Box and Blocks Test Protocol I, II, IIIa, IIIb

Reference No / Version	P-BBT-1.1.0 / P-BBT-1.2.0 / P-BBT-1.3a.0 / P-BBT-1.3b.0
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Purpose	To assess the performance of a robotic system for a pick and place task. The benchmark proposes a simplified scenario in terms of perception and object shape, and therefore focuses on evaluating the manipulator design, planning, and control performances.
Task Description	Move colored blocks from the start container to the goal container over a barrier dividing the two in minimal time. Depending on the protocol some blocks will need to be picked in a certain order or placed in a specific location. Please refer to the paper for specific details. 
Setup Description	**<u>Description of the Manipulation Environment:</u>** Place two clear containers (YCB Obj. #69) next to one another on a support surface in front of the manipulator such that the long sides of the containers are separated by a container lid acting as a barrier (YCB Obj. #70). The separating barrier lid should be placed such that the height is 292mm. Place the entire setup directly in front of the manipulator with no obstructions or sensory occlusions. The following benchmarks will be completed: YCB-Modified BBT (Protocol I; M-BBT), YCB-Targeted BBT (Protocol II; T-BBT), YCB-Timed-Standard BBT (Protocol IIIa; Timed S-BBT), YCB-Untimed-Standard BBT (Protocol IIIb; Untimed S-BBT).
	<u>List of Objects and their descriptions:</u> <u>Protocol I, II</u>: Sixteen colored blocks (YCB Obj. #71) of four colors, chosen by the user, should be placed into one of the containers (four blocks of each color) on top of the specified template (downloadable from attached multimedia or www.ycbbenchmarks.com/protocols). The start container, where the blocks begin, is left up to the user. Two templates are provided (left/right). Block location "1" should be the furthest and outermost block in each of the bins with respect to the robot.

	Protocol III: One hundred colored blocks (YCB Obj. #71) of all six colors should be placed into one of the clear containers.
	Initial pose of the objects: Protocol I, II: Blocks are placed on the supplied 16-block pattern such that blocks of the same color are aligned in a row (as specified on the template). The decision for which four colors are used is left up to the user. The template should be placed such that it is centered inside of the container and can be affixed to the bottom. Protocol II only: In addition to the above constraints, ensure that an additional block template is affixed to the bottom of the goal (empty) container. Protocol III: Blocks are placed within the container randomly such that they are equally distributed throughout the container. This can be achieved by placing the lid on the container and shaking. Per the number of blocks and the volume of the container, blocks should not be stacked higher than two. Block colors should also be equally distributed throughout the container and not in specific regions.
Robot/Hardware/Subject Description	**Targeted robots/hardware/subjects:** Any robotic manipulator that can pick up lightweight (10.8g) wood blocks. Any and all sensing modalities and manipulators are welcomed to complete the task.
	Initial state of the robot/hardware with respect to the setup: The task is to be set up directly in front of the manipulator and according to the protocol desired as previously described. The manipulator must start in a neutral state such that the end effector is outside of either of the containers.
	Prior information provided to the robot/hardware/subject: The starting position/geometry of the two containers and their barrier and the geometry/color of the blocks can either be provided *a priori* or sensed using on-board hardware. The location/pose of the blocks must be achieved through perception.
Procedure	Protocol I, III: A successful transfer constitutes that the block crossed over the dividing barrier before dropping, i.e. object cannot be tossed over the barrier. Protocol I: Setup the environment as specified. In minimal time, transfer all sixteen wooden blocks over the barrier. The end effector can only transfer one block at a time. If the container moves or more than one block is transferred, the test must be reset with a score of 0 for that execution. Blocks must be transferred in order from 1-16. If neighboring blocks are knocked during execution, the task can continue as long as the same order of blocks are picked as determined by the beginning of the task. Protocol II: Setup the environment as specified. In minimal time, transfer all sixteen wooden blocks over the barrier and target each block's target location according to the template. A block that is

	picked from position X must be placed in position X. The end effector can only transfer one block at a time. If the container moves or more than one block is transferred, the test must be reset with a score of 0. Blocks can only be manipulated once. If the manipulator knocks neighboring blocks undesirably during placement, they cannot be reoriented. Points are awarded at the end of the task. Protocol IIIa: Setup the environment as specified. Within one minute, transfer as many blocks as possible over the barrier. Transfers of more than one block only count as a single point. Protocol IIIb: Setup the environment as specified. As an untimed task, transfer as many blocks as possible over the barrier until all 100 blocks are removed from the start container. Transfers of more than one block only count as one point for the score. If the user decides to end the task prematurely (before all blocks are transferred), this must be reported.
Execution Constraints	User cannot physically alter the blocks/container/obstacles in any way, i.e. user cannot place markers on the objects or paint them different colors. Human intervention during task execution is prohibited.