Sorting Weights with Closed Loop Interactive Embodied Reasoning
Supplementary material

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A. *Weight measurements details*

To perform weight measurements in our experiment, we rely on the external force reported by libfranka. We assume that the only external force is incurred by the objects held in the hand, i.e., that the robot is not in collision with the environment. To avoid errors due to model inaccuracies, we measure the force in the z-direction twice: once with the empty gripper and once with the object lifted to the same robot configuration. The difference divided by the constant g proved to be a reliable indicator of the weight sufficient for our applications. If more accurate numbers are needed, we could use a digital scale, but this would have no effect on the reasoning side.

For simplicity, we assume that for each considered property, we have a suited (primitive) measurement procedure that interacts with the objects and produces an estimate of the property. It is true that we could, for example, from the same interaction estimate the object's inertia or the center of gravity. Reusing the data would possibly lead to shorter action sequences for complex queries, but this is not in the scope of this paper.

Attributing a measurement to several objects is currently not implemented. It is theoretically possible to formulate constraints on sets of properties to encode and reason about combined measurements. We will consider that in our future work.

In Figure 1 we show graphs of the Force in the z direction over time for measuring the weight of a mug and a spam can. Figure 2 shows the robot in the moments of force assessment (also marked in the graphs by the vertical lines). Our method results in an estimate of the mug weight of 95.5g (ground truth 96g) and 22.2g for the spam can (ground truth 24g), ground truth shown in Figure 3. For a measurement with the empty gripper, we observed an estimated weight of -2 g. This shows that we can distinguish the weight of all objects in the presented tasks and also reach a surprisingly good absolute precision.

B. *An example of the scene graph*

In order to better explain the details of our approach, in Figure 4 we show an example of the execution of the query that includes notation for program execution, action planning, and updates of the scene graph.

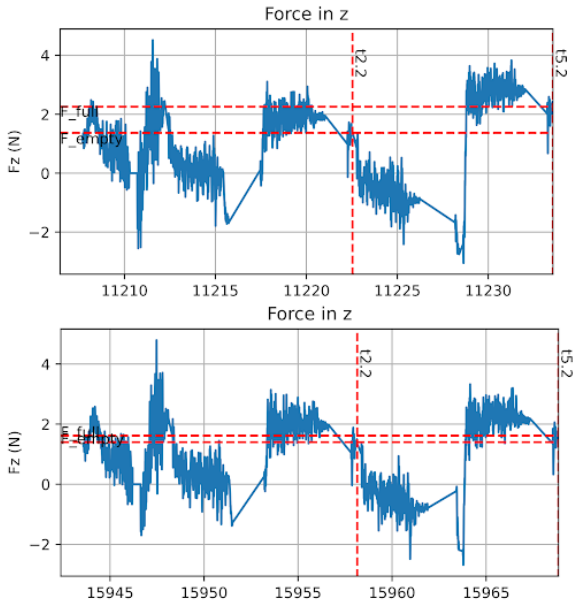

Fig. 1. Graphs of the force in the z direction for weighing the mug (top) and the spam can (bottom)

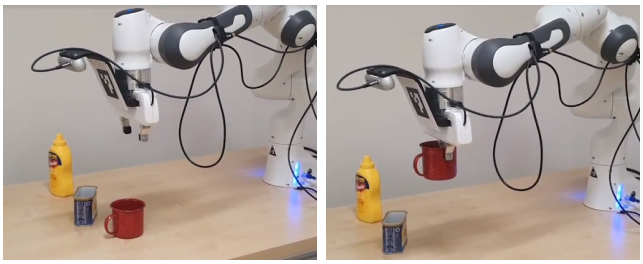

Fig. 2. Robot configurations corresponding to weight estimation.

Fig. 3. Ground truth weight measurements for mug (left) and spam can (right).

