ROBOSOFT COMPETITION 2025

RoboSoft Competition 2025

Scenarios and rules[1]

Date:

23-26th April 2025

Venue:

Swiss Tech Conference Centre[2]

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version date: 03/12/2024

[1] The organizers can change, refine, and develop the following rules till the first day of the competition. Please visit regularly https://robosoft2025.org/ for the latest version.
[2] actual date and venue TBC

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Competition Overview

The RoboSoft Competition 2025 invites teams to test the design and control of their robots in challenging scenarios. The competition will showcase novelties of soft robots like resilience, body compliance, delicate contact, and deformability.

The principal aim of the competition is twofold: first, to challenge state-of-the-art soft robots; second, to demonstrate the performance of soft robots to increase their impact value.

Teams may comprise any combination of students, faculty, industrial partners, private partners, or government institutions without restricting the number of participants per team. One member of the team must be elected as Team Leader (TL) and will act as contact point for the team.

The RoboSoft Competition 2025 is made of scenarios which focus on real-world robot applications. This year competition will focus on three specific challenges: "**in-pipe locomotion**", "**harvesting of delicate fruits**", and "**medical screening and intervention**". In the 2025 edition, we invite both autonomous and teleoperated robots. **For all scenarios, teams are invited to bring their own robot**. However, a standard manipulator (UR5) will be provided, if requested.

Each scenario is split down into tasks: points are awarded by executing partially or completely each task. The robot that will earn the maximum number of points will be considered the winner of the RoboSoft Competition 2025. Each team participates with one robot, but multiple entries of the same team with different robot designs are allowed.

OFFICIAL INFORMATION

The official information and interpretation about rules will be available on the RoboSoft 2025 website https://robosoft2025.org/).

Rules (including this documents) and scenarios are subject to minor changes. Please check regularly the RoboSoft 2025 website for last updates.

In case of any question, participants are invited to read carefully this document, and for further requests to contact the competition chairs Marcello Calisti, (mcalisti@lincoln.ac.uk) Kieran Gilday, (kieran.gilday@epfl.ch). For logistic questions, please contact Dr. Kieran Gilday.

Venue and Schedule

FIGURE 1: COMPETITION VENUE, SWISSTECH CONVENTION CENTER, https://maps.app.goo.gl/YM8CYr2sP2gnxP229

The RoboSoft Competition 2025 will take place at the **Swisstech Convention Center** next to the EPFL Campus at **Rue Louis Favre 2, 1024 Ecublens, Switzerland** on **23rd–26th April 2025.**

A preliminary schedule of the competition is shown below (please note this has to be confirmed):

Day	Date	Events
1	23rd April 2025 Wednesday	• Teams' arrival and registration • Team set-up and preliminary tests
2	24th April 2025 Thursday	• Morning: Team set-up and tests • Afternoon: Robosoft Competition 2025 1st round/qualifiers
3	25th April 2025 Friday	• Morning: RoboSoft Competition 2025 2nd round/finals • Afternoon: Awards ceremony

Teams have the option to arrive on the first day of the conference to set-up and test their systems. Space will be provided for each team for this purpose; the actual space size, allocation, and facilities provided will be confirmed early January 2025.

The venue will be equipped with the following:

- 1 Table per team
- 230 50Hz VAC power extension (max 13A)
- Internet (Wi-Fi)
- Portable compressor: 2.5HP, 8 Bar, 200L/min, 24L tank, 64mm nozzle diameter (shared equipment)

The committee will evaluate additional equipment upon request. However, teams should try to bring all the materials and equipment they need. Further information regarding schedule and facilities will be provided later.

The main phases of the application procedure are reported below, along with the most important dates.

Submission Procedure

To ensure competent entries only, a selection phase will take place in which a technical committee will evaluate the eligibility of each robot. The technical committee will be supervised by the competition chairs, which will be possibly aided by experts.

To manifest your interest to participate, please visit https://robosoft2025.org/ and fill the online form: RoboSoft Competition Form (also available within the competition section of the Contribution tab). The form should be submitted before **17th January 2025**; and it will contain a technical description of the robot and a video (max 2 minutes, 10Mega). Videos should be privately uploaded online, and the access should be provided with a link within the online form. The video should demonstrate the skills of the robot at the current state of development, while the technical document can summarize the expected improvements to be shown at the competition.

The acceptance notification will be on **27th January 2025.**

Participants will be requested to confirm their participation by **17th March 2025.**

Skills to be shown in the video / evaluation criteria

Skills to be shown are directly related to scenarios and tasks: teams should demonstrate minimum capabilities of their robots allowing them to be competitive during the competition. A complete list is presented here, grouped by or capabilities:

1. Locomotion
    a. Locomotion inside a straight pipeline
    b. Locomotion inside a curved pipeline (minimum 45 degrees, arbitrary curvature)
2. Delicate objects picking
    a. Grasping and lifting of an object (by pinching, curling around, etc…)
    b. Compliance of the gripper
3. Medical inspection and intervention
    a. Deliver an end effector (e.g. inert camera) along an s-shaped path (minimum 2x 45 degrees, maximum 50 mm radius)
    b. Pushing/lifting a small object

The evaluation criteria will be on a do-it basis, thus a simple video demonstrating the ability to perform one of the skills listed above grants the eligibility.

It is mandatory to demonstrate the softness of the submitted entries within the technical documents. To be as inclusive as possible, we will evaluate softness either as material and/or as structural compliance, but the soft/compliant parts have to:

- Clearly enable the function of the robot; OR
- Clearly improve the capabilities of the robot

On the day of the competition, robots which will differ significantly from the submitted entries will be disqualified.

Robots could be tethered for both processing and/or computational purposes. Bear in mind that, if the tether will generate any kind of impediment for locomotion or manipulation, it has to be considered as part of the robot.

Restrictions

Despite the competition is open to participants' creativeness, some restrictions are required due to logistic requirements. Restrictions will be disclosed as soon as possible.

<u>Keep in mind that the organizers are not responsible to damage to persons or objects. Teams are responsible for all the safety requests their robot demands, or for the safety of their actions during the competition.</u>

THE ROBOSOFT COMPETITION 2025

The RoboSoft Competition 2025 proposes three scenarios described in detail in the next sections. During a trial, teams will receive a maximum time slot upon which they must complete the scenario or part of it (that is completing a certain number of tasks). Only two operators (one operator should be the TL himself) can participate in the attempts during the competition day, and are allowed to operate inside the competition field, together with at least one judge who will supervise the execution of the trials.

The execution of a task can be stopped at any moment by the judges, or the TL can request to stop the trial. This can happen for safety issues or because the operators consider the robot stuck. After the TL request, judges allow the team to physically interact with the robot and to repositioning it to perform another attempt. A maximum number of three (3) attempts for each task can be performed, after which the task is considered not completed and the robot should be moved by the operators to the next task. A fraction of the total points can be assigned to the robot in case the task is partially completed.

The number of trials required to complete a task also affects the scoring, i.e. the maximum score can be earned by completing the task with the first attempt, then the score decreases at each subsequent attempt. The complete scoring is reported in Scoring section.

To emphasise robust operation, the locomotion and picking scenarios will offer teams multiple competition runs with a qualifying round and a bracketed round. The qualifying round determines seeding, then the bracketed round operates head-to-head trials on parallel scenarios eliminating teams until a winner is determined. If more than 8 teams each scenario will participate, qualifying rounds will reduce the number of teams to 8; in case of 8 or less team participating, qualifying rounds will be used to determines the seeding (highest vs lowest seeding approach).

