FIELD ROBOT EVENT 2025 GUIDELINES

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1 Remarks

- **Important and real-time information will be given on Discord. Click here to join the server.**
- On the Discord server, we will discuss task rule adjustments in February. Registration is going to open on the 3rd of March and will be available until the 25th of April. The registration fee per participant (for each team member) will be announced at the official opening of registration. Further details will be provided at that time.
- There are no plans to offer virtual participation or a competition in a virtual environment.
- The organizing team aims to describe the tasks as clearly as possible, but teams should be aware that the rules may need to be modified before or even during the contest to clarify and resolve ambiguities. Any changes will be decided by the jury and communicated to all teams.
- Results are attributed to a team, not an individual field robot. Teams may use multiple robots for different tasks, but only one robot may perform each task.
- If a robot fails to start within one minute after the start signal, it is allowed a second start after the last robot has finished the task. A third attempt is not permitted.
- Performance is assessed by an independent jury committee based on measured or counted parameters, as well as creativity and originality (in the Freestyle task).
- Prizes will be awarded for the top three ranks in each task, and an overall competition winner will be determined based on cumulative results.
- Participating teams earn at least one point, while non-participating teams earn zero points. In the event of a tie in the overall ranking, the team with better placements across all tasks will be ranked higher.

1.1 General Rules

- The use of GNSS receivers is prohibited for all tasks except the Freestyle task. For the other tasks, the focus must be on relative positioning and sensor-based behaviors.
- **Crop plants:** The crop plants for the tasks are maize (*Zea mays*). The plants will have a height of approximately 20–40 cm, depending on the location-specific growing conditions.
- **Damaged plants:** A maize plant is considered damaged if it is permanently bent, broken, or uprooted. The jury or assistants will decide whether a plant has been damaged by a robot.
- **Parc fermé:**
  - All robots must wait in the *parc fermé* during the contests. No performance modifications are allowed during task runs.
  - All PC connections (wired or wireless) must be disconnected or switched off, and a battery-saving mode is recommended to avoid any advantage.
  - The starting order will be random, and the next robot will be asked to prepare for starting while the current robot is moved to the starting point.

- **Navigation:** Robots must drive between the crop rows and not above them for Tasks 1 and 2. Damaged plants will be replaced with spares to ensure consistent conditions for all robots.

1.2 General Requirements for All Robots

1. **Autonomous mode:** Robots must act autonomously in all tasks except the Freestyle. Remote control is not allowed, except for manual corrections using the START/STOP controller.
2. **Start conditions:**
   - Robots must start from the predefined starting point marked with a white line. No part of the robot may exceed this line before the start.
   - Robots must start within one minute of the start signal. A second chance is allowed after basic repair and placement back into the *parc fermé*.
3. **Remote controller:**
   - All robots must have a wireless START/STOP controller with clearly marked buttons (or colors) for START and STOP.
   - The controller must be presented to the jury before each run.
4. **Manual corrections:** Up to two team members may manually correct the robot after pressing the STOP button and ensuring it is completely stopped.
   - No team member is allowed in the field while the robot moves.
   - Once the robot is stopped, the team member can enter the field from the starting position and reposition the robot.
   - The robot can resume operations when the team members have exited the field.
   - While manual repositioning of the robot is carried out the round time is not stopped.
   - The robot may be rotated but not moved, except to return to the path if a wheel or track has collided with a crop.
   - If the robot fails to perform an end-of-row turn, it must be repositioned at the end of the raw it successfully navigated to try again the whole turning process.

