COMMENTS TO SUBMIT – Towel

Details of the setup

Robots

This bi-manual task is executed by two mobile manipulator robots TIAGo. Its specifications can be found at the PAL Robotics website https://tiago.pal-robotics.com/.

Each robot provides a workspace versatility with 12 degrees of freedom, without the end-effector: The base platform has 2 DoF, the torso lift has 1 extra DoF, 2 additional DoFs for the neck to orient the cameras, and 7 DoFs of the robotic arm.

The kinematic structure of the arm consist in 3 DoFs for the shoulder, 1 DoF for the elbow and 3 DoFs for the wrist.

Figure 1. TIAGo robot.

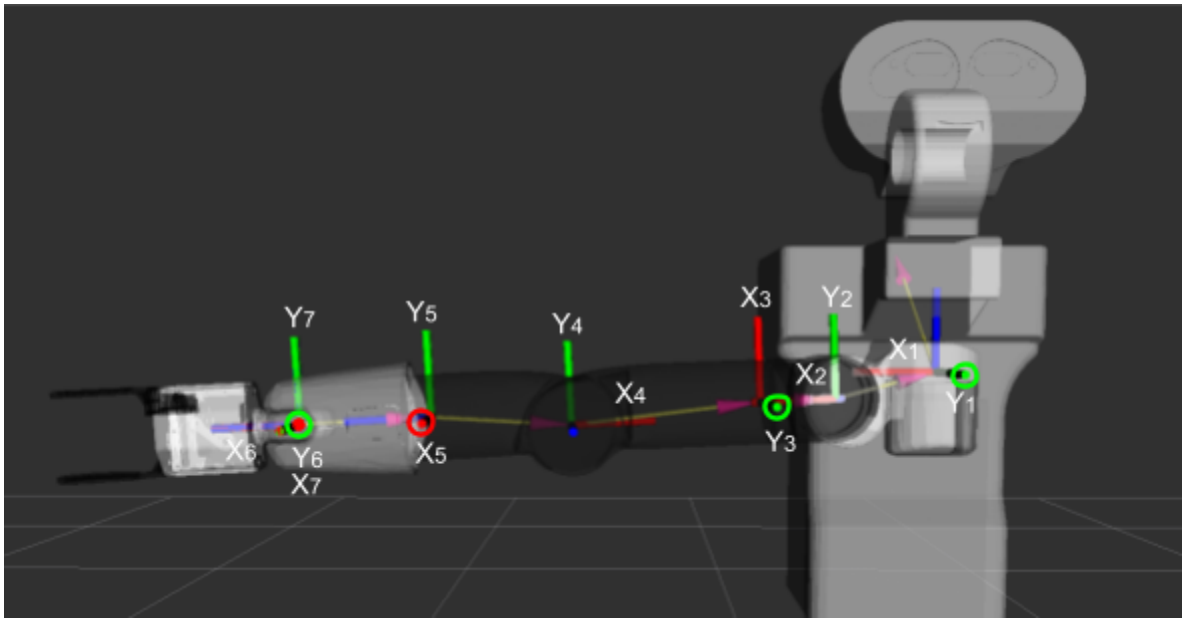

Figure 2. Kinematic chain of TIAGo robot.

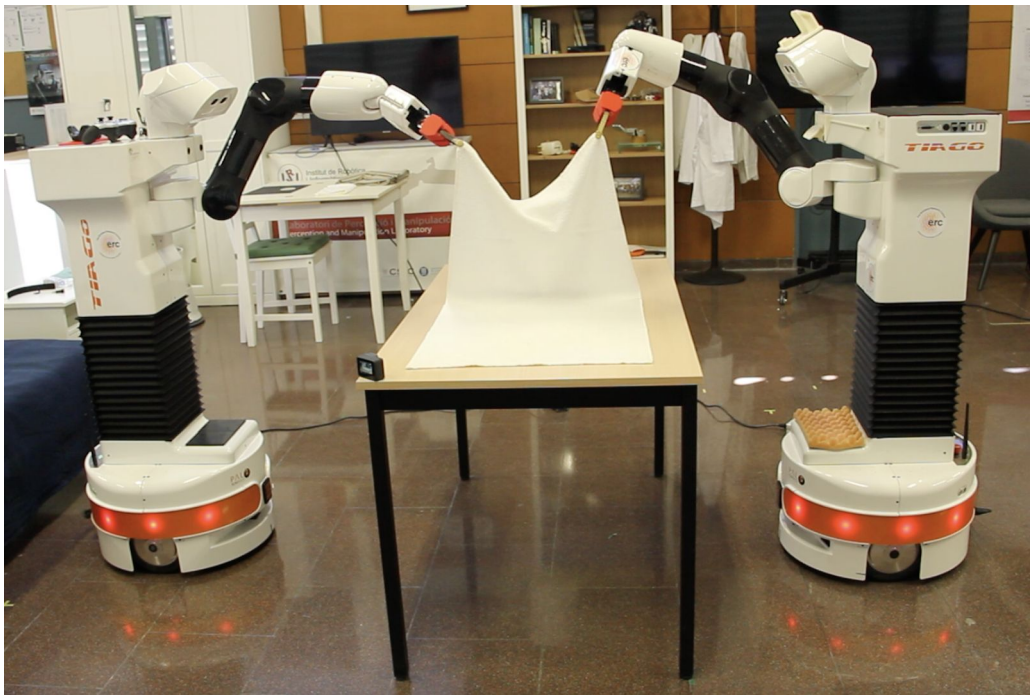

Figure 3. Task setup.