IN-PIPE LOCOMOTION

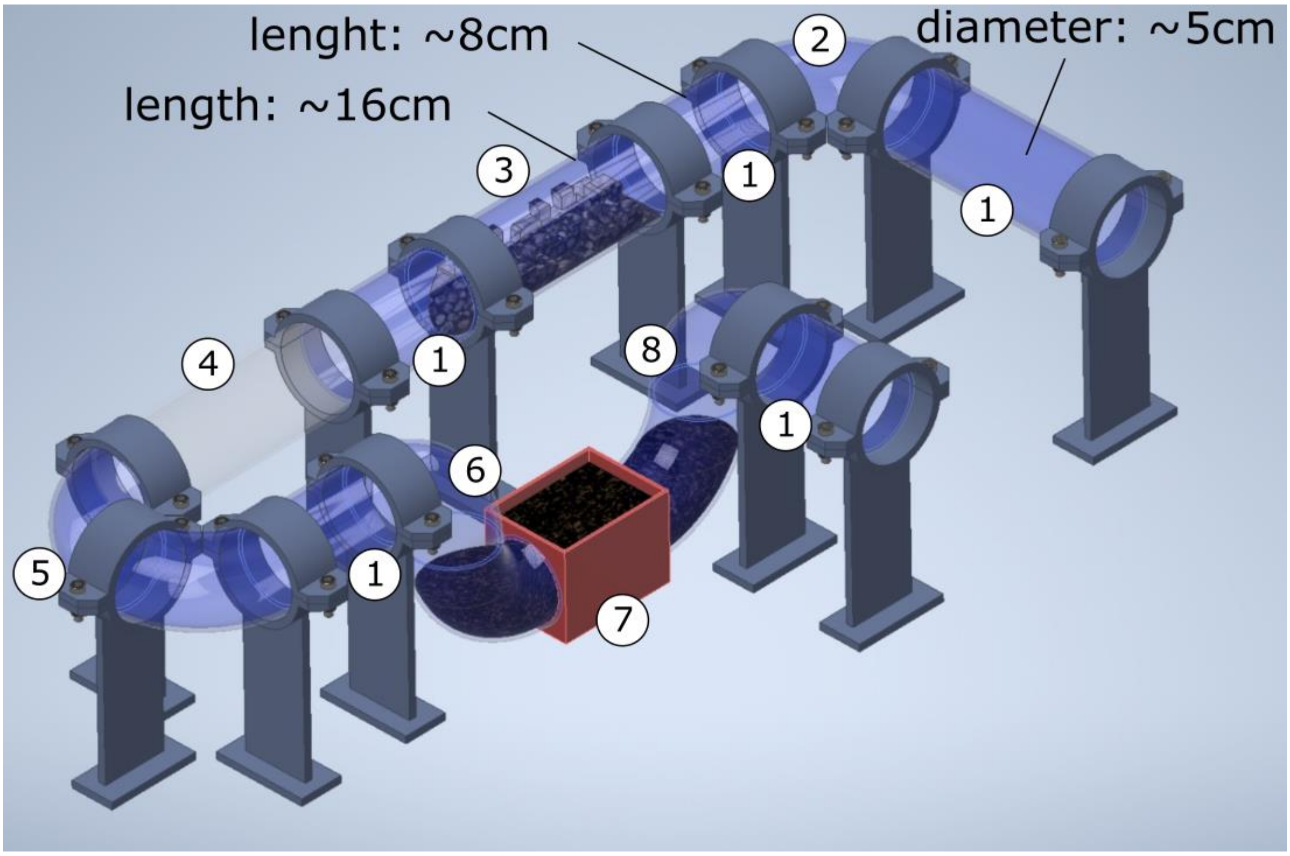


FIGURE 1: THE LOCOMOTION SCENARIO. IT COMPRISES STRAIGHT TUBES OF DIFFERENT LENGTHS (1), CURVES OF 90 (2) AND 180 (5) DEGREES, ONE SECTION WITH RUBBLE THAT PARTIALLY OBSTRUCTS THE SEGMENT AND PRESENT AN IRREGULAR INTERNAL SURFACE (3), ONE SEGMENT WITH WALLS MADE OF SILICONE (OR SIMILAR FLEXIBLE MATERIAL) (4), A DOWNWARD S-CURVE (6), A SAND PIT THE ROBOT AS TO BURROW THROUGH (7), AND FINALLY AN UPWARD S-CURVE AND TURN (8).

Generality:
Locomotion in confined spaces appears one of the most relevant domains for soft robots, that can exploit compliance, delicateness, and locomotion dexterity. This scenario aims to showcase the capabilities of the robot replicating motion within a pipeline, in a rubble area, inside the human body, and in soil. The robot is competing to reach the end of the tunnel and exit as soon as possible.

Description:
The pipes are connected to create a maze the robot has to navigate into, from start to exit, either autonomously or teleoperated. Six different types of segments are proposed: straight, curved, restrictions (rubble), flexibles walls, slopes, and sand. The segments can be easily disassembled for the recovery of the robot. In case the robot has to start a specific task, it will do so from the previous straight segment. Tasks6 to 8 have to be completed together.

The task proposed challenge the robot to navigate in the following segments:

Task1: A straight segment.
Task2: A 90-degree turn.
Task3: A segment with rubble on the walls.
Task4: A segment with flexible walls.
Task5: A 180-degree turn.
Task6: A downward slope.

Task7: A sand pit: this segment is open on top, and rigidly connected with segments 6 and 8, and it is a paralepidid rather than a cylinder.

Task8: An upward slope.

The completion of multiple straight segments will award points individually (i.e. you can score multiple times the straight segment task).

Material type used for the pipes, junctions, etc., will be disclosed soon. The whole track will be available as .igs and .stp files, to be downloaded from the Appendix.

A maximum time of 10 mins is given. The robot has to perform the pipe sequentially. If the robot gets stuck in any of the segments, the teams can ask for a reset, up to three times per task, after which the tasks is considered failed and the robot has to be moved onto the next straight tube. Disassembling and reassembling the pipes is not stopping the clock (therefore, this is intended to be a significant drawback). Due to the pipe configuration and the potential risk of entanglement of the tether, autonomy should provide a significant advantage but points are not specifically awarded for autonomous robots.

HARVESTING OF DELICATE FRUITS

Generality:

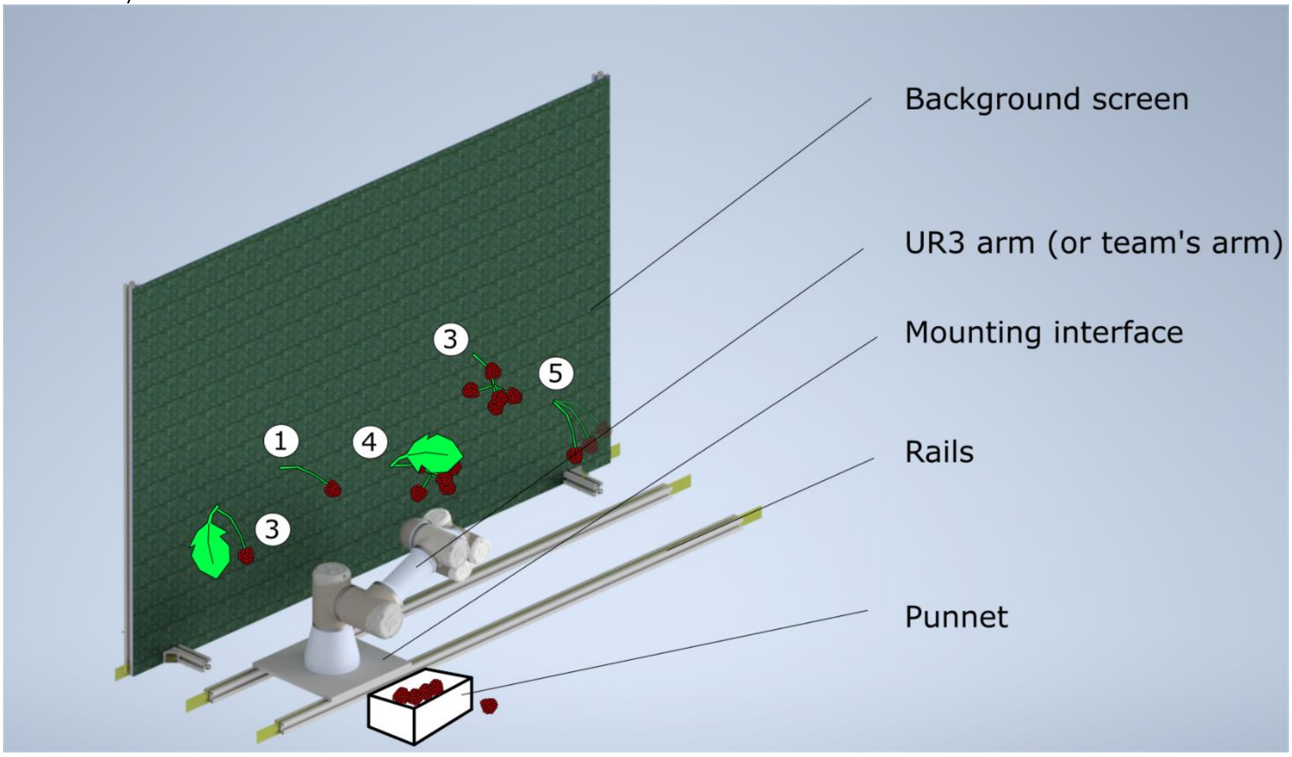


Figure 2: Harvesting scenario. Rails and background screen will be potitioned at a fixed distance, and berry randomly placed within the working space of a UR5 arm. collecting punnet can be potitioned by the teams but cannot be tocuhed once the robot starts picking. Labels 1 to 5 identify picking tasks are reported below.

Grasping of agricultural produces appears one of the most relevant domains for soft robots, that can exploit compliance, delicateness, and grasping adaptability. This scenario aims to showcase the capabilities of the robot in fruit picking tasks, specifically on raspberries harvesting. The robot is competing to collect all berries and place them in a punnet as soon as possible.