2 Tasks

2.1 Task 1: Autonomous Field Navigation

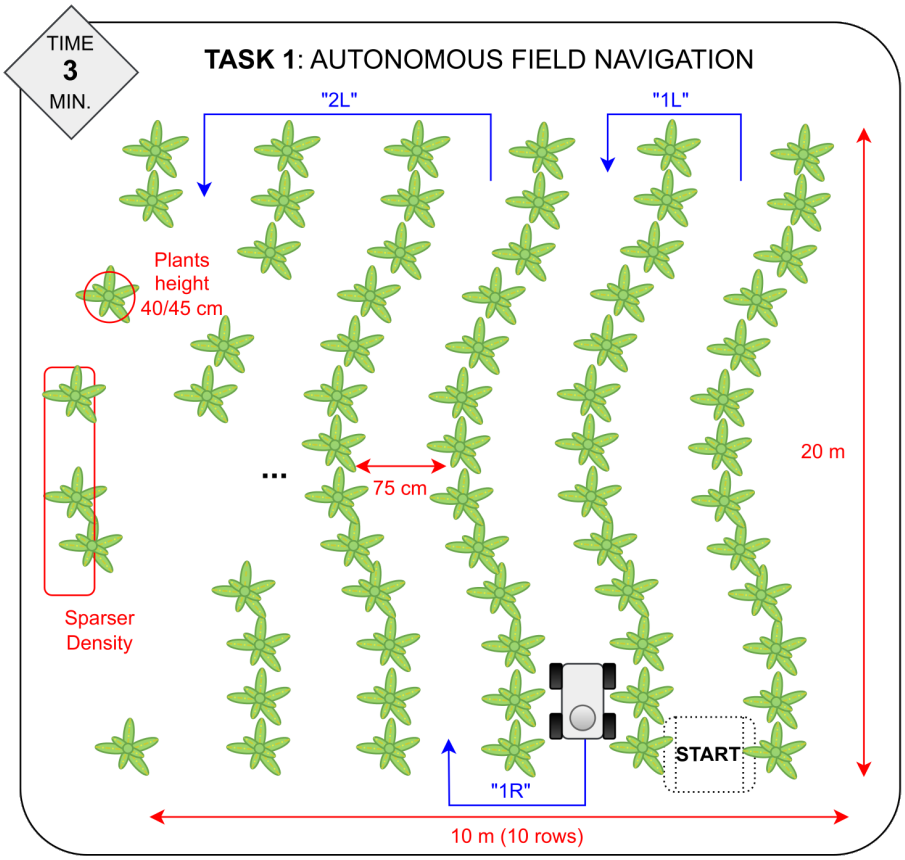

Figure 1: Navigation in a maize field. Robots start at the initial location START and follow adjacent rows as specified in the task rules.

Task 1: Autonomous Field Navigation

General Description

In this task, robots navigate autonomously through a maize field (see Fig. 1) starting at the location START. The field consists of parallel rows spaced 0.75 m apart. Some of the plants in the rows may be missing, but not at the beginning or end of any row. The maize plants are expected to have a height of approximately 0.3 - 0.4 m.

Rules for the Robots

Each robot has to start within 1 minute after the signal for the start. The maximum time is 3 minutes for every field robot beginning with the individual start. The robot must follow a sequence of commands provided in a text file. Each command consists of a number and a direction:

- **1R**: Turn right and move to the next adjacent row.
- **1L**: Turn left and move to the next adjacent row.
- **2R**: Skip one row and enter the second row to the right.
- **2L**: Skip one row and enter the second row to the left.
- **3R**: Skip two rows and enter the third row to the right.
- **3L**: Skip two rows and enter the third row to the left.
- **And so on...**: The pattern continues for any positive integer n, where nR means skip $(n-1)$ rows and enter the n-th row to the right, and nL means skip $(n-1)$ rows and enter the n-th row to the left.

Example Command Sequence
For the command sequence `1L, 1R, 2L, 3R`, the robot will:

1. Turn left and move to the next adjacent row.
2. Turn right and move to the next adjacent row.
3. Skip one row and enter the second row to the left.
4. Skip two rows and enter the third row to the right.

Scoring
The scoring P includes the travelled distance, the number of damaged plants causing a penalty, and a time-dependent, linearly increasing bonus distance if the field robot finishes before the 3-minute time slot has ended:

$$P_{\text{Task1}} = P_{\text{Distance}} - P_{\text{Penalty}} + P_{\text{Bonus}}(t)$$

The penalty is $P_{\text{Penalty}} = 5\,\text{m}$ per plant, and the bonus distance is $P_{\text{Bonus}}(t) = 0.8\,\text{m} \times t$, with t being the time in seconds the robot finishes faster than the 3-minute limit.

