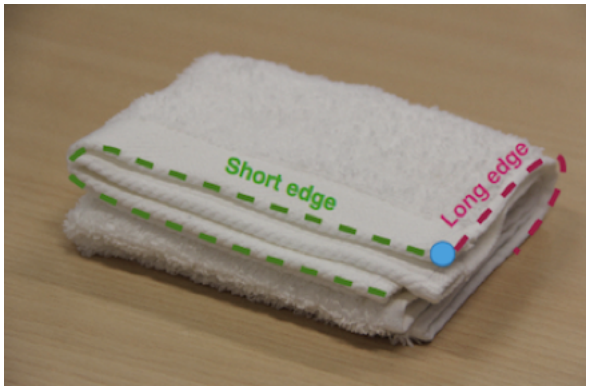
Task 1. Folding/Unfolding cloth



Unfolding: A piece of folded cloth is presented in the robot's workspace. The robot is requested to unfold the cloth flat on the table. Unfolding is a useful task for setting the objects to its canonical form for recognition purposes or as a preparation step for continuing with other tasks as folding or spreading. This task basically consists on grasping a corner of the cloth and then locating and grasping the second corner until having the cloth spread on the table.

Assessment: The results will be measures by the shape of the cloth after unfolding and match it to the predefined geometry of the object. Also, the distance of the corners to their desired locations are used to give scores. This part of the task should be finished in 2 minutes.

Folding A piece of cloth will be laid on the table and in the robot's workspace. Grasp two adjacent corners and manipulate the cloth to join the contrary adjacent, folding the cloth by half.

Assessment: We will measure the initial and final area of the cloth and compare them. The final area should be 1/8 of the entire area of the cloth. This part of the task should be finished in 2 minutes.

The task is designed based on the cloth manipulation benchmark published in: *Garcia-Camacho, I., Borràs, J., Calli, B., Norton, A. and Alenyà, G., 2022. Household cloth object set: Fostering benchmarking in deformable object manipulation. IEEE Robotics and Automation Letters, 7(3), pp.5866-5873.*

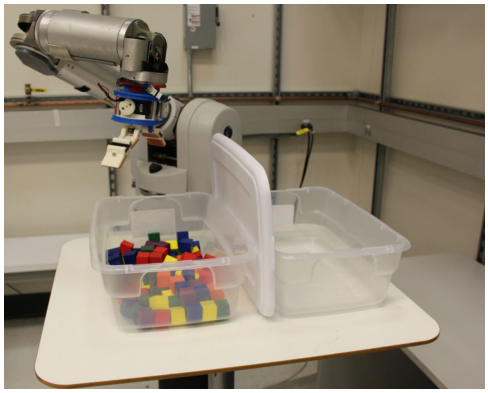
Task 2. Object Re-arrangement

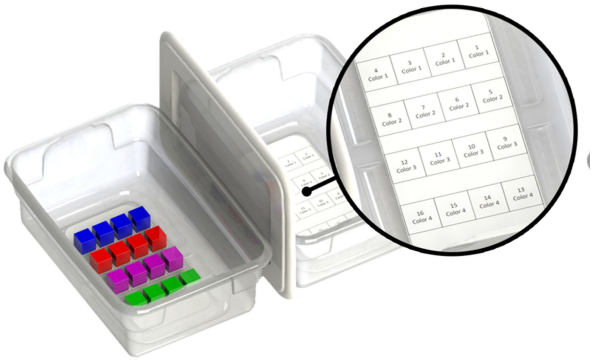
Ten objects from YCB object set will be randomly laid on the table within the robot's workspace. The task is to arrange the objects to defined locations with orientation. The objects could be stacked initially. Placing each object to the right location with the right orientation will earn 10 points.