Description:

A wall, replicating the growing conditions of raspberries, is presenting fruits in different growing conditions: single, partially covered by leaves, in cluster, and subject to external disturbances (e.g. wind, nearby pickers, etc.). Berries are magnetically attached to a plastic stalk, with a selection of magnet to replicate the range of force required for harvesting. Berries are fabricated to withstand a pre-defined picking pressure, close the one exerted when manually harvested (i.e. with a two-finger pinch): if such pressure is exceeded, the berry is considered damaged.

The task proposed are the following:

Task1: The robot has to pick a single berry.
Task2: The robot has to pick berries in a cluster.
Task3: The robot has to pick a single berry partially occluded by leaves.
Task4: The robot has to pick berries in a cluster partially occluded by leaves.
Task5: The robot has to pick single berries that are moving.

Task can be proposed multiple times, i.e. more than five berries will be presented. Berries will have a distinctive red color, while the background and the leaves will be green. Actual details of the implementation will be presented soon in Appendix.

A maximum time of 10 mins is given. The team can attempt to pick any berry, in any preferred order, up to three attempts each berry. If the fruit is damaged, another fruit will be placed in the same position. During resets, the clock is not paused.

Medical screening and intervention

This task concerns minimally invasive surgery and is split into two parts to evaluate the suitability of soft robots across a spectrum of medical robotic requirements from flexible navigation to safe interactions. Teams will complete each part sequentially, though setup time will be given between each. This scenario is not run with qualifying and bracketed rounds. However, teams will be given multiple opportunities to complete the tasks and ranked by average score.

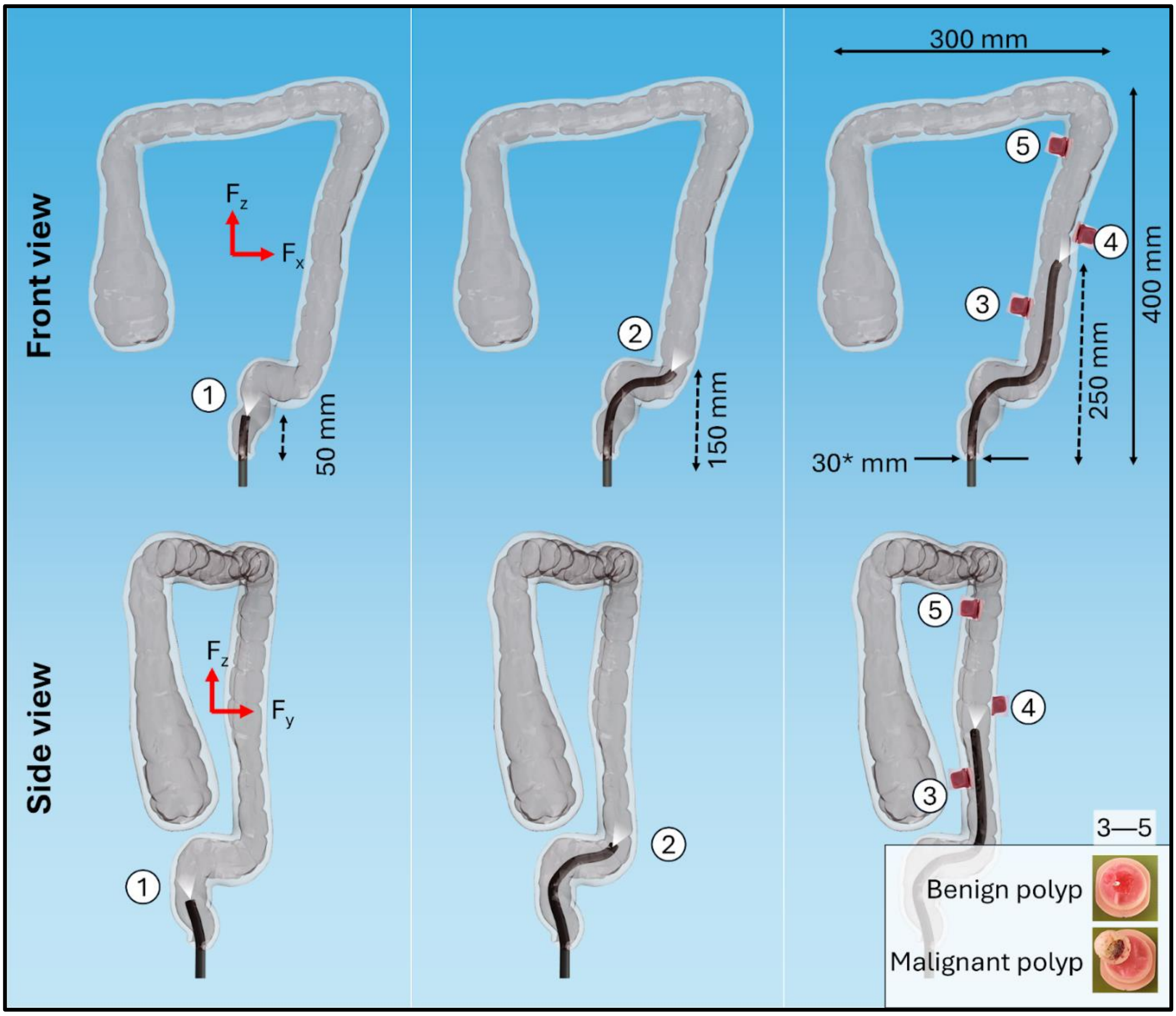


Figure 4: Colonoscopy case and landmarks.

Part 1: Diagnostic task (Colonoscopy)

Generality:

Soft robots can reduce patient discomfort and access deeper into the gastrointestinal tract than other endoscopic approaches. Colorectal cancers are one of the most prevalent cancers, and colonoscopy is a critical screening tool for detection, assessment, and finally treatment. Soft robots should be able to navigate the complex shape of the colon with ease and reduce forces applied which could cause discomfort.

Description:

The competition task takes place inside a colonoscopy phantom, fabricated from DragonSkin silicone, including polyps (growths) along the walls of the descending colon, and mounted on load cells to measure net applied forces. Robots will gain points from the depth of navigation, correct identification of polyps, and speed of completion. Points are deducted from detection of excess forces. Internal phantom views through windows and spectator cameras are restricted to teams.

The task and phantom extend from the rectum to the top of the descending colon. No restrictions are given to the size of the robot. The maximum depth of the task is ~400 mm and the elastic entry to the colon has a diameter of 30 mm.

Task1: Navigation through the rectum. The robot must enter the colon through an elastic (DragonSkin) 30 mm hole and navigate the initial turn.
Task2: Navigation through the sigmoid to the descending colon. This includes a sharp ~90° turn and turns in x- and y-axes.
Task3–5: Benign vs. malignant polyp identification. Using only information gathered by the robot (visual or otherwise), teams must classify polyps at three known locations but randomised polyps and explain why the classification is given.
Task6: The robot must fully retract from the phantom.

A soft phantom of the rectum and colon is provided, equipped with load cells to measure exerted force and cameras to stream internal views. Robots should be equipped with an endoscopic camera (one can be provided) for identification tasks and can be used to assist navigation.

The phantom is mounted on a standing desk with adjustable height. Tables or tripods can be provided for teams to mount their robots upon request and subject to robot weight. Phantom specifications and 3D files to be downloaded from the Appendix.

Polyps are added to the phantom in fixed locations (3–5) in a random selection which should be identified by teams during the procedure from visual information.

A maximum time of 10 mins is given. Teams can request up to three resets if their robot gets stuck and must reset their robot to at least the previous position (1–5). During resets, the clock is not paused and penalties are not reset.

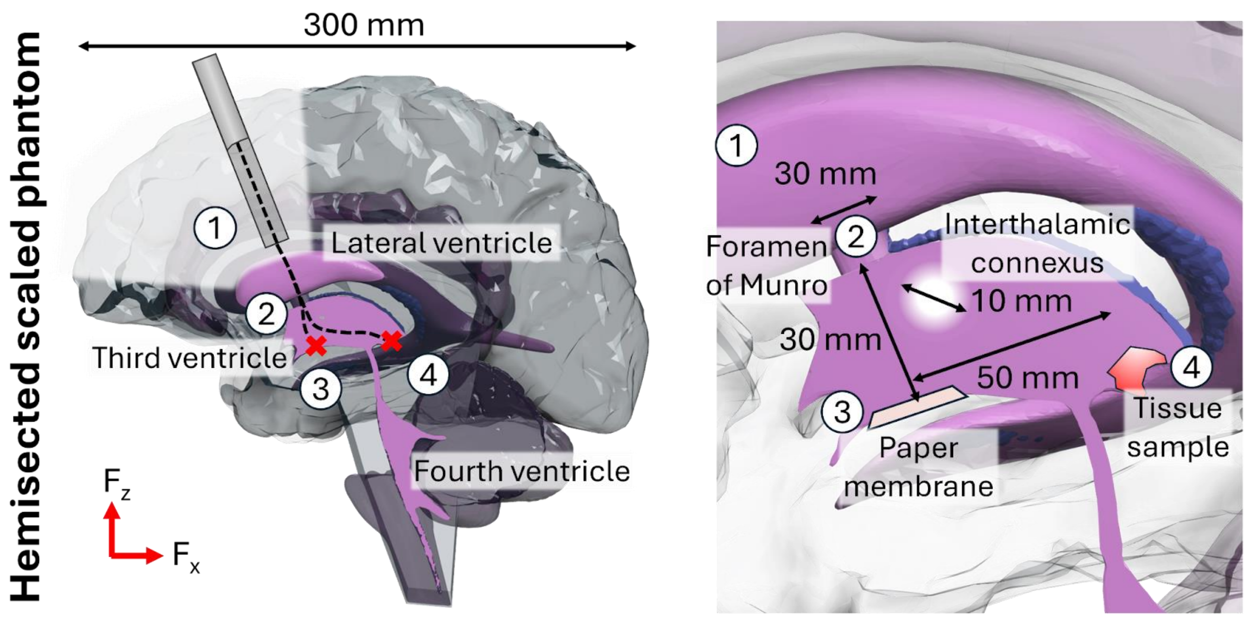


Figure 5: Neuroendoscopy case and landmarks.

