

# IN-HAND MANIPULATION PROTOCOL

Reference No / Version	
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Purpose	The purpose is to evaluate the planning and control aspects of in-hand manipulation systems.
Task Description	<p>A task is defined by initial and desired contacts between the hand and the object and initial and desired hand pose with respect to the object frame. There are three levels of achieving the task:</p> <ul style="list-style-type: none"> <li>Level I: only considering the hand pose;</li> <li>Level II: only considering the contacts;</li> <li>Level III: considering both pose and contacts.</li> </ul>
Setup Description	<p><b>List of objects and their descriptions:</b>            Tasks have been defined on these YCB objects: hammer, phillips screwdriver, adjustable wrench, scissors, wood block, power drill, spatula, plate, mug, bowl, bleach cleanser, pitcher base, banana, potted meat can, gelatin box, tuna fish can, mustard bottle, tomato soup can, sugar box, cracker box.</p> <p><b>Initial and target poses of the objects:</b>            The tasks are available in the website:  <a href="https://robot-learning.cs.utah.edu/project/benchmarking_in_hand_manipulation">https://robot-learning.cs.utah.edu/project/benchmarking_in_hand_manipulation</a></p> <p><b>Description of the manipulation environment:</b>            No specific constraints on the environment. System that rely on pushes against fixtures or contact surfaces can have them placed as desired.</p>
Robot/Hardware/Software/Subject Description	<p><b>Targeted robots/hardware/software:</b>            Any.</p> <p><b>Initial state of the robot/hardware/subject with respect to the setup:</b>            No specific constraints.</p> <p><b>Prior information provided to the robot:</b>            Any information required by the considered method.</p>
Procedure	<p>The procedure runs as follows:</p> <ol style="list-style-type: none"> <li>1. The object is put inside the robot's hand to match the task's initial pose and/or contacts (a human can place the object, the robot can pick it, etc.)</li> <li>2. The in-hand manipulation method is run; the object should be moved from the initial configuration to the desired one. This step includes both planning and execution.</li> </ol>

	<p>3. The final grasp configuration and the necessary time to achieve it (both planning and execution) is recorded.</p> <p>Each task must be executed 5 times.</p>
Execution Constraints	<p>A human cannot intervene once the object is placed inside the robot hand.</p> <p>The object should be in a stable grasp at both initial and final configuration.</p> <p>The object can break contact with the robot, but not to favor placements on a support surface: several pick-and-place executions are not allowed.</p> <p>Pushes against external surfaces while the object is still grasped, and tossing the object in the air to catch it in a different configuration are allowed.</p>