2.2 Task 2: Autonomous Field Navigation with Straberry Bushes Detection

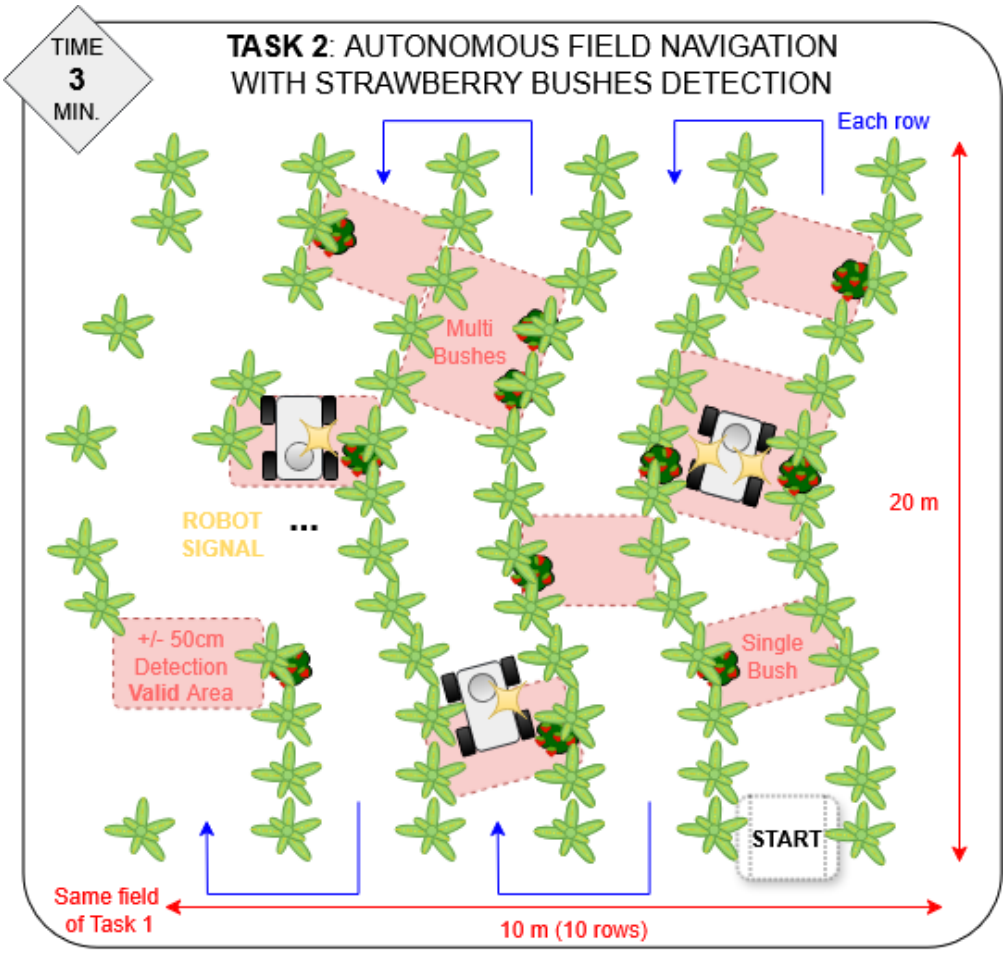

Figure 2: Navigation and weed detection in a maize field. The robot must traverse every row and detect strawberry bushes (weeds) positioned arbitrarily to the left or right within a valid detection area.

Task 2: Autonomous Field Navigation with Straberry Bushes Detection

General Description This task builds upon Task 1. Robots must navigate autonomously through the maize field (see Fig. 2), traversing every row without skipping. The primary objective is to detect strawberry bushes (considered weeds), which may be positioned arbitrarily to the left or right of the robot. Detection is valid only within a range of $-50\,\text{cm}$ to $+50\,\text{cm}$ relative to each strawberry bush. If the valid detection areas of multiple bushes overlap, they are additive and merged into a union area.

Rules for the Robots

- Robots must navigate each row consecutively without skipping.
- Robots must detect strawberry bushes positioned to the left or right within the specified valid detection area.

- Teams must specify to the judges how the robot signals detected strawberry bushes (e.g., as weeds), using methods such as lights, voice, or other clear means.

