also referred as co-manipulation systems. Even though the final use of such systems can diverge enormously, they share analogous interaction behaviors between the user and the robot. The development of a comprehensive robotic tool demands a complete behavior scheme that takes into account all the expected interaction typologies, as well as the transition among them. We propose a break down analysis of how the interaction behaviors can evolve, and list all possible interaction modes required for the specific scenario of a robotic tool co-manipulation system.

Materials and Methods: Three criteria have been considered for the classification of the possible situations in which the robot and the human interact in a shared setting. A first criterion is the existence of physical contact between the robot and the human, against a contactless interaction. A second criterion for the classification is the nature of the interaction, accidental versus deliberated. And the third criterion is considering whether the goal is to develop a cooperative operation or to accomplish an autonomous task. Since all three criteria allow two opposite conditions, there are eight possible categories, e.g.: teleoperated guidance is contact-deliberate-cooperative, whereas an emergency stop is contactless-accidental-autonomous. Given the partition of the task space into these eight interaction modes, the transition between them is determined by the computation of kinematics with entropy minimization, accomplishing a smooth and natural transition.

Results and discussion: The human robot interaction test-bed chosen consists of a laparoscopic intervention scenario. In such case, the classic master-slave teleoperation architecture has been complemented with a comanipulation scheme. The experiment involves the special event of a manual guidance after detecting a collision. The task evolves through: autonomous, accidental, manual and autonomous again, without affecting the position of the end effector, and thus avoiding any hazard. Although the scope of this work does not include a complete implementation of all possible human-robot interactions, it constitutes a step towards the formalization of a framework for HR cooperation. Under this HRI

experimental scenario, the approach has proved to merge successfully eight interaction modes. In addition, a safe and smooth transition between interaction modes also contributes to the definition of a safer framework for comprehensive cooperation tasks.

Keywords: Robotics, Human Robot Interaction, Co-manipulation.