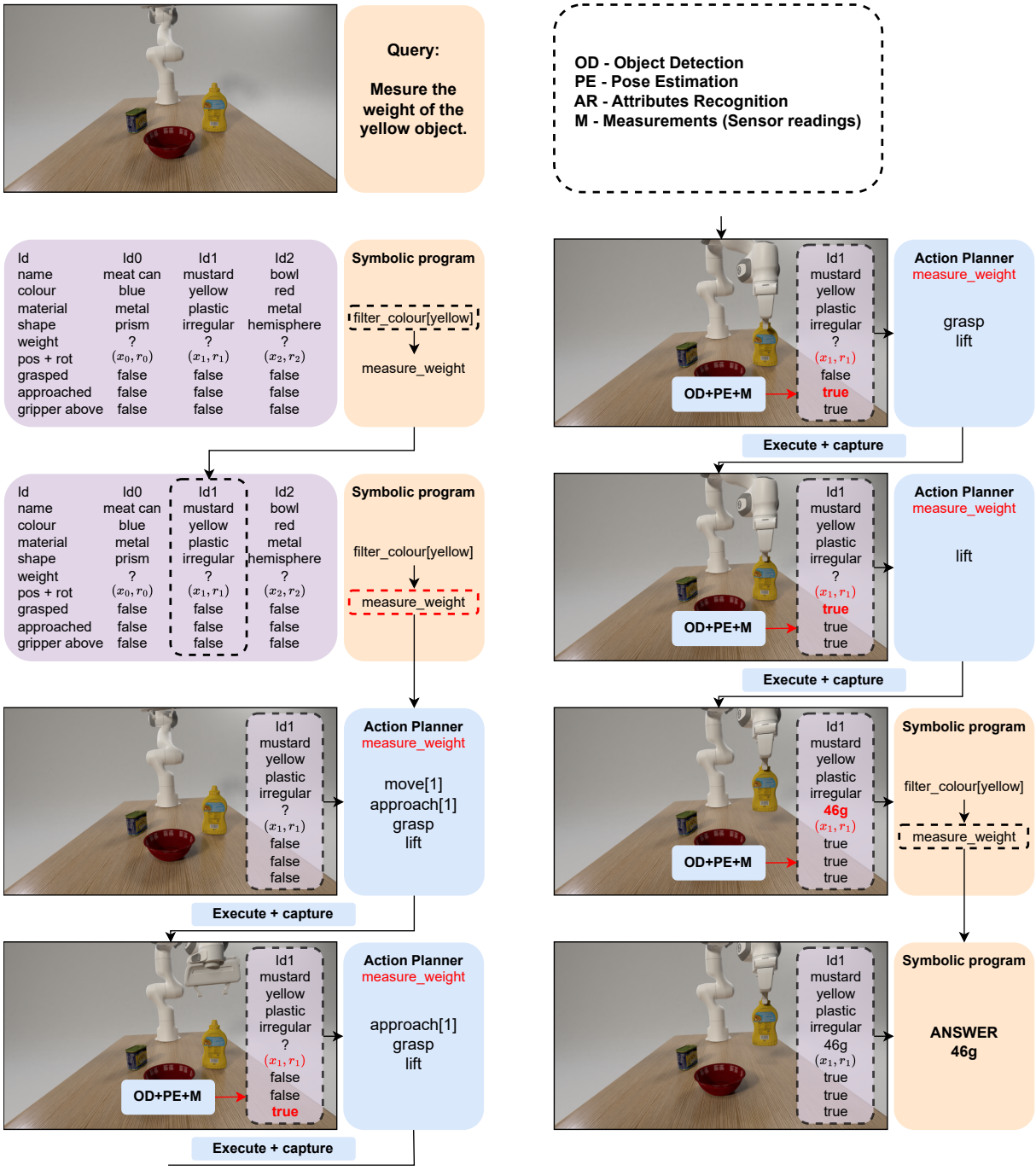

Fig. 4. An example of task execution by CLIER approach.