Part 2: Therapeutic task (Neuroendoscopy)

Generality:
Combined endoscopic third ventriculostomy (ETV) and tumor biopsy is a common neurosurgical procedure whose risks could be lessened with the use of soft robotic endoscopes. Soft robots allow

for a single surgical entry, rather than multiple, and flexibility to avoid and reduce forces in the highly sensitive ventricular system.

Description:
The competition takes place in a x2 scale ventricular system phantom fabricated primarily from Ecoflex silicone and mounted on load cells to measure 3-axis force. The robot must navigate through a lateral ventricle and the third ventricle to perform a fenestration (cutting) at the base, and a biopsy (tissue sampling) in the pineal region. Points are gained for successful navigation, completion of interactions, and speed of operation. Points are deducted for excess forces exerted by the robot onto the phantom. Internal phantom views through windows and spectator cameras are restricted to teams.

Task 1: Navigation through the lateral ventricle. The robot can enter the brain from any frontal approach. Once the robot begins deployment through where the hemisphere would be, the approach direction can no longer be changed.
Task 2: Navigation through the foramen of Munro into the third ventricle. This includes a narrow elastic channel approximately 20-30 mm.
Task 3: Fenestration for draining cerebrospinal fluid. The robot must navigate to and pierce a paper membrane by any means. The membrane is placed directly across from the foramen of Munro with a cavity behind and mounted in a rigid frame which slots into the silicone phantom.
Task 4: Tumor biopsy in the pineal region of the third ventricle. The robot must navigate to and collect a sample of soft tissue (e.g. gelatin) using any means.
Task 5: The robot must fully retract from the phantom.

A soft phantom of the ventricular system is provided, equipped with sensors to measure exerted force and cameras to stream internal views. Robots should be equipped with an endoscopic camera (one can be provided) and an end effector for cutting and/or sampling.

The phantom is mounted on a standing desk with adjustable height. Tables or tripods can be provided for teams to mount their robots. Phantom specifications and 3D files to be downloaded from the Appendix.

Heavier penalties are given for collisions, with a lower force threshold compared to Part 1. For biopsy, teams can gather samples with any method, though needles for fine-needle aspiration (FNA) biopsy can be provided on request (details to follow).

A maximum time of 10 mins is given. Teams can request up to three resets if their robot gets stuck and must reset their robot to at least the previous position (1–4). During resets, the clock is not paused and penalties are not reset.

Scoring

Points are assigned for each completed part of the task. Additional points are awarded based on the number of attempts required to complete a part of the task. All scoring methods can be seen in the score tables (preliminary points, to be confirmed).

Terrestrial race

The scoring form for the Terrestrial Race is the following:

Task	***min***	***fair***	***good***	***I***	***II***	***III***
Straight segment (each)	1	2	4	4	2	1
Turn (90deg)	1	2	4	4	2	1
Rubble segment	2	4	8	8	4	2
Flexible walls segment	3	6	12	12	6	3
Turn (180deg)	1	2	4	4	2	1
Slope (down)	1	2	4	4	2	1
Sand pit	2	4	8	8	4	2
Slope (up)	1	2	4	4	2	1

Points are assigned based on completion of part of the task:

	min	*fair*	*good*
Task X	The frontal part of the robot enters segment 1	The rear part of the robot enters enter segment 1	The rear part of the robot exits segment 1

If the robot damages the walls in the "Flexible walls segment", no points are awarded for this task.

Manipulation

The score for the manipulation challenge is based on the number of undamaged berries collected in the punnet and the relative harvesting difficulty. Partial points will be given for incomplete tasks.

Task	***min***	***fair***	***good***	***I***	***II***	***III***
Single berry (each)	1	2	4	4	2	1
Clustered berry (each)	2	4	8	8	4	2
Occluded single berry (each)	2	4	8	8	4	2
Occluded clustered berry (each)	4	8	16	16	8	4
Moving berry (each)	3	6	12	12	6	3

Points are assigned based on the following condition criteria:

	min	*fair*	*good*
Task X	Berry detached but not released, or released far from the punnet	Berry release in proximity of the punnet (less than 5cm)	Berry collected into the punnet

If the robot damages any berry during the task, or damage the plant, no points are awarded for this task. If, while attempting a cluster, the robot damages nearby berries, those will be replaced by they will count as attempted. If the robot damages nearby berries three times, such berries cannot be attempted any more.

MEDICAL SCREENING AND INTERVENTION

Task	Feature	Points	Description
1	Recto-sigmoid navigation	10	The head of the robot reaches landmark (1) ~50 mm depth
			No partial points
2	Descending colon navigation	10	The head of the robot reaches landmark (2) ~150 mm depth
			No partial points
3–5	Polyp identification	20 x 3	Correct classifications of polyp given by teams
		(5)	Partial points for navigation to each of the landmarks but incorrect or no classification given
6	Retraction	20	The entire robot leaves the phantom from position (5)
		(10)	Partial points for retraction from sigmoid (2)
Bonus	Speed	x2	A score multiplier is applied to positive points scaled by the duration of the task (x1 for 5 mins and slower, increasing linearly up to x2 for 2 mins and faster)
Penalty	Collisions	-1	Lastly, a point is deducted for each 5 second window where the net force applied by the robot onto the phantom exceeds 1 N at least once.

Part 2	Feature	Points	Description
1	Lateral ventricle	10	The head of the robot reaches through the hemisphere to the lateral ventricle
			No partial points
2	Foramen of Monro	10	The head of the robot reaches through the foramen of Munro to the third ventricle
			No partial points
3	Fenestration	30	Navigate to and the pierce paper membrane by any means. The cut or hole should measure at least 5 mm
		(10)	Partial points if membrane is touched but not pierced or pierced with a hole smaller than 5 mm

4	Biopsy	30	A tissue sample is taken and retrieved
		(10)	Partial points if tissue is reached but sample collection is unsuccessful (not picked or dropped)
5	Retraction	20	The entire robot leaves the phantom from position (4)
		(10)	Partial points for retraction from position (3)
Bonus	Speed	x2	A score multiplier is applied to positive points scaled by the duration of the task (x1 for 5 mins and slower, increasing linearly up to x2 for 2 mins and faster)
Penalty	Collision	-1	Lastly, a point is deducted for each 5 second window where the net force applied by the robot onto the phantom exceeds 0.5 N at least once.

APPENDIX

IMPLEMENTATION DETAILS

This Appendix reports details of the implementations, including CAD files, link to purchase commercial items we are planning to use, and other implementation details. Teams are invited to reproduce the scenarios to test their solutions in lab.

However, Teams should keep in mind that modifications might happen due to unpredictable logistic constraints. We are trying to minimize the diversions from the implementation reported and no major changes are expected.

