FIELD ROBOT EVENT 2025 RULES - v3.0

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Contents

Each task includes its own errata corrige. In case of any contradiction with the task rules, the errata corrige takes precedence and reflects the most accurate interpretation.

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

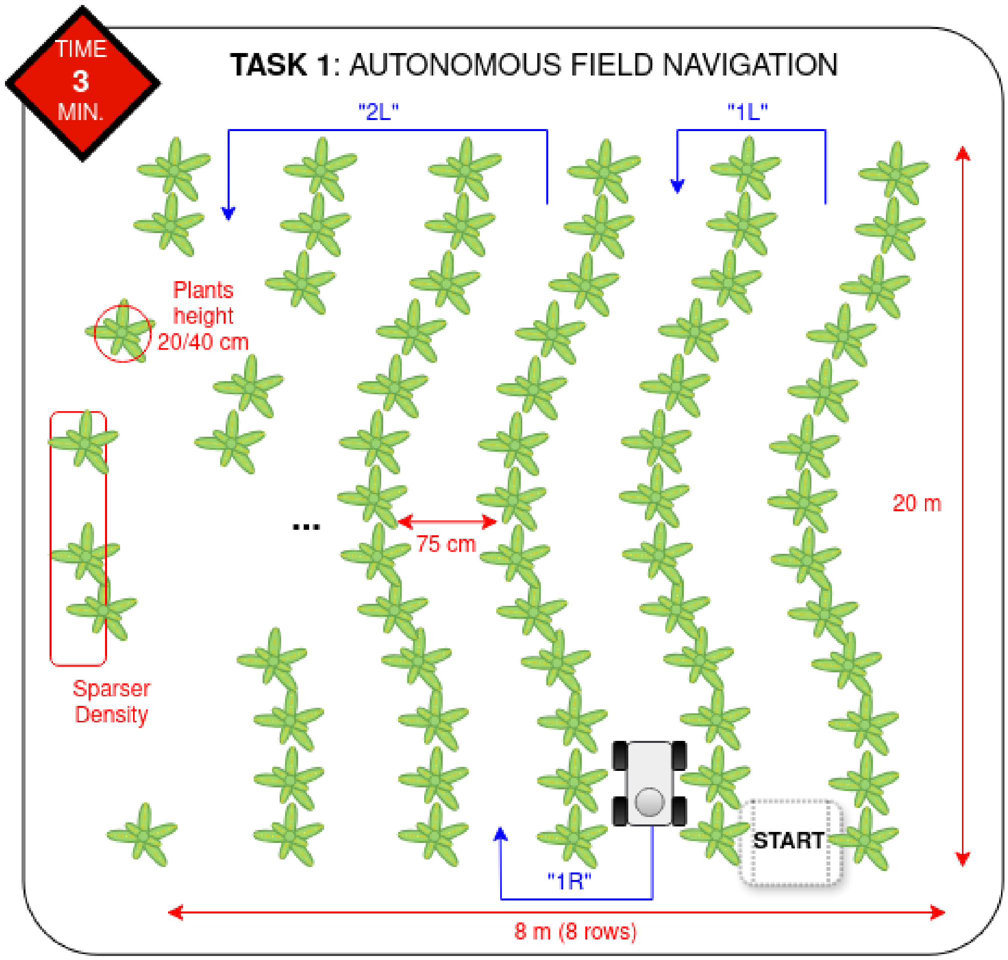

Figure 1: Navigation in a maize field. Robots start at the initial location START and follow adjacent rows as specified in the task rules.

> **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 75 cm 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 20 - 40 cm.
>
> **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 10 commands provided in a text file. The first three commands are always fixed as follows: **1L, 1R, 1L**. The remaining seven commands in the sequence will be unknown

until a few minutes before the round begins.
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-minutes** limit.

Errata Corrige 1: Autonomous Field Navigation

- **Field Layout:**
  - The layout of the maize field will be the same for **Task 1 and Task 2**.
  - **Pre-computed maps are not allowed.** Robots must begin each run without prior environmental knowledge.
- **Field Structure and Surface:**
  - The field will consist of **8 maize rows**, each with a **width of 75 cm**, as per standard agricultural seeding machinery.

  - The ground is expected to be **bare soil without weeds**.
  - The expected **maize height** ranges between **20–40 cm**, though variation may occur.

- **Perception and Localization:**
  - **External localization systems** such as GPS or Pozyx UWB **are not permitted**.
  - All perception must be **strictly relative to the robot**.
  - The competition emphasizes **full autonomy without external assistance**.

- **Rule details**
  - The robot must follow a sequence of 10 commands provided in a text file. The first three commands are always fixed as follows: **1L-1R-1L**. The remaining seven commands in the sequence will be unknown until a few minutes before the round begins.