Scoring
The scoring P in this task is based entirely on weed detection:

- $P_{\text{Valid}} = 2$ points per strawberry bush correctly detected within the valid area.
- $P_{\text{Invalid}} = -3$ points per strawberry bush incorrectly detected outside the valid area.
- $P_{\text{Misdetection}} = -1$ point per strawberry bush missed inside the valid area.

The total score is computed as:

$$P_{\text{Task2}} = P_{\text{Valid}} + P_{\text{Invalid}} + P_{\text{Misdetection}}$$

This scoring system rewards precise detection within the valid area and penalizes incorrect or missed detections. Distance traveled is not considered to avoid giving an advantage to the winners of Task 1.

2.3 Task 3: Fruit Counting

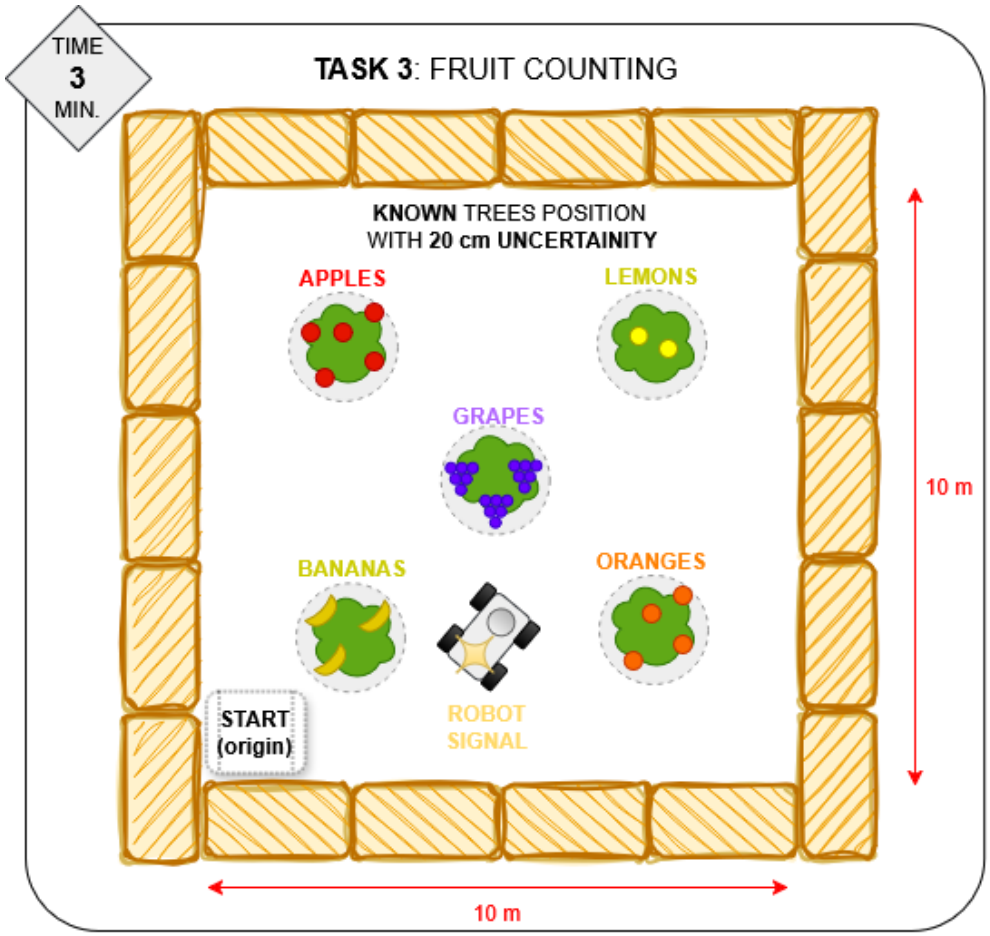

Figure 3: Fruit Couting: The robot navigates an 10×10 meter field delimited by hay bales, mapping the locations of fruit trees.

Task 3: Fruit Counting

General Description

In this task, the robot operates within a field of dimensions 10×10 meters, delimited by hay bales (see Fig. 3). The field contains five fruit trees, each representing a different fruit: apples, lemons, bananas, grapes, and oranges. These globular artificial trees are positioned at known locations, but with an uncertainty of 20 cm. Thus, the positions are provided but should not be assumed to be exact.

