BIMANUAL CLOTH MANIPULATION PROTOCOL - DRESSING
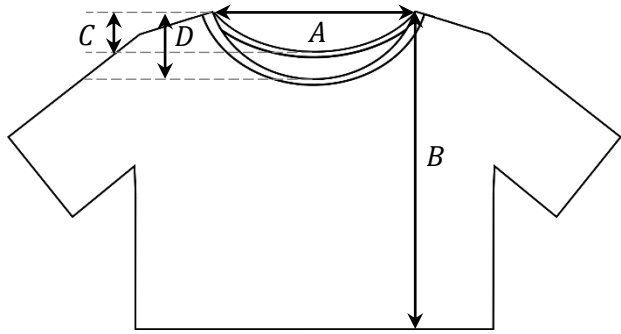
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Purpose	Performance evaluation of bimanual robotic systems for cloth manipulation with a simplified dressing scenario.
Task Description	This task consists in putting a T-shirt over a human-like head starting from different initial configurations.
Setup 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).
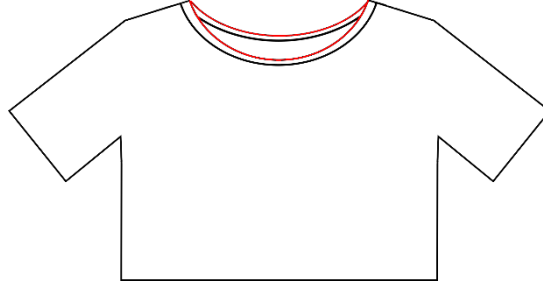
Figure 5 – T-shirt template with neck length in red

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;
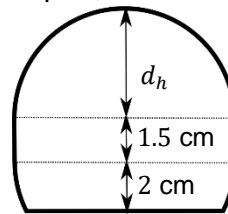

Figure 6 – Top part of the head

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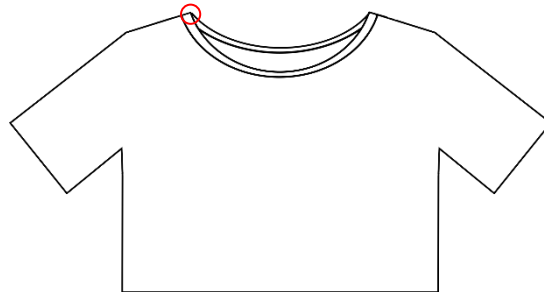
Figure 7 – T-shirt template with grasping point for **[cr]**

- 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.

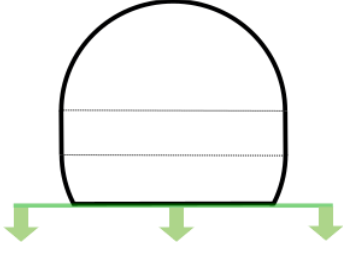|	
	 Figure 9 – Goal position
	Description of the manipulation environment: Fix the head on any planar surface. There is no clutter in the workspace.
Robot/Hardware/Software/Subject Description	Targeted robots/hardware/software: Any bimanual robotic system with grasping capabilities is allowed.
	Initial state of the robot/hardware/subject with respect to the setup: 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.
	Prior information provided to the robot: 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.

Start

Fix the big or small head on a planar surface

Starting config.

[pg2]
Manually grasp the T-shirt at two grasping points

Start execution time

[pg1]
Manually grasp the T-shirt at one grasping point

Start execution time

[GR2] phase: Autonomously grasp the second grasping point

[cr]
Grasp the T-shirt at the indicated point for [cr]

Drop the T-shirt from the indicated height as specified for [cr]

Start execution time

[GR1] phase: Autonomously grasp the first grasping point

[GR2] phase: Autonomously grasp the second grasping point

[ft]
Place the T-shirt flat and with no wrinkles on a planar surface

Start execution time

[GR1] phase: Autonomously grasp the first grasping point

[GR2] phase: Autonomously grasp the second grasping point

[fd]
Place the T-shirt folded as specified for [fd]

Start execution time

[GR1] phase: Autonomously grasp the first grasping point

[GR2] phase: Autonomously grasp the second grasping point

[MAN] phase:
Move T-shirt over the head such that the head passes through the neck hole of the T-shirt and is below the indicated green line in Figure 9

Stop execution time

trials — < 5

End

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.