2.2 Task 2: Autonomous Field Navigation with Strawberry Bushes Detection

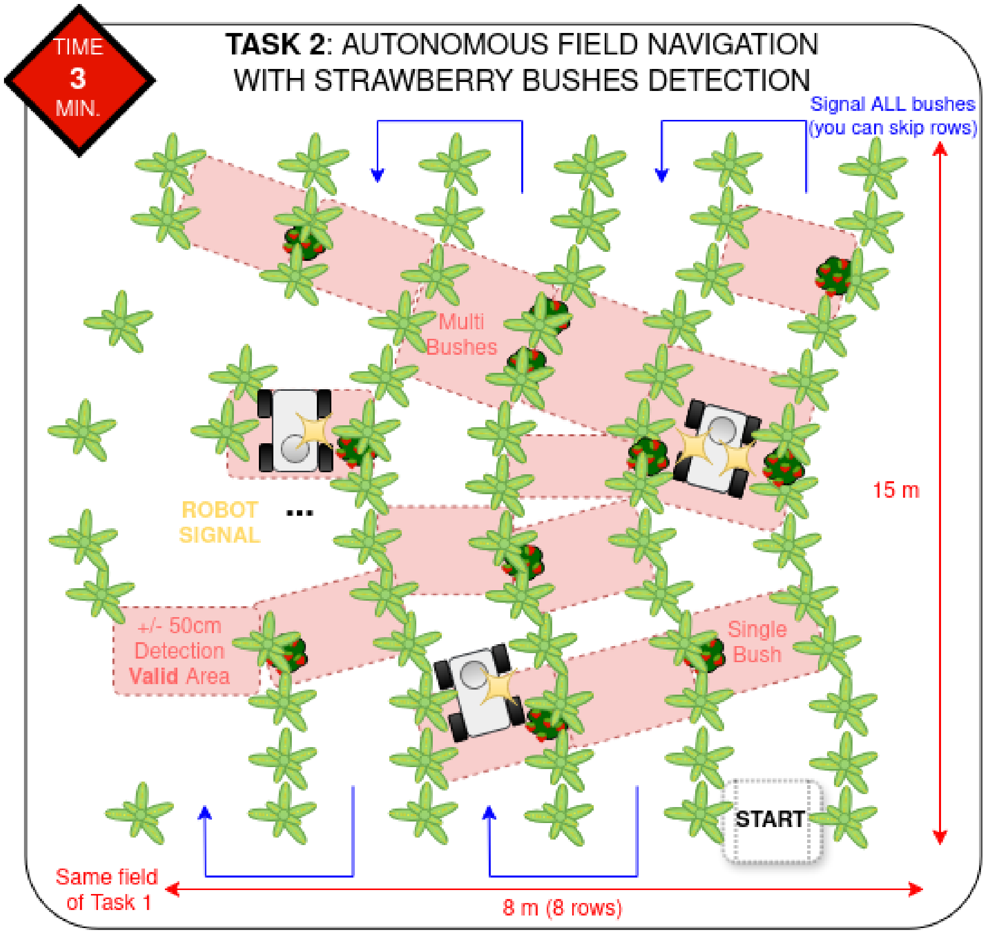

Figure 2: Navigation and weed detection in a maize field. The robot must traverse every row and detect strawberry bushes (weeds) positioned arbitrarily to the left or right within a valid detection area.

Task 2: Autonomous Field Navigation with Straberry Bushes Detection

General Description This task extends Task 1. Robots must autonomously navigate the maize field (Fig. 2) within 3 minutes. The main goal is to detect **all** strawberry bushes (treated as weeds), which may be placed arbitrarily on either side of the robot. Any strategy that ensures full coverage of the detection area is acceptable, including skipping rows, provided the perception system can identify and clearly signal intra-row bushes. A detection is valid only if it occurs within a range of $-50,\text{cm}$ to $+50,\text{cm}$ from the bush. If detection zones of multiple bushes overlap, they are merged into a single union area.

Robot Rules

- Robots may skip rows, provided their strategy ensures complete coverage of the detection area and reliable identification of intra-row bushes.
- Strawberry bushes positioned to the left or right must be detected within the valid

range of $-50, \mathrm{cm}$ to $+50, \mathrm{cm}$.

- Teams must inform the judges how the robot signals detected bushes (e.g., as weeds), using lights, audio cues, or other clear and unambiguous methods.

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 calculated 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. The distance traveled is not considered to avoid giving an advantage to the winners of Task 1.

Errata Corrige 2: Autonomous Field Navigation with Strawberry Bushes Detection

- **Task Modification:**
  - The original corn cob detection task has been replaced with **strawberry bush detection** at ground level to simplify execution.
  - All detections are assumed to occur at **ground level**.
  - Valid detection range: within **-50 cm to $+50$ cm** of each bush. Overlapping detection areas are merged.
- **Bush Placement and Appearance:**
  - Bushes are placed **between maize plants** and **symmetrically across inter-rows**, so they are visible from both directions.
  - Bushes are planted **into the soil** as shown in reference pictures.
  - Expected bush height: **10–30 cm**. Maize height: **20–40 cm**.
- **Row Structure and Navigation:**
  - The field layout is **identical to Task 1**, including the **