

A Unified Human-Likeness Criterion for Evaluating Human-Like Motion Retargeting on Bimanual Manipulation Tasks

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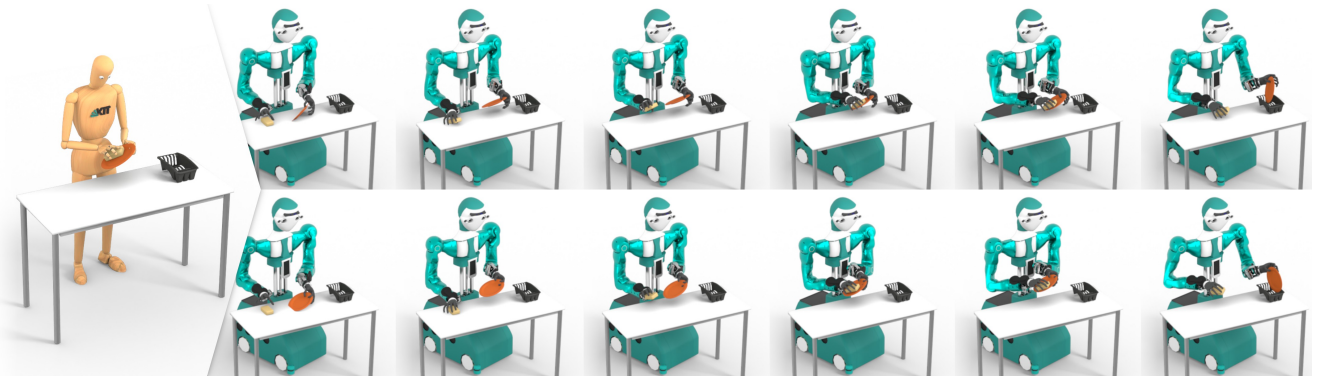


Fig. 1: Comparison of two motion retargeting approaches for wiping a plate on ARMAR-6 in a kinematic simulation. An importance-based approach (*top*, $m_{hl} \approx 0.63$) leads to an increase in the proposed unified human-likeness criterion $m_{hl} \in [0, 1]$ compared to end-effector pose tracking (*bottom*, $m_{hl} \approx 0.56$). Both non-linear optimization-based approaches are augmented with the same human-likeness criterion as additional objective and qualitatively provide similar human-like robot motions.

Abstract—Understanding bimanual and human-like motion is pivotal to equip humanoid robots with human-like capabilities and manipulation skills and to enable intuitive human-robot interaction. In this extended abstract, we present a multi-modal dataset of accurate whole-body human bimanual manipulation actions. Moreover, we conceptualize and derive a novel unified human-likeness criterion to assess human-like robot motions, which we evaluated across applications related to motion retargeting on bimanual manipulation tasks. Building on these results, we propose an importance-based motion retargeting approach improving human likeness.

I. INTRODUCTION

To assist humans with a variety of household tasks, humanoid robots must be able to learn new skills and adapt them to different scenarios. In order to increase efficiency and tackle more complex tasks, humans tend to perform such daily activities using both hands simultaneously. Robot manipulation similarly benefits from the integration of both arms and the use of bimanual coordination strategies [1]. A promising method to achieve such human-like manipulation capabilities involves learning from human demonstration [2]. This poses several challenges, including learning suitable

bimanual task representations on symbolic and subsymbolic levels, and reproduction across various humanoid robot kinematics. Another important factor is the quality of the executed robot motion. Human-like motions are key to enable intuitive human-robot interaction and increase the predictability and acceptability of robot movements in collaborative and assistive robot scenarios [3], [4].

II. THE KIT BIMANUAL MANIPULATION DATASET

To better understand bimanual and human-like motion, we provide a comprehensive multi-modal dataset (about 176 minutes) of whole-body human bimanual manipulation tasks with variety of short actions [5] and longer tasks [6]. The recorded sensor data is converted to the Master Motor Map (MMM) data format [7]¹, a unified format for whole-body motion data that decouples the motion capture process from further post-processing tasks. The dataset contains accurate whole-body human motion and hand kinematics mapped to the MMM model — a reference model of the human body including statistical, kinematic, and dynamic properties based on biomechanical studies — and the 6D poses of objects involved in the task. The motions are manually segmented and annotated with individual actions for each hand (e.g., approach, hold, pour, stir) and, to some extent, with bimanual categories based on our bimanual manipulation taxonomy (e.g., loosely coupled, tightly coupled symmetrical) [1]. The dataset is publicly available as part of the KIT Whole-Body Human Motion Database². It offers valuable insights into

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¹<https://mmm.humanoids.kit.edu>

²<https://motion-database.humanoids.kit.edu/details/datasets/3521>

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