End effector

Tiago robots are equipped with a parallel gripper with big highly anti-slippery fingertips. We have modified the gripper to substitute the fingertips with flat and small fingertips that are flexible when they approach the table but rigid when they grab.

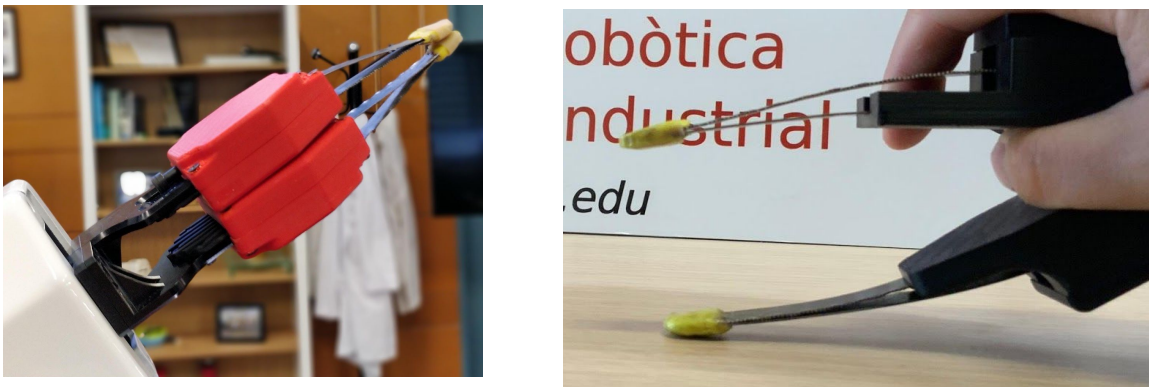

Figure 4. Modified gripper.

Sensors

An RGB-D camera, which is mounted inside TIAGo's head, is used for localizing the first grasping point and for detecting obstacles with which there could be collision, such as the table.

Workstation specifications

Each TIAGo robot has an onboard computer equipped with Intel i7 and 16GB. Two development computers, one for each robot, are used with Ubuntu 16.04 as operative systems.

Software architecture

A ROS-based software architecture is used with ROS Kinetic. The entire task of folding a towel is divided into three phases: **[GR1]** grasping one corner of the towel by the first robot; **[GR2]** grasping another corner by the second robot; **[MAN]** manipulation of the towel until it is folded.

As the first steps needed for folding a towel are very similar to task 1, we only report the manipulation phase. This phase consists on the synchronized execution of trajectories by both robots using Dynamic Movement Primitives (DMP) representation of the motion learnt by demonstration.

Results

What makes the system successful?

The system succeeds when both corners match two by two, resulting in a folded towel with half of its initial area. As the towel's position and length are known, the success on the folding greatly depends on the synchronization of both robots, that is to say, that the execution of the folding motions are done at the same time.

What makes the system fail?

The trials where we obtained a failure where due to the gripper's nature. The composition of the towel along with the friction of our grippers caused the corner to get sticked at the release step of the motion in one trial, creating an unwanted bending. This bending, which was not corrected by the robot, implies a failure of the trial.

What was improved compared to other methods?

The task of grasping a towel and folding it is a classical task in cloth manipulation. Both, the strategy of performing an edge-tracing motion for grasping the second corner and the use of two mobile manipulator robots for bi-manual tasks such as this one, gives the possibility of adaptation to different sized cloths and tables.

Chosen grasping points and/or grasping strategy

The chosen grasping points are the usual in a rectangular cloth: the corners. Our modified grippers allow to slide one of the fingertips between two layers of the folded towel or below a flat towel placed over the table, without damaging neither the table or the gripper due to its flexibility and size, in order to grasp a corner without the need of extra manipulation actions.

The second corner is grasped using the same strategy as Task 1: once the first interest point is grasped (marked on the right figure with a red circle), an edge-tracing trajectory is executed until arriving to the second corner of the towel.

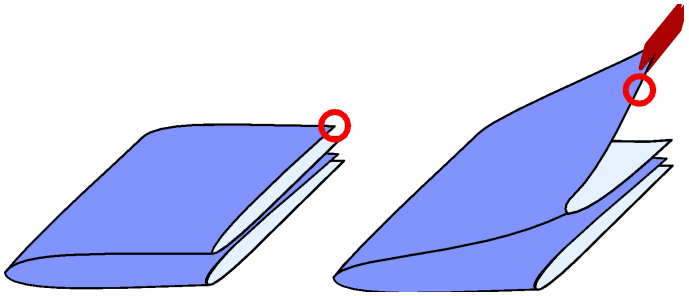

Figure 5. Towel grasping points.