BIMANUAL CLOTH MANIPULATION PROTOCOL - DRESSING
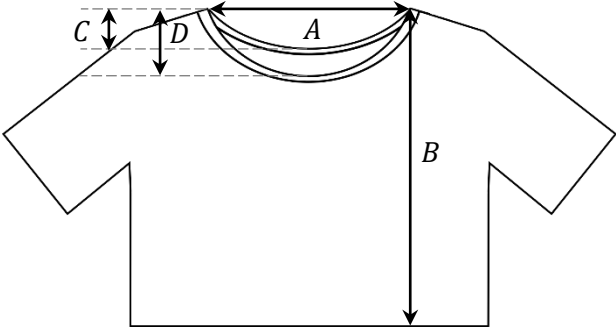
Reference No / Version	RAL-SI-2020-P19-0832_3-V1.0 (for the latest versions of the protocol, please refer to https://ral-si.github.io/cloth-benchmark/#resources or http://www.ycbbenchmarks.org/protocols-and-benchmarks/)
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Purpose	Performance evaluation of bimanual robotic systems for cloth manipulation with a simplified dressing scenario.
Task Description	This task consists in putting a T-shirt over a human-like head starting from different initial configurations.
Setup Description	<u>List of objects and their descriptions:</u> The following objects are used: **T-shirt**: Basic T-shirt whose type of collar is reported in Figure 1. The following dimensions are allowed: • $A \in [13, 25]$ cm; • $B = 50$ cm; • $C \in [1.5, 5]$ cm; • $D \in [7, 13]$ cm. Figure 1 – T-shirt template with measures To measure $A - D$, put the T-shirt flat on a planar surface and position it so that the plane through shoulder seams is parallel to the surface (see Figure 2). The measures are taken in unstretched configuration.

Figure 2 – Shoulder seams positioning

The maximum allowed stretched measure for A is 170%. The following examples qualifie:

Figure 3 – Female S T-shirt by H&M 95% cotton 5% Elastan with measures in cm $A = 19, B = 50, C = 4.5, D = 8.3$

Figure 4 - Female L T-shirt by Zara 100% cotton with measures in cm $A = 19, B = 50, C = 2.9, D = 10$

A final measure is the length of the neck L_n, indicated in red in Figure 5, which is used to determine the head size. To measure it, put the T-shirt flat on a planar surface and outline the inner ring of the neck (e.g. with a thread).
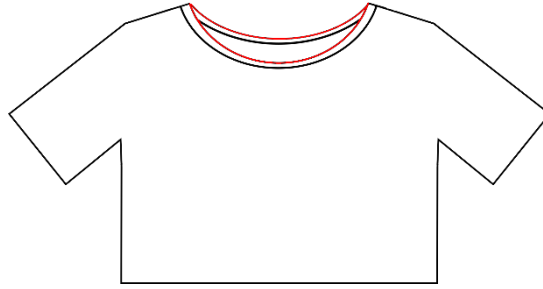
Figure 5 – T-shirt template with neck length in red

Head: Two sizes for the head are considered which are referred to as small (**[sh]**) and big (**[bh]**) in the following. The head is composed of two parts:

1. The top part is shown in Figure 6 and consists of: a hemisphere with diameter $d_h = \frac{\alpha_h}{\pi} L_n$, where $\alpha_h = 1.11$ for **[bh]** and $\alpha_h = 0.72$ for **[sh]**, a cylinder with height of 1.5 cm and diameter $d_c = d_h$ and another hemisphere with diameter d_h which is cut off at 2 cm to mount the bottom part;
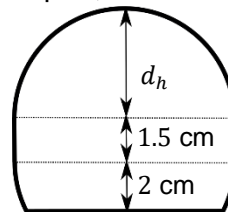

Figure 6 – Top part of the head

2. The bottom part is a cone that can be used as an easy stand for the head.

Edit the provided script with the measure L_n and execute the command "freecadcmd generate_head_stls.py". The script will generate six stl files, three for big and small head, respectively. 3D print, using PLA or any similar rigid filament. Use either the *_full version to print both parts combined or use *_bottom and *_top to print them separately. Note that it is also allowed to have a custom headstand as long as it is smaller than the head diameter d_h and does not offer any additional functionality.

The tasks are designed for both head sizes, the user can choose to tackle either one of them or both.

Planar surface: any planar surface with dimensions sufficient to completely spread the T-shirt on it can be used.

Initial and target poses of the objects:
The following starting configurations must be considered for the objects.

T-shirt: Five possible starting configurations are defined:
- Two pre-grasped points (**[pg2]**). The user can freely

choose two pre-grasped points on the T-shirt.

- One pre-grasped point (**[pg1]**). The user can freely choose one pre-grasped point on the T-shirt.
- T-shirt random on a planar surface (**[cr]**). The T-shirt must be dropped on a planar surface: grasp it at the point highlighted with the red circle in Figure 7 and release it such that the minimum distance between the T-shirt and the surface is greater than 10 cm.
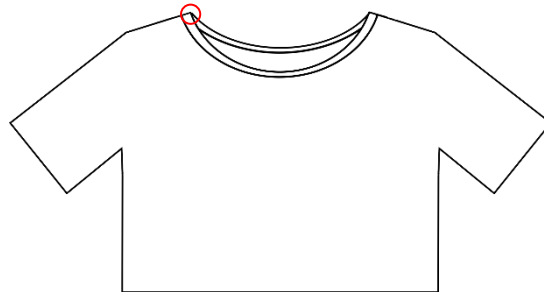

Figure 7 – T-shirt template with grasping point for **[cr]**

- T-shirt flat on a planar surface (**[ft]**). The T-shirt is not pre-grasped and is placed flat onto a planar surface with as less wrinkles as possible;
- T-shirt folded on a planar surface (**[fd]**). The T-shirt is not pre-grasped and is placed folded onto a planar surface. To fold the T-shirt, follow the steps reported in Figure 8.
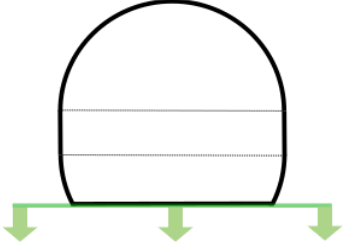

Figure 8 – Folding steps

Head: The head can be placed anywhere in the workspace of the robots and must be fixed.

