Learning to Hang Crumpled Garments with Confidence-Guided Grasping and Active Perception

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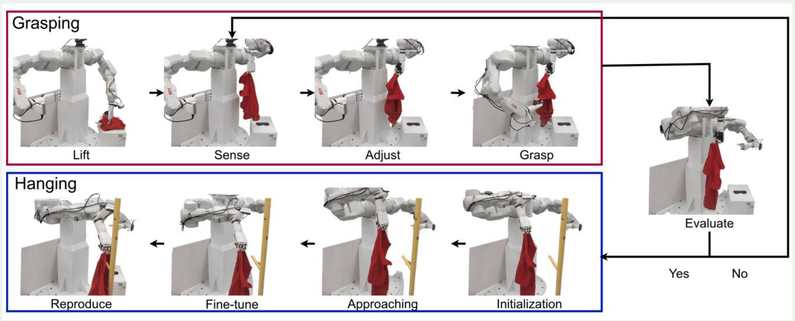
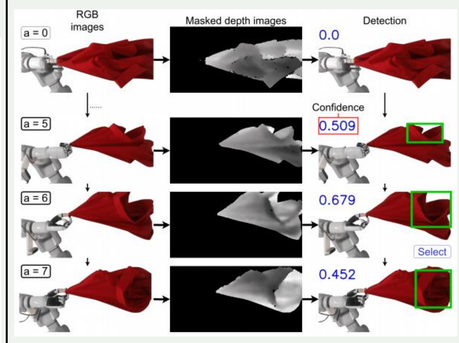
Pipeline

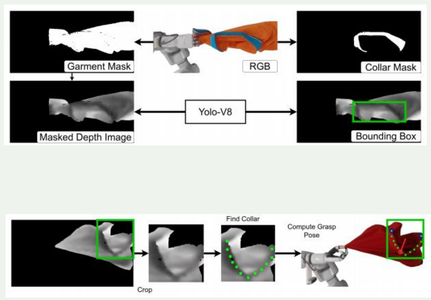


In this study, we concentrate on the task of hanging crumpled garments on a rack, a common scenario in household environments. This context presents two primary challenges: (1) perceiving and grasping the structural regions of garments that exhibit severe deformations and self-occlusions; (2) adjusting the configuration of garments to fit the supporting components of the rack.

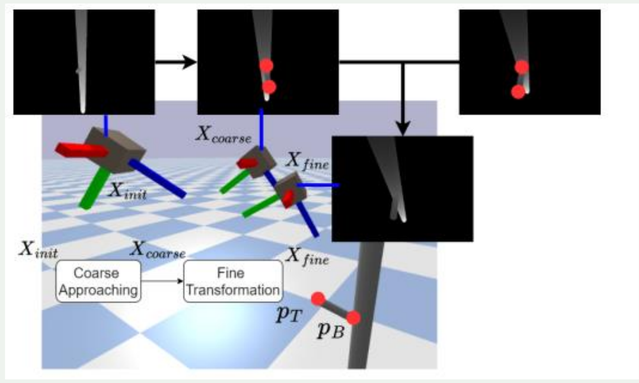
To address these challenges, we propose a confidence-guided grasping strategy that actively seeks garment collars through handovers between dual robotic arms. Furthermore, we formulate the hanging task as one-shot imitation learning with an egocentric view. To precisely align the collar with the supporting item, we propose a two-step hanging strategy that involves coarse approaching followed by fine transformation. We perform comprehensive experiments and show that our framework notably enhances the success rate compared to existing methods.

Method



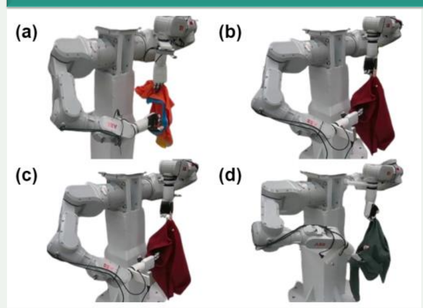


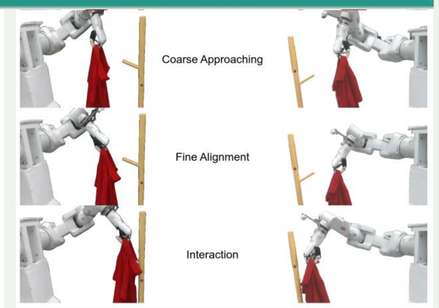
Grasping: Initially, one arm lifts the crumpled garment with a random pick point. The wrist camera on the slave arm then captures multiple images while the master arm rotates, allowing for the collection of information about the garment from various angles. Next, the collar detection network scans these images to locate the collar. The master arm rotates to the angle with the highest confidence, and the slave arm re-senses to determine the optimal grasping pose. The phase concludes if our close-loop evaluation confirms a successful grasp; otherwise, the roles of the dual arms are switched to initiate another search for the collar.



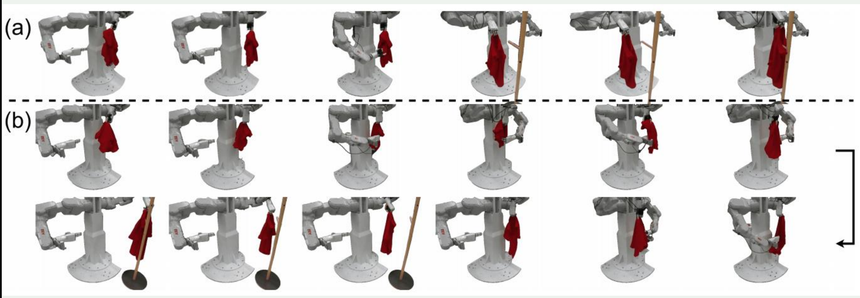
The **hanging** task is formulated as achieving a user-defined pose relative to the object of interest, followed by an open-loop replay of the demonstrated end-effector trajectory. To adapt the collar with the rack in three-dimensional space, we propose a two-step strategy to achieve the desired pose. First, we estimate a displacement to adjust the camera's view-point, improving the clarity of crucial information regarding the rack. Second, we identify the keypoints of the supporting items and calculate a fine-grained transformation to attain the desired relative pose. Finally, the end-effector reproduce the demonstrated interaction trajectory.

Results





The enhanced performance of our method can be primarily attributed to the active search for the collar by adjusting the configuration of crumpled garments. Additionally, the close-loop success evaluation significantly minimizes the chances of false prediction from the models. The figure illustrates several successful examples across various kinds of garments. It is crucial to emphasize that the hand pose is specifically designed to insert into the hole of the collar to achieve a stable grasp. . The position adjustments provided by the coarse approaching enable the camera to achieve a pose that is more conductive to sensing the key structures of the supporting item, thus facilitating a more accurate alignment with the demonstrated pose. Fig. 8 illustrates the entire process of our two-step hanging strategy using dual arms respectively.



Two typical complete episodes are shown. In Fig. (a), only one search attempt is needed to locate and successfully grasp the collar. The success is attributed to the collar being visible to the camera mounted on the slave arm, which facilitates the detection and arrangement of an appropriate grasping pose. After grasping the collar, the hanging algorithm guides the end-effector to approach and interact with the rack. Conversely, as shown in Fig. (b), multiple handovers are required in certain cases. This requirement arises when the collar is obscured within the garment and is not visible to the camera. As a result, the dual arms perform handovers until the collar is detected, at which point the grasp pose is established.