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Mapping Human to Robot Motion with Functional Anthropomorphism for Teleoperation and Telemanipulation with Robot Arm Hand Systems

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Abstract— **In this paper teleoperation and telemanipulation with a robot arm (Mitsubishi PA-10) and a robot hand (DLR/HIT 2) is performed, using a human to robot motion mapping scheme that guarantees anthropomorphism. Two position trackers are used to capture position and orientation of human end-effector (wrist) and human elbow in 3D space and a dataglove to capture human hand kinematics. Then the inverse kinematics (IK) of the Mitsubishi PA-10 7-DoF robot arm are solved in an analytical manner, in order for the human's and the robot artifact's end-effectors to achieve same position and orientation in 3D space (functional constraint). Redundancy is handled in the solution space of the robot arm's IK, selecting the most anthropomorphic solution computed, with a criterion of "Functional Anthropomorphism". Human hand motion is transformed to robot hand motion using the joint-to-joint mapping methodology. Finally in order for the user to be able to detect contact and "perceive" the forces exerted by the robot hand, a low-cost force feedback device, that provides a mixture of sensory information (visual and vibrotactile), was developed.**

I. Introduction

Over the last fifty years mapping human to robot motion was one of the major problems in Robotics. Recently anthropomorphism became a necessity for social (e.g., robot likeability) and safety reasons (e.g., safety in human robot interaction applications). In this paper we perform an experimental validation of the human to robot motion mapping scheme that we proposed in [1], which guarantees specific functional constraints (e.g. same position and orientation for human and robot end-effectors) and optimizes anthropomorphism of robot motion, minimizing structural dissimilarity between human and robot configurations.

II. Apparatus and Methods

The robots that we use in this study are, the Mitsubishi PA-10 anthropomorphic robotic manipulator, which has seven rotational DoFs and the DLR/HIT 2 five fingered robot hand, which has five kinematically identical fingers with three DoFs per finger (two DoFs for flexion/extension and one DoF for abduction/adduction). More details regarding the Mitsubishi PA-10 and the DLR/HIT 2, can be found in [1].

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In order to capture human arm kinematics the Liberty (Polhemus Inc.) magnetic motion capture system is used. Two sensors are placed on the human elbow, and wrist respectively. The human hand kinematics are captured with the CyberGlove II (Cyberglove Systems) dataglove, which has 22 sensors measuring all joint values of all fingers.

The low-cost force feedback device is based on RGB LEDs and vibration motors to provide visual feedback (through color alternations) and vibrotactile feedback respectively, as described in [2]. In order to map human to robot arm motion we used a forward-inverse kinematics approach computing the analytical IK of Mitsubishi PA-10 robot arm using the IKFast library of the OpenRAVE simulation environment [3]. Redundancy is handled selecting the solution that minimizes the structural dissimilarity between human and robot arm configurations. This solution leads to a robot arm configuration for which the sum of distances between the human elbow and all robot joint positions, becomes minimum. Human hand motion is mapped to robot hand motion, using the joint-to-joint mapping methodology [4].

III. Conclusions and Discussion

The efficacy of the proposed methods is experimentally validated. The paradigms involve different movements in 3D space, as well as manipulation tasks executed by the user with everyday life objects. The accompanying video validates our claims and discusses methods and results in detail. Regarding future directions the authors plan to use the proposed human to robot motion mapping scheme with the whole robot arm hand system, as described in [5]. The HD version of the video can be found at the following url:

http://www.youtube.com/watch?v=Gm-JAzd8F-w

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