The task is designed based on the competition, whose details are published in: *Liu, Z., Liu, W., Qin, Y., Xiang, F., Gou, M., Xin, S., Roa, M.A., Calli, B., Su, H., Sun, Y. and Tan, P., 2021. Ocrtoc: A cloud-based competition and benchmark for robotic grasping and manipulation. IEEE Robotics and Automation Letters, 7(1), pp.486-493.*

Task 3. Block Pick-and-Place

3.a The task is to transfer as many randomly configured blocks as possible (out of 100) across the barrier in two minutes. Start and goal containers are positioned on a support surface in front of the manipulator, close enough that the entire volume of the bin is reachable. The determination of which bin is filled (start container) and which bin is empty (goal container), is left up to the user. The end effector must start in a position outside of either container.



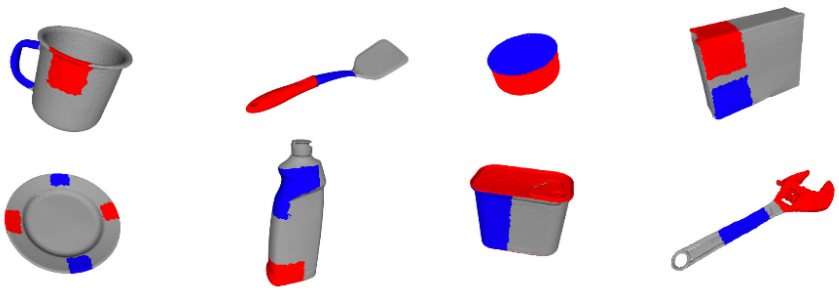


3.b The task is to transfer 10 ligned up blocks from container A to container B and matching the original block patterns in container A.

The task is designed based on the benchmark published in: *Morgan, A.S., Hang, K., Bircher, W.G., Alladkani, F.M., Gandhi, A., Calli, B. and Dollar, A.M., 2019. Benchmarking cluttered robot pick-and-place manipulation with the box and blocks test. IEEE Robotics and Automation Letters, 5(2), pp.454-461.*

4. In-hand manipulation

The task is to adjust to pose of a grasped object within the robotic hand via dexterous in-hand manipulation skills. The initial and desired contact regions are designed on various target objects as shown in the figure below; the initial contact regions are marked with red and the final contact regions are marked with blue. The success will be measured by the execution time and geodesic distances between achieved contact locations and desired contact locations. This task designed based on the benchmark published in: *Cruciani, S., Sundaralingam, B., Hang, K., Kumar, V., Hermans, T. and Kragic, D., 2020. Benchmarking in-hand manipulation. IEEE Robotics and Automation Letters, 5(2), pp.588-595.*



5. Human-to-robot handovers

The task will assess the generalization capabilities of the robotic control when handing over previously unseen objects filled (or not) with unknown content, hence with a different and unknown mass and stiffness. No object properties are initially known to the robot or the team. The task consists of three steps, namely human maneuvering, dynamic handover, and robot maneuvering. After the handover, the robot places the object on the table at a pre-defined location.

The task has four drinking cups with different properties: high deformability, medium transparency (Cup 1); average deformability, low transparency (Cup 2), average deformability, high transparency (Cup 3), and no deformability, high transparency (Cup 4). Cup 4 is the plastic wine glass from the YCB object database. These cups are inexpensive and available worldwide (Protocol), have different shapes and sizes, different degrees of deformability, include textureless regions, transparencies and reflections that make the vision-based pose estimation challenging. Moreover, to further challenge the task, we vary the properties of each cup (mass and deformability) with two different amounts of rice (which are easy to purchase and - unlike liquids - harmless for the hardware): 0% (empty), and 90% (filled) of the total volume of the cup. The filling amounts are rounded to the smaller quarter of 100ml to ease the replicability of the configurations.

The task is designed based on the benchmark published in *Sanchez-Matilla, R., Chatzilygeroudis, K., Modas, A., Duarte, N.F., Xompero, A., Frossard, P., Billard, A. and Cavallaro, A., 2020. Benchmark for human-to-robot handovers of unseen containers with unknown filling. IEEE Robotics and Automation Letters, 5(2), pp.1642-1649.*