The robot starts in the bottom-left corner of the field at the origin $(0, 0)$ and is free to navigate within the field while avoiding the trees. The objective is to produce a map identifying the type and location of each tree.

During the task, the robot can move freely, using pre-determined strategies or by improvising. For each fruit detected, the robot must signal it to the judges in real time using a signal such as voice, light, or any other paradigm, as part of the evaluation. At the end of the task, the

robot must generate a CSV file containing its mapping results in the following format:

`fruit_type, x_coordinate, y_coordinate`.

The origin $(0, 0)$ corresponds to the bottom-left corner of the field. For each entry, a visual proof of identification must be provided as confirmation to the judges (i.e., an image of the detected fruit).
The task duration is limited to 3 minutes, and the robot must complete its mapping within this time.

Rules for the Robots

- Robots must navigate autonomously within the 10×10 meter field, avoiding collisions with trees.
- The robot must generate a CSV file at the end of the mapping task, for each fruit mapped, with the format:

  `fruit_type, x_coordinate, y_coordinate`.

- The task must be completed within 3 minutes.

Scoring
The scoring P is based on the accuracy of the mapping, comparing the robot's output to ground truth data:

$$P_{\text{Task3}} = P_{\text{Correct}} + P_{\text{Missed}} + P_{\text{False Positive}} + P_{\text{Collision}},$$

where:

- $P_{\text{Correct}} = 5$ points per correctly identified fruit at run-time(to be confirmed with proofs).
- $P_{\text{Missed}} = -1$ points per fruit not identified.
- $P_{\text{False Positive}} = -2$ points per incorrectly mapped fruit that does not exist.
- $P_{\text{Collision}} = -3$ points per tree collision.

Output Assessment

- The submitted CSV file is compared to the ground truth data.
- Each row of the CSV is validated for:
  - Correct fruit type.
  - Position error within 1 m (this check is not intended as a strict requirement but rather as a soft verification of the robot's real-time performance relative to the environment).

This scoring system rewards precise and complete mapping performance while penalizing missed or incorrect detections.

Additionally as show in 4, the fruit height can be at maximum 130cm from ground level.

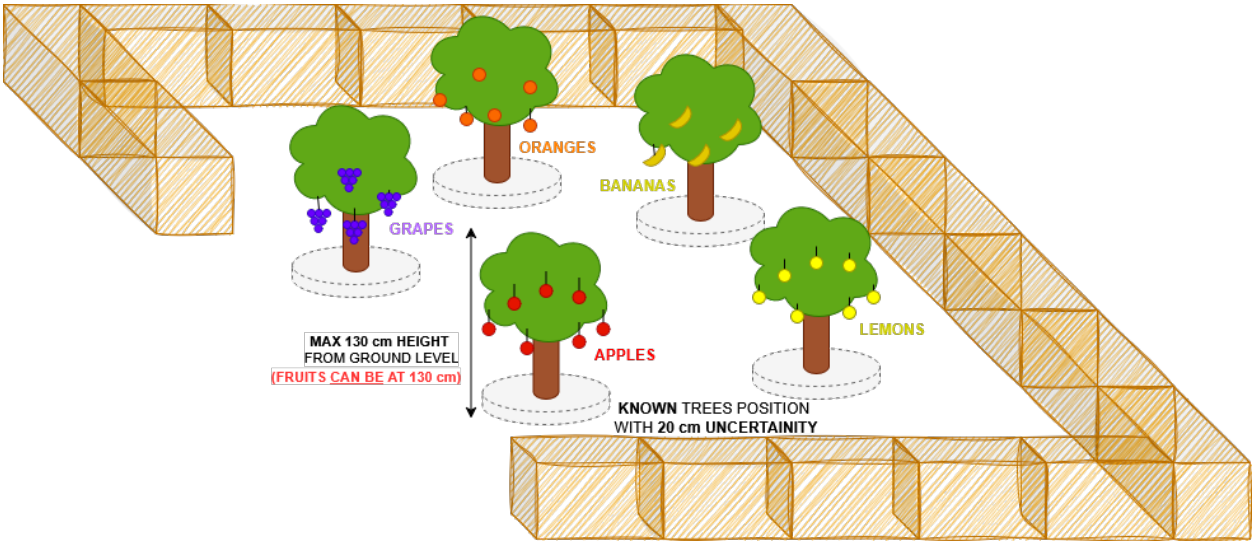

Figure 4: 3D Overview of the fake orchard thats is going to be used during Task 3 for Fruit Counting.