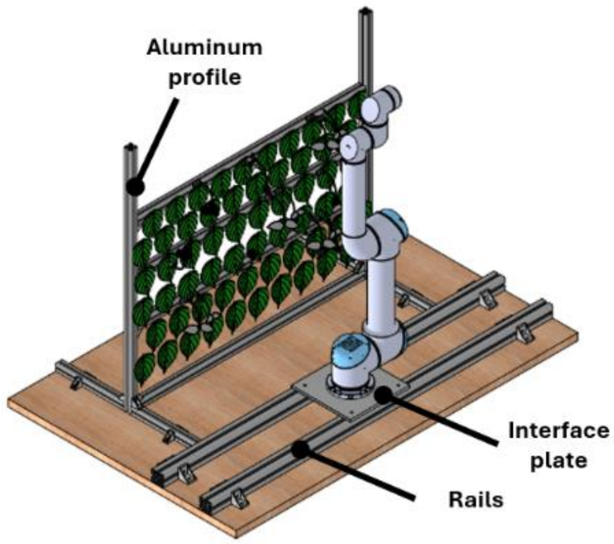
LOCOMOTION

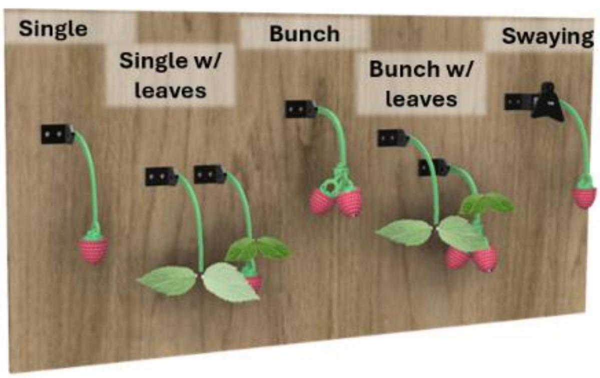
Associated implementation files can be downloaded here: Locomotion implementation. This folder contains CAD files in .igs format, .step or others can be provided on request. The "BoM_locomotion.xlsx" contains materials and links for setup reproduction.

The setup is primarily constructed from 5.5 cm tubing and rigid 3D printed mounts and connectors. Other 3D printed parts include solid obstacles and molds for flexible walls. In case of issues, sections of the tubes will be disconnected, and the robot retrieved. Subsequent Tubes are not expected to be glued or connected, but they will keep in place with the clamps: therefore, gaps and irregularities are expected in the joining points.

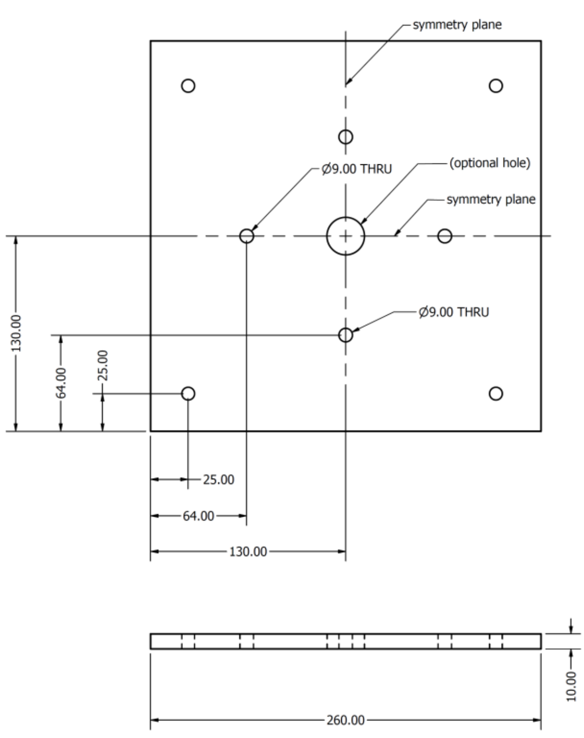
MANIPULATION

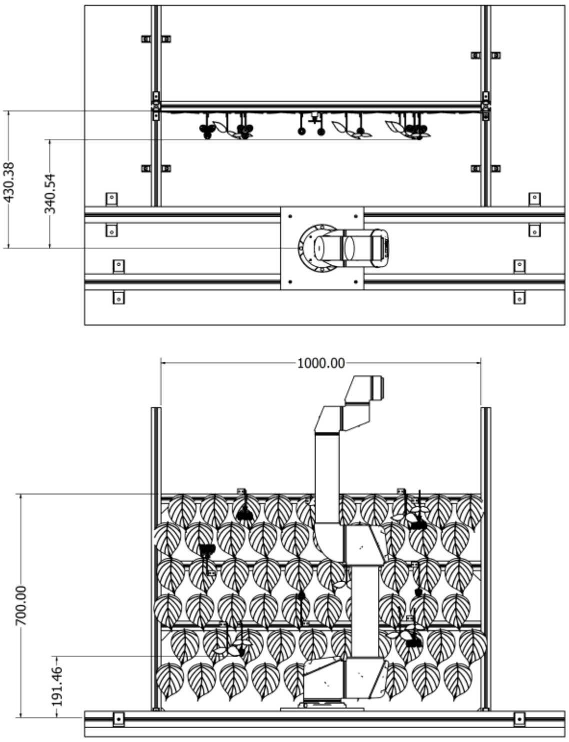
Associated implementation files can be downloaded here: Manipulation implementation. This folder contains CAD files in .igs format, .step or others can be provided on request. The "BoM_manipulation.xlsx" contains materials and links for setup reproduction.





Participants are free to bring their own arm to perform manipulations and should either bring suitable mounting plates to interface with the provided rails or contact us about additional mounting options (see mechanical drawing below, measurements in millimeters). For participants bringing just a gripper, a UR5 is provided.



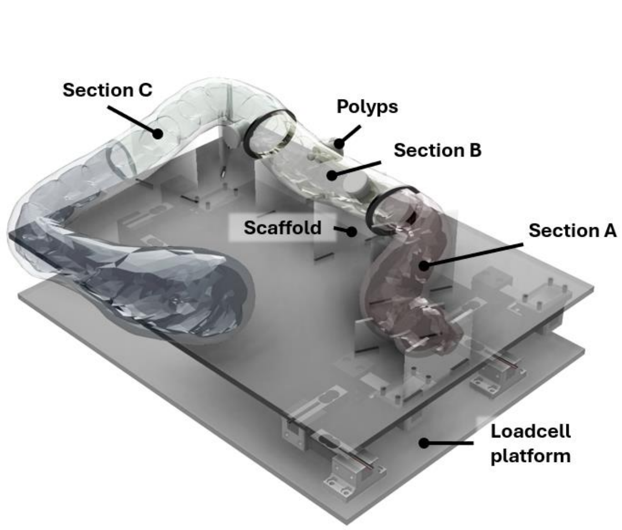


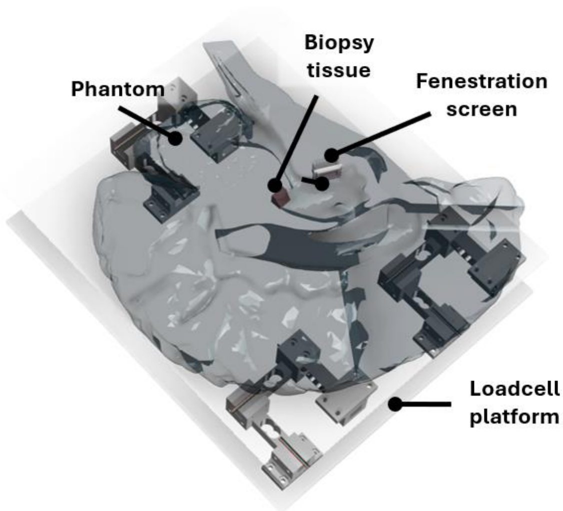
The setup is primarily constructed from selected aluminum profiles. Raspberries are cast in a breakable hydrogel, the particular formula to be released shortly. Example TPU stems are presented in the implementation files, however, these are subject to random variations approximately 50—150 cm from the wall, 0—100 mm vertical height, and any angle within the hemisphere of stems pointing towards the back wall.

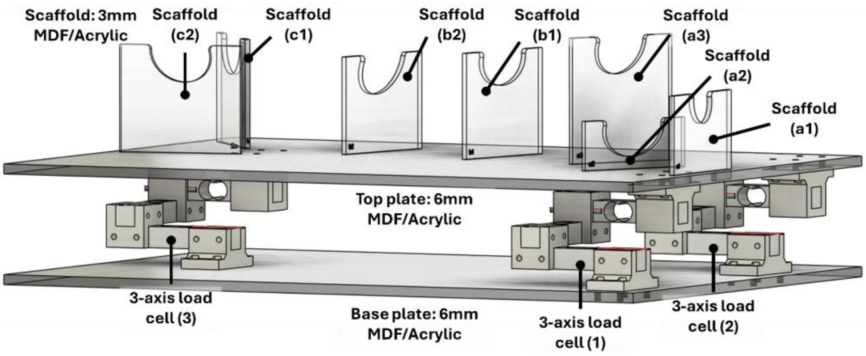
Medical Intervention

Associated implementation files can be downloaded here: MIS_implementation. This folder contains CAD files in .igs format, .step or others can be provided on request. The “BoM_MIS.xlsx” contains materials and links for setup reproduction.

The setup for each subtask contains a platform for 3D load measurements up to 3 kg and sensitive to forces of 100 mN. Serial data collection and processing will be released closer to the competition date.







For the colonoscopy case. The phantom is cast in DragonSkin-20 in three sections, base molds can be provided on request but subject to future changes for access and view ports. The phantom is self-supporting between scaffolding which can be laser cut. Exact models of the polyps and variations will only be released during the competition.