Note that it is not allowed to touch the head with the T-shirt in the initial configuration.

To complete the task, the shirt needs to be fully below the top part of the head (denoted with a green line in Figure 9) and the head needs to pass through the neck hole of the T-shirt during the process.

	 Figure 9 – Goal position
	<u>Description of the manipulation environment:</u> Fix the head on any planar surface. There is no clutter in the workspace.
Robot/Hardware/Software/Subject Description	<u>Targeted robots/hardware/software:</u> Any bimanual robotic system with grasping capabilities is allowed.
	<u>Initial state of the robot/hardware/subject with respect to the setup:</u> The robots can be in any configuration if not specified otherwise. In **[cr]**, **[ft]** and **[fd]** the robots are not allowed to touch the T-shirt at the starting.
	<u>Prior information provided to the robot:</u> Position, shape and color of the head are known. The T-shirt dimensions A and B are known. In **[cr]**, **[ft]** and **[fd]**, the configuration of the T-shirt is known.
Procedure	The following flow chart specifies the procedure considering the different initial configurations.
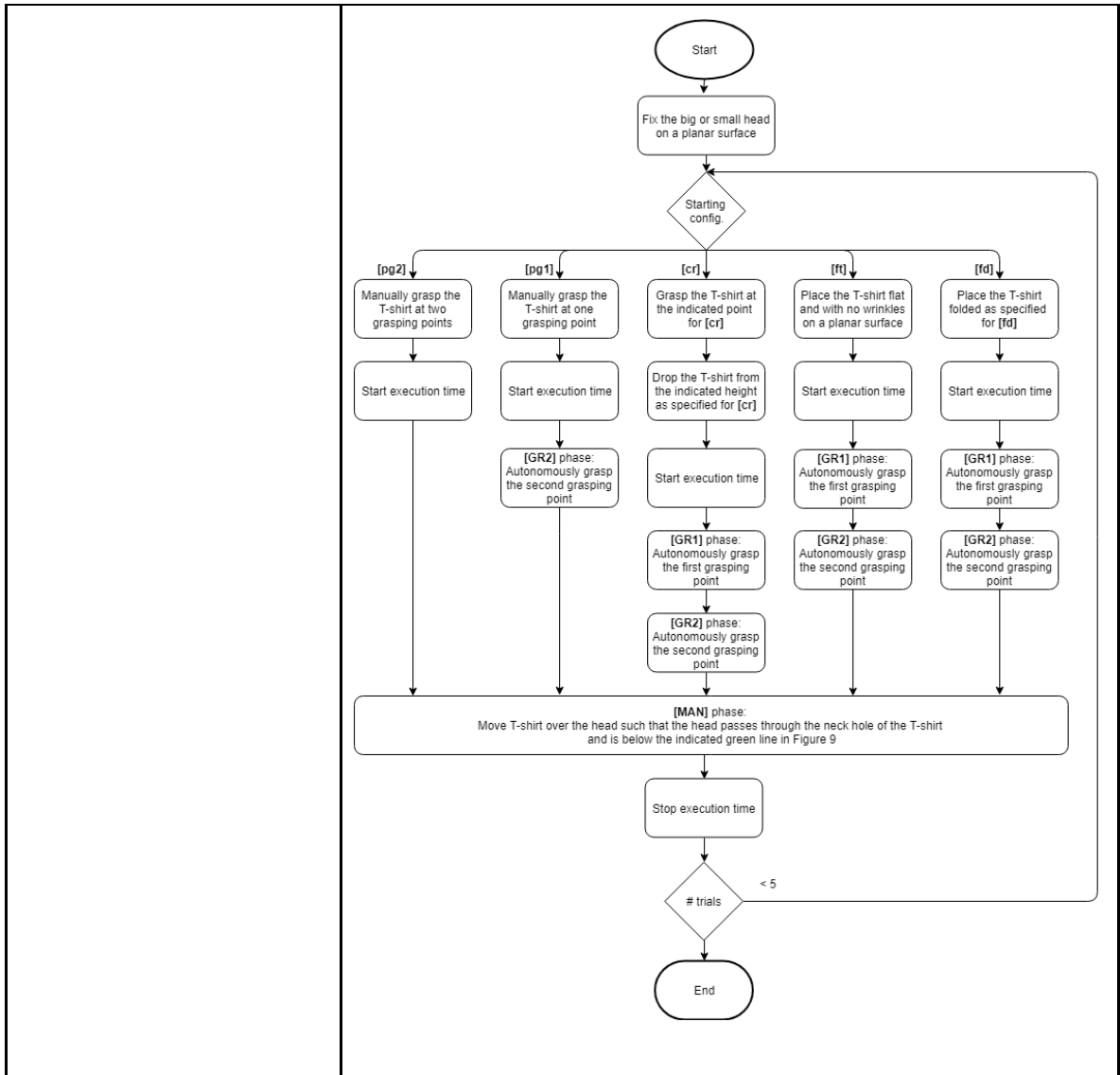
Execution Constraints	Any type of gripper and grasping strategy can be used. However, grippers, grasping strategy, head size and position must not change during the five evaluation trials.