2.4 Task 4: Bioluminescent Fungi Discovery

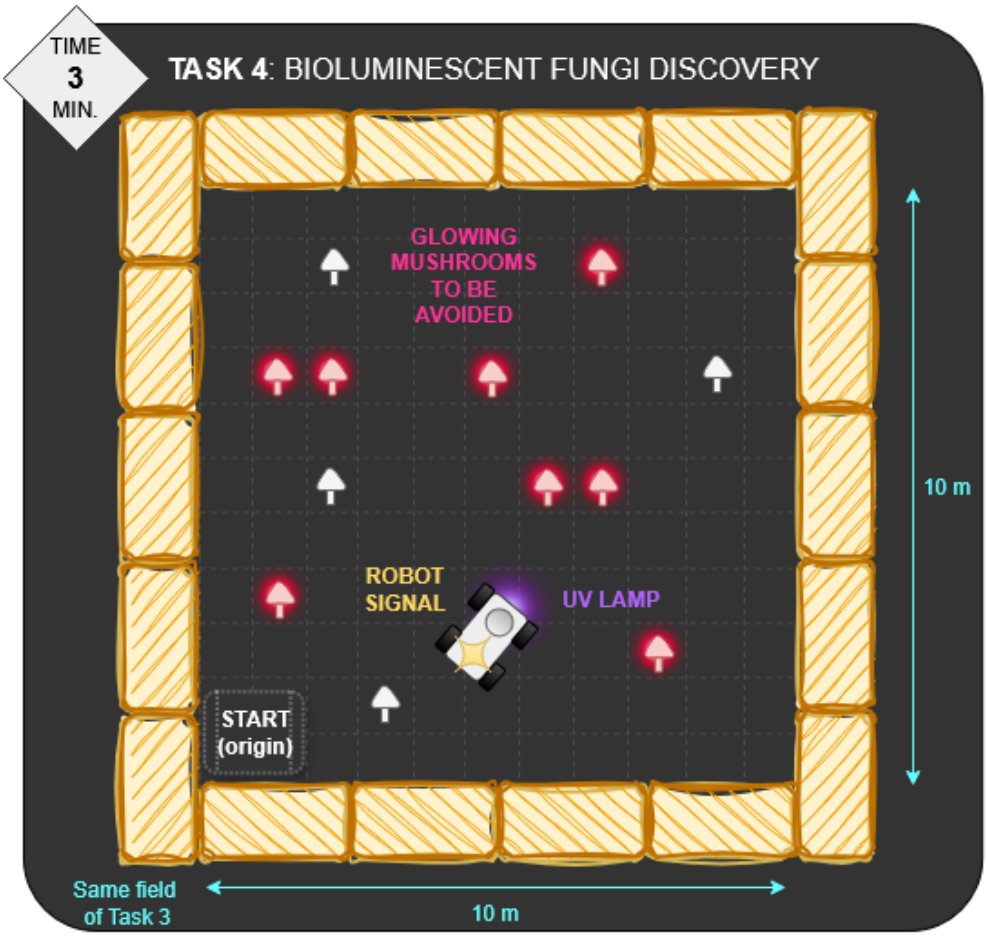

Figure 5: Bioluminescent fungi discovery: The robot navigates an 10×10 meter field at night to locate glowing mushrooms using a UV lamp.

Task 4: Bioluminescent Fungi Discovery

General Description

In this task, the robot operates in the same 10×10 meter field as in Task 3 (see Fig. 5). However, the task is conducted under night conditions. The robot is equipped with a UV lamp to identify glowing mushrooms scattered throughout the field.

The robot's objective is to locate as many glowing mushrooms as possible while avoiding collisions that may destroy them. Additionally, there may be non-glowing mushrooms in the field, which must not be mapped. Mapping non-glowing mushrooms will result in a penalty. At the end of the task, the team must provide a CSV file listing the coordinates of the detected glowing mushrooms in the format:

`x_coordinate, y_coordinate.`

A virtual discrete grid is used to evaluate the task, with soft scoring applied if the provided coordinates are near but not exactly within the correct grid cells. This allows for some

flexibility in the robot's detection accuracy.
The task duration is limited to 3 minutes, and the robot must complete its search within this time.

Rules for the Robots

- The robot must navigate autonomously within the 10×10 meter field.
- The robot must use its UV lamp to identify glowing mushrooms.
- The robot must avoid destroying mushrooms by collision.
- Non-glowing mushrooms must not be mapped. Mapping non-glowing mushrooms will result in a penalty.
- The team must submit a CSV file at the end of the task in the format:
  - `x_coordinate, y_coordinate`.
- The task must be completed within 3 minutes.

Scoring The scoring for Task 4 is calculated as follows:

$$P_{\text{Task4}} = P_{\text{Detected}} + P_{\text{Missed}} + P_{\text{Destroyed}} + P_{\text{False Positive}},$$

where:

- P_{Detected}: Points awarded for correctly detected glowing mushrooms, based on their proximity to the correct grid cell:
  - 3 points for mushrooms detected in the correct grid cell.
  - 2 points for mushrooms detected in immediately adjacent cells.
  - 1 point for mushrooms detected within two cells away.
- P_{Missed}: Penalty for missed glowing mushrooms:
  - -2 points per mushroom missed.
- $P_{\text{Destroyed}}$: Penalty for glowing mushrooms destroyed by collision:
  - -5 points per mushroom destroyed (either glowing or not).
- $P_{\text{False Positive}}$: Penalty for incorrectly mapping non-glowing mushrooms:
  - -3 points per non-glowing mushroom mapped.

Output Assessment

- The submitted CSV file is compared to the ground truth mushroom locations.
- Each mushroom detection is evaluated based on its proximity to the correct grid cell, using the soft scoring mechanism.
- Non-glowing mushrooms mapped by the robot are identified and penalized as false positives.

- The scoring system rewards precise navigation and detection while penalizing missed, destroyed, and incorrectly mapped mushrooms.

This scoring system encourages teams to balance speed, accuracy, and careful navigation to maximize their score while minimizing penalties. Special attention must be paid to distinguishing between glowing and non-glowing mushrooms to avoid false positives.

2.5 Task 5: Freestyle

Task 5: Freestyle

General Description
In this task, teams are encouraged to present innovative ideas and their implementations on self-chosen topics. Each team must present their idea and explain their solution. Ideas with strong agronomic motivation are particularly welcomed.
Rules for the Robots

- There are no specific rules for this task.
- Teams have complete freedom to showcase their creativity and ingenuity.

Scoring
The scoring for Task 5 is based on three criteria:

$$P_{\text{Task5}} = r_{\text{agronomic}} + r_{\text{techn.complexity}} + r_{\text{performance}}$$

where:

- $r_{\text{agronomic}}$: Score for the agronomic idea, ranging from 0 to 5.
- $r_{\text{techn.complexity}}$: Score for the technical complexity of the implementation, ranging from 0 to 5.
- $r_{\text{performance}}$: Score for the field robot's performance, ranging from 0 to 5.

The total score is the sum of these three components, with a maximum of 15 points.

3 Location & Schedule

The event will be held at **Agriturismo da Pippo** (Figure 6), *Piazza Grassi 3, 20090 Rodano (Milano)* (Figure 7), from June 9 to June 12. It is 12 km from Milano Linate Airport and 17 km from Milano Central Station.

Camping with your own tents is feasible at the venue, offering a more immersive and flexible experience for attendees. Detailed information regarding camping arrangements, including designated areas and facilities, will be provided during the registration process. Additionally, a list of suggested accommodations nearby will be shared to cater to those who prefer alternative lodging options.

Figure 6: Agriturismo da Pippo.