For the neuroendoscopy case. The phantom is cast from a 10:1 mix of Ecoflex and slacker to reduce shore hardness towards 00-05. Base molds can be provided for the internal section (third ventricle). The third ventricle will be partially enclosed and viewpoint restricted. The fenestration subtask will use a thin grade paper in a replaceable frame and the biopsy subtask will have swappable hydrogel tissue samples.

Frequently Asked Questions:

Generic:

1. **how "soft" is defined for this competition**

As mentioned in Skills to be shown in the video / evaluation criteria, :

the soft/compliant parts have to:

- Clearly enable the function of the robot; OR
- Clearly improve the capabilities of the robot

However, it is important to mention that we want to be as inclusive as possible, and we do not want to restrict creativity of the participants. If the solution is normally accepted as soft in the state of the art, we will not restrict participation.

2. **What control methods are permitted in the competition? For instance, is VR-based teleoperation an acceptable approach?**

Autonomy is not mandatory in this edition of the competition, so we are expecting to see teleoperation in most of the robots.

3. **Do teams must use the same robot for completing the three challenges?**

You are <u>not requested</u> to use the same robot for the three different scenarios, but you might if you want. In case the same robot participates in more than one scenarios, please fill separate online forms for each scenario, to allow a proper allocation of robots.

Manipulation:

4. **Is it necessary for our robotic system to include a mechanism for cutting the stems of berries during the harvesting process?**

The stem is not required to be cut. We are attaching the raspberries with magnets. we are taking as a reference for the construction of the berry:

Junge, K., & Hughes, J. (2022, April). Soft sensorized physical twin for harvesting raspberries. In 2022 IEEE 5th International Conference on Soft Robotics (RoboSoft) (pp. 601-606). IEEE.

LOCOMOTION:

5. **Are untethered or autonomous getting bonus points?**

No. As a result of a quick survey with the community, most researchers are still focusing on fundamental skills. However, showcasing autonomy should speed the completion of the task, and tether can impair locomotion, so these features will give a direct advantage to the team.

MEDICAL INTERVENTION:

6. **How the colon and brain phantom will be built and instrumented, and their "exact" geometry (CAD files ?)**

Material and CAD are available to download, but implementation details might be subject to change due to unforeseeable logistic issues. No major changes are expected.

Rationale for the 2025 edition

This section outlines the rationale for the 2025 edition of the competition, co-designed by taking into consideration the input of the Soft Robotics and Generalist Robotics Communities, collected via questionnaire.

Poll results

The questionnaire has been released on the 2nd of August, and the responses have been collected over the subsequent weeks.

The questionnaire asked:

1. Did you participate in previous editions of the competition?
2. What is your academic/research position?
3. Which domains would you like to see in the competition?
4. Would you be interested in participating in any of the listed domains?
5. Would you prefer to see a competition focused on a specific task (for example: picking a fruit, packing objects, moving in a specific setting, etc.) or a more generic one where the robots have to show capabilities on different domains (for example: moving delicate objects, turning valves, performing in-hand manipulation, sensing the environment, etc.)?
6. Would you like to see more autonomous behaviour on the robots?
7. Would you prefer a goal-based scoring system (i.e. points assigned for the achievement of some objectives), or a peer-evaluated competition (i.e. a panel evaluation on the robot)?
8. What are your priorities when deciding whether to participate in this competition?
9. Would you like to suggest a complete refresh with respect to previous editions (for example: having a simulation competition, a control-based contest, a fabrication one, or something else)?
10. Do you have any other comments?
11. Do you want to be notified when the rulebook will be released?

Twenty two responses have been collected from the Soft Robotics community (previous participants, organizers, or members of the soft robotics mailing list); 11 responses from other mailing lists related to robotics in general. The salient answers are reported in the following figures:

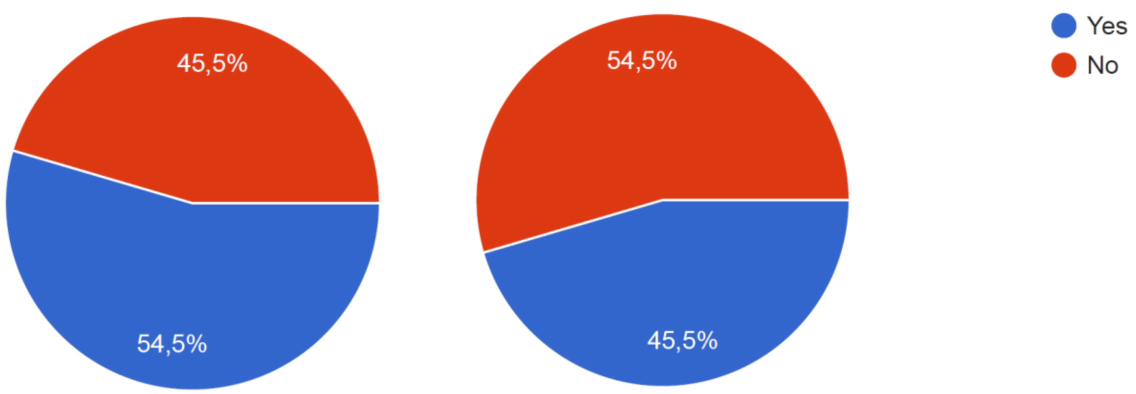


Figure 2: Question 1. Responses of the soft robotics community (left). Responses that include also other robotics communities (right).

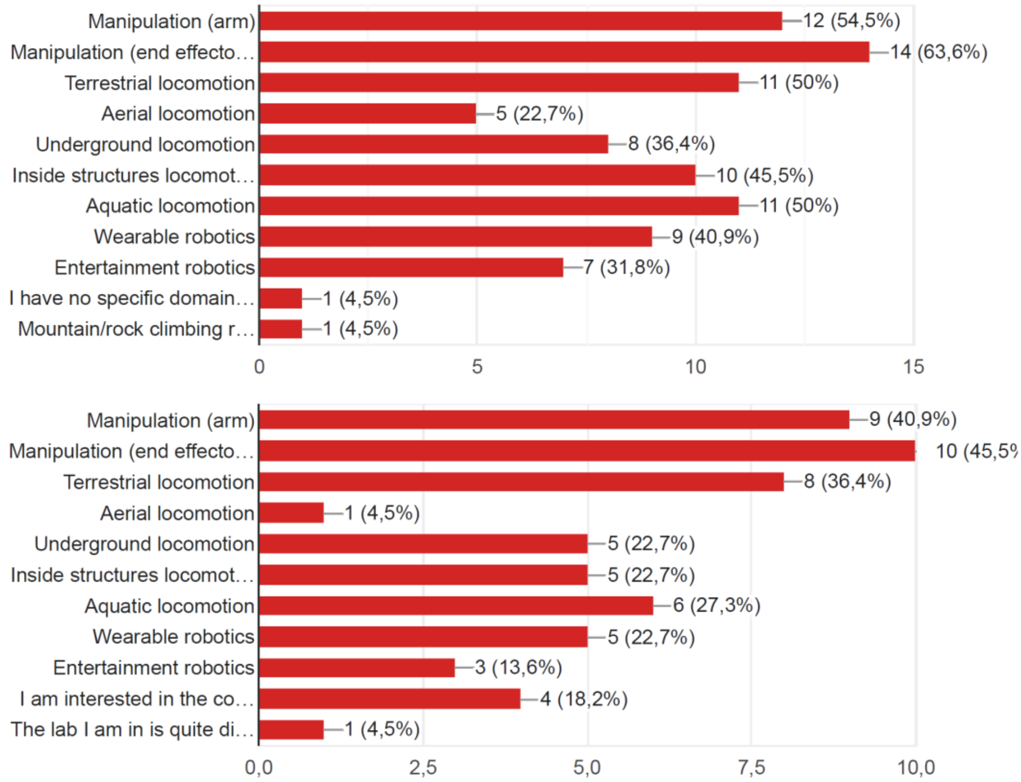


FIGURE 3 QUESTIONS 5 (TOP), QUESTON 6 (BOTTOM). RESPONSES OF THE SOFT ROBOTICS COMMUNITY

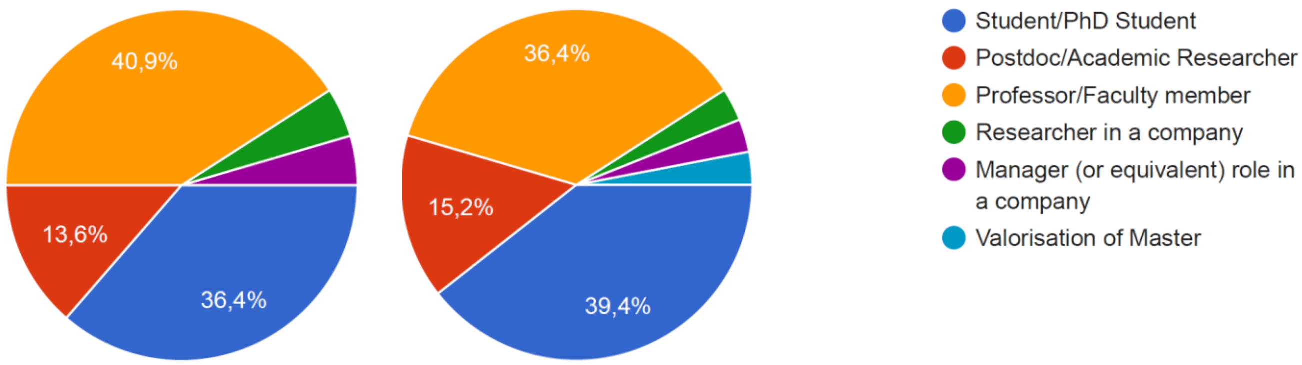


FIGURE 4 QUESTION 2. RESPONSES OF THE SOFT ROBOTICS COMMUNITY (LEFT). RESPONSES THAT INCLUDE ALSO OTHER ROBOTICS COMMUNITIES (RIGHT).