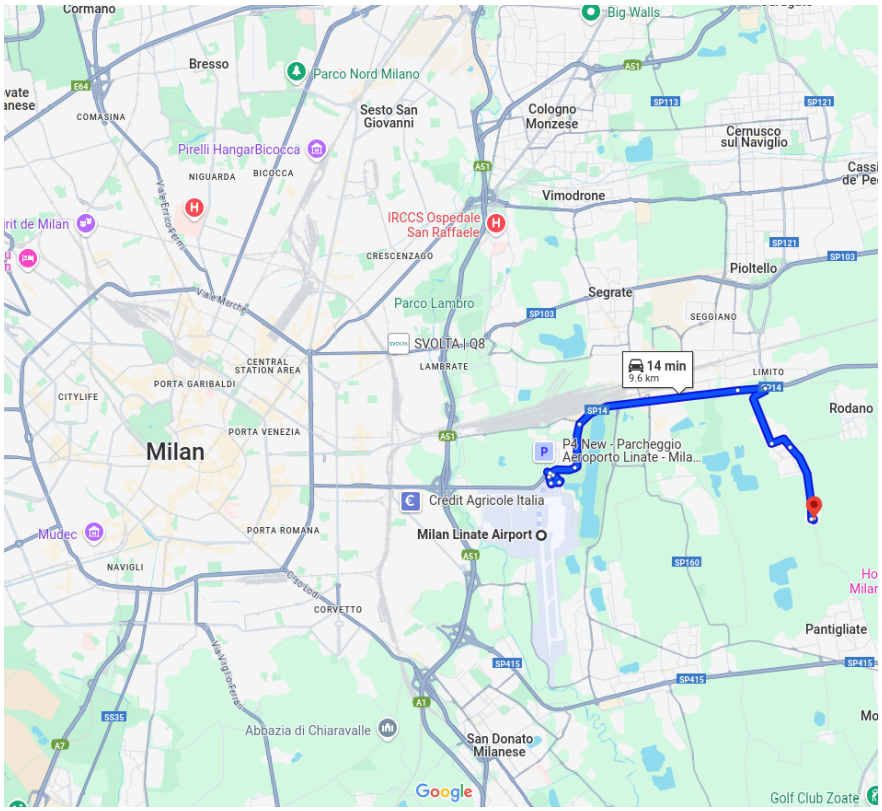

Figure 7: Google Maps location with respect to Milano Linate Airport.

Figure 8 presents the tentative schedule for FRE 2025, covering the period from Monday, 9 June,

to Thursday, 12 June, 2025. The schedule includes a variety of activities such as meals, tasks, tests, and social events.

9/6/25 – 12/6/25	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
8:00	TEST	Breakfast + Opening	Breakfast	Breakfast
		TASK 1	TEST	TASK 5
10:00				
12:00		Lunch	Lunch	FINAL AWARDS + FAREWELL
14:00		TASK 2	TASK 3	Private Transfer
16:00				
		AWARDS	TEST	
18:00				
	Dinner	BBQ	Dinner	
20:00				
	TEST	SOCIAL NIGHT	TASK 4	
22:00				
00:00	Private Transfer	Private Transfer	Private Transfer	

Figure 8: FRE 2025 schedule from Monday 9th June to Thursday 12th June 2025.

4 Suggested Products List

Note: You are not required to buy the exact same products listed in Table 1. These are just the ones we tested to give you an idea of their appearance. You can use your own solutions as long as they align with the following guidelines.

Amazon Links	Image	Description
💡 **UV Light** (Task 4)		Wavelenght: $400nm$.
🎨 **Glowing Painting** (Task 4)		Color: red
🍄 **Artificial Mushrooms** (Task 4)		Dim: $6.5 \times 6.5 \times 13.0cm$, Color: brown/red
🍓 **Artificial Strawberries** (Task 2)		Dim: $21.0 \times 5.5 \times 5.5cm$, Color: red.
🍋 **Artificial Lemons** (Task 3)		Dim: $9.5 \times 6.5 \times 6.5cm$, Color: yellow
🍊 **Artificial Oranges** (Task 3)		Dim: $7.5 \times 7.5 \times 7.5cm$, Color: orange.
🍌 **Artificial Bananas** (Task 3)		Dim: $22.3 \times 3.0 \times 3.0cm$, Color: yellow.
🍎 **Artificial Apples** (Task 3)		Dim: $9.0 \times 8.0 \times 8.0cm$, Color: red.
🍇 **Artificial Grapes** (Task 3)		Dim: $16.0 \times 5.0 \times 5.0cm$, Color: purple.

Table 1: List of Amazon links, images, and descriptions.