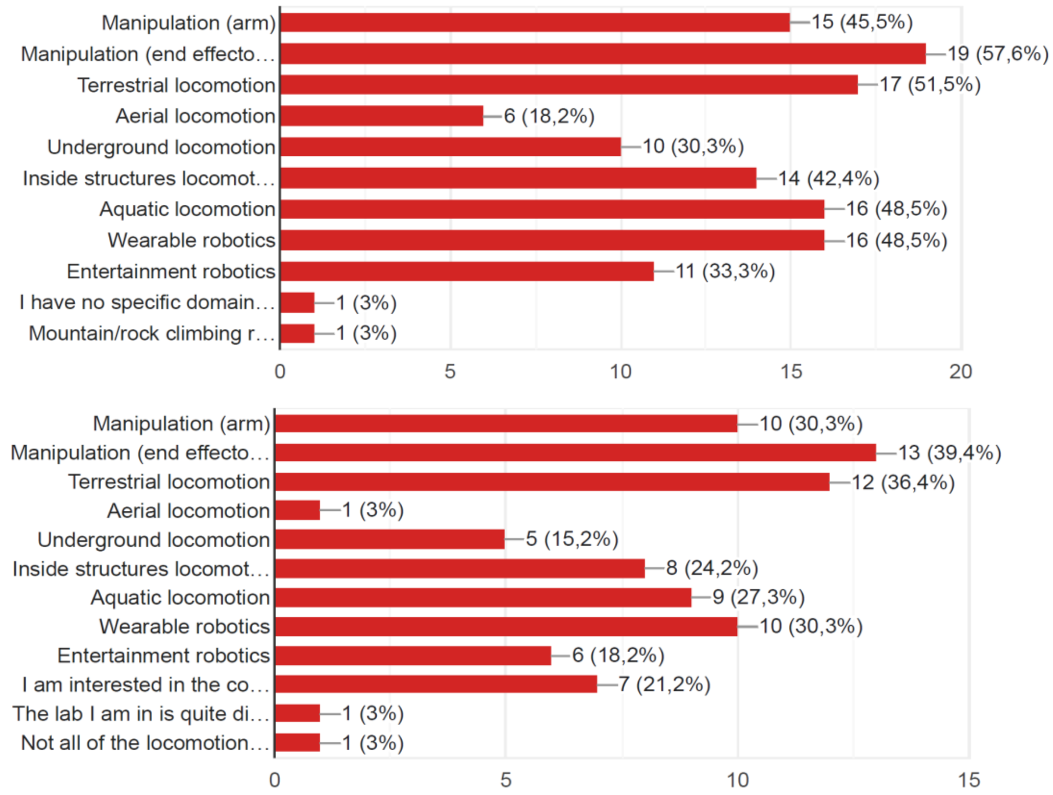


FIGURE 5 QUESTIONS 5 (TOP), QUESTON 6 (BOTTOM). RESPONSES OF THE ENTIRE ROBOTICS COMMUNITY

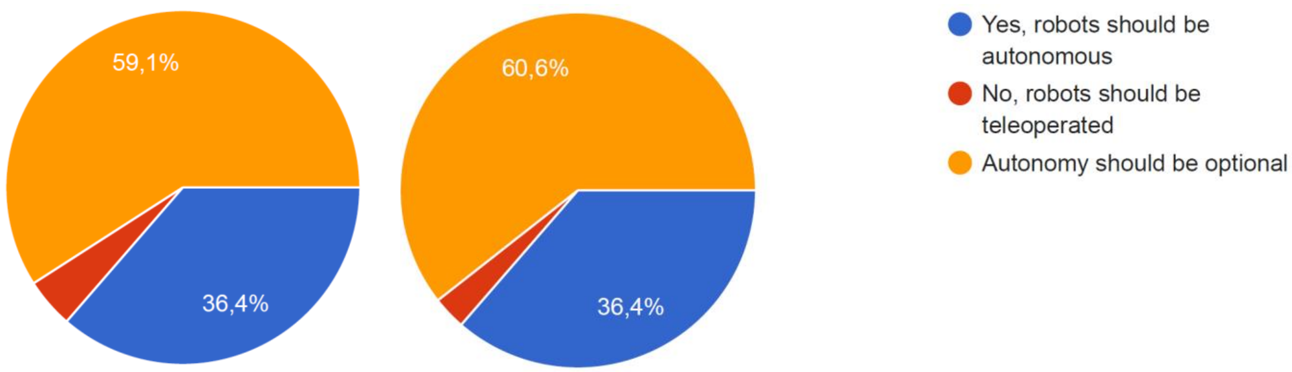


FIGURE 6: QUESTION 8. RESPONSES OF THE SOFT ROBOTICS COMMUNITY (LEFT). RESPONSES THAT INCLUDE ALSO OTHER ROBOTICS COMMUNITIES (RIGHT).

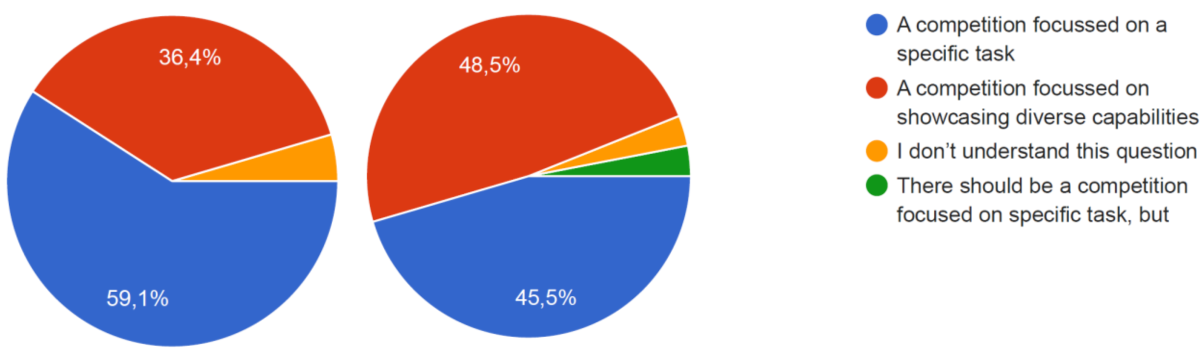


FIGURE 7: QUESTION 7. RESPONSES OF THE SOFT ROBOTICS COMMUNITY (LEFT). RESPONSES THAT INCLUDE ALSO OTHER ROBOTICS COMMUNITIES (RIGHT).

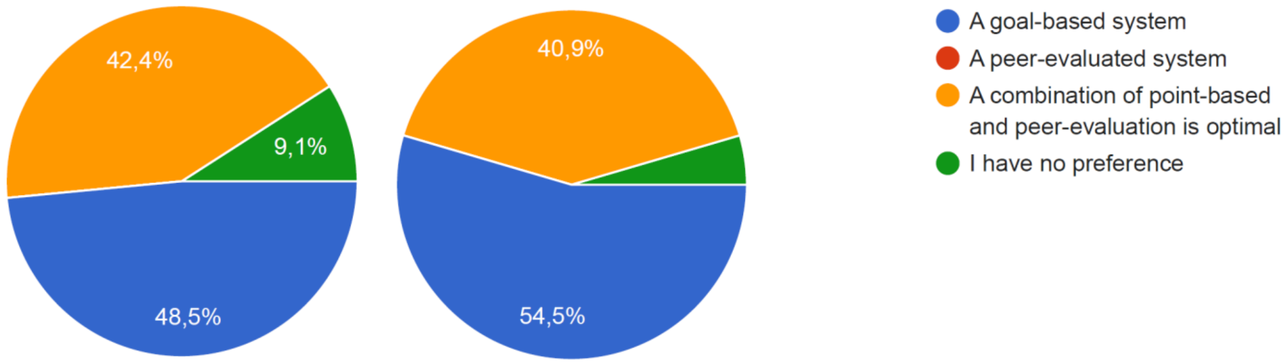


FIGURE 8: QUESTION 2. RESPONSES OF THE SOFT ROBOTICS COMMUNITY (LEFT). RESPONSES THAT INCLUDE ALSO OTHER ROBOTICS COMMUNITIES (RIGHT).

Some discrepancies exist between the answers of the SR community and the answers who also include the comments of other robotics communities. In our approach, whenever the whole robotics community did not demonstrate a strong preference, we adopted the preference expressed by the SR community. This the case for Question 7 (Figure 7), being the percentages – by chance – exactly the same (excluding the respondent who did not understand the question).

By taking into considerations the answers reported, and with the intention to maximize the participation, the following three domains have been selected: manipulation (arm), manipulation (gripper), locomotion (terrestrial); we decided to keep autonomy as an option for the team; adopt a goal-based system; and eventually select specific applications for the three domains.

APPLICATION SELECTION

With the objective of select an application which is relevant, timely, and participated by the community, quick literature surveys have been conducted on the three mentioned domains. The methods and the results of the literature review for the gripper competition is reported hereafter (similar approaches have bene followed for the arm, and the locomotion competition).

The query in Table 1, first row, has been used to select papers from Scopus Database within the 2017 and the 2024. Years have been selected to exclude the first edition of the RoboSoft Competition (The RoboSoft Grand Challenge) for which extensive literature reviews have been conducted in the 2016. This is to highlight if trends changed in the last seven years (approximately).

As exclusion criteria, we removed papers where the applications have not been specifically reported, review papers, papers where no hardware have been developed, that focus on specific components, that were incorrectly pooled as soft robotics paper, repetition of the same solution, or related to micro-manipulation.

TABLE 1: SURVEY QUERY FOR THE GRIPPER DOMAIN

Query	TITLE-ABS-KEY ((soft OR compliant) AND (gripper* OR end AND effector*) AND application) AND PUBYEAR > 2016 AND PUBYEAR < 2025	412
Exclusion Criteria (title)	• No specific application presented (i.e. only functional tests) • Reviews • No physical hardware • Focus on Components • Not soft devices	93
Exclusion Criteria (abstract)	• As above • Micro-manipulation (cell levels to millimiter) • Same authors	64
	Final papers analysed	64

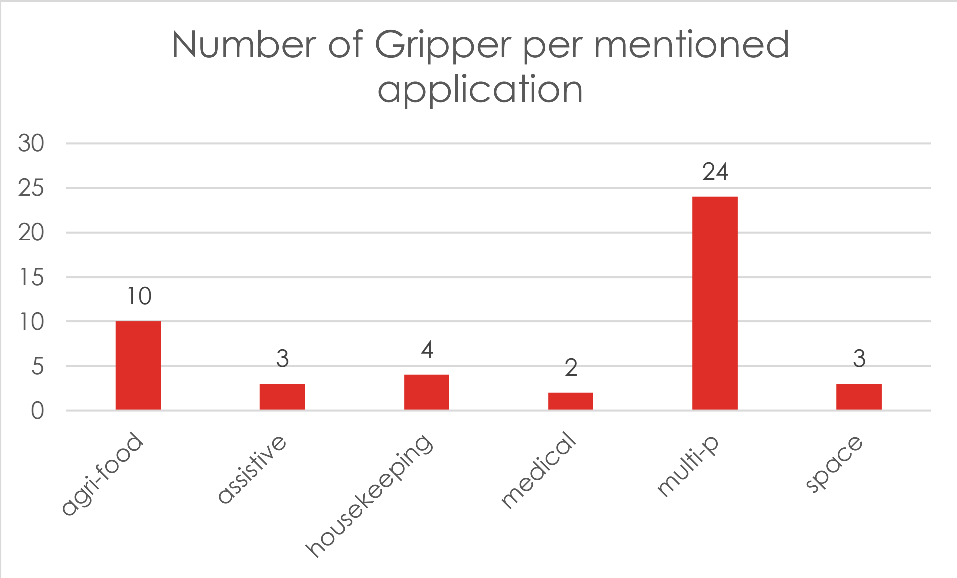


FIGURE 9: POPULAR APPLICATIONS FOUND FROM THE LITERATURE SURVEY

From this screening, 64 papers have been analyzed in detail. From these papers, 18 papers have been removed for missing any type of application in the main body, or due to quality issues[3].

As reported in Figure 10, most of the papers (24) focused on more than one application, being consistent with the capabilities and narrative of soft robotics grippers. Ten papers specifically addressed agri-food tasks, from picking fruit into farms, to manipulating food elements into factories. Other applications follow, with similar number.

Therefore, we decide to select a task in the agri-food domain, and we decided to propose a fruit picking tasks with multiple difficulties, with the hope to showcase multiple capabilities of participating grippers and reflect the current trend of the community.

Please note that, in the case of the terrestrial locomotion, there was a conflict between the desire to have a specific task, and the generality of the "terrestrial locomotion". By investigating the literature of "soft robots locomotion" as a whole, the in-pipe locomotion resulted the most investigated application.

TABLE 2: SURVEY QUERY FOR THE ARM DOMAIN

Query1	TITLE-ABS-KEY ((soft OR compliant) AND (manipulator OR arm OR continuum AND robot) AND application) AND PUBYEAR > 2016 AND PUBYEAR < 2025	1422
Exclusion Criteria (title)	• No arm • Control/modelling/sensing only • Reviews • No physical hardware • Not soft devices	232
Exclusion Criteria (abstract)	• As above • No clear application • Same authors	119

[3] We acknowledge that such papers have been peer reviewed and published, but here we exercise our personal evaluation of the work.

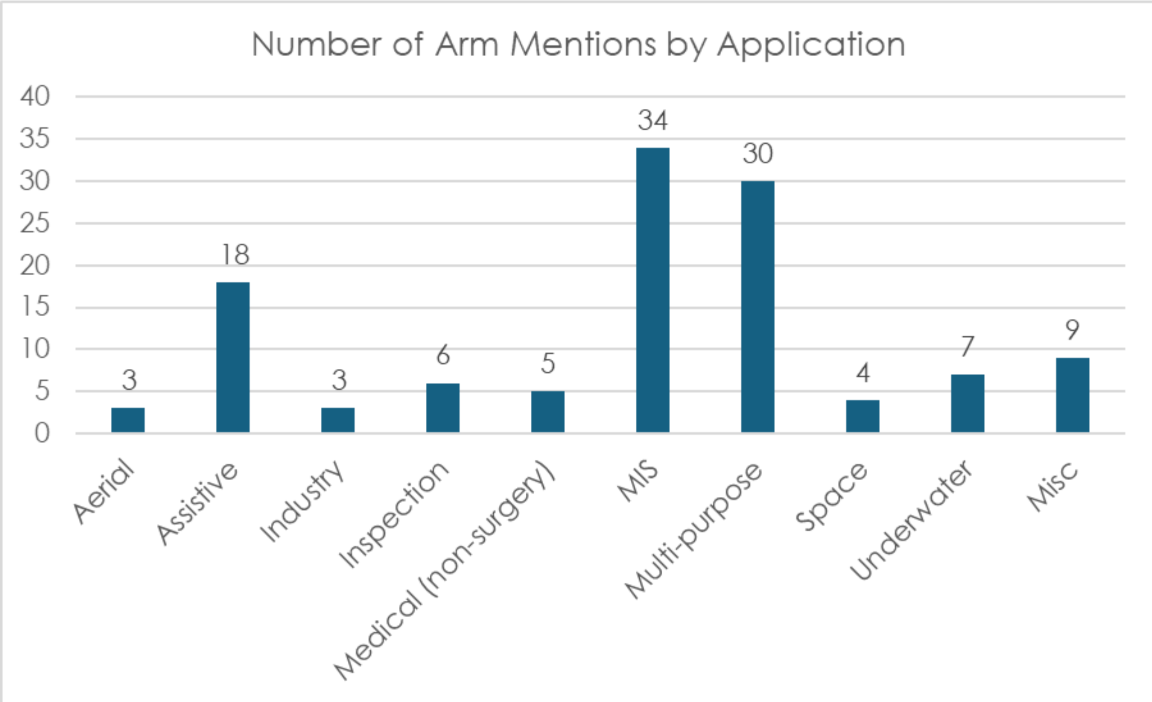


FIGURE 11: POPULAR APPLICATIONS FOUND FROM THE LITERATURE SURVEY

As reported in Figure 11, minimally invasive surgery was the clear plurality, followed by systems with suggested applications in more than one domain, then the category of assistive robot arms. Within minimally invasive surgery applications, a diverse range of operations, scales and specifications are present, so we decided to propose a competition testing more than one potential surgical application to emphasise the adaptive and multi-purpose capabilities promised by soft robotic arm technologies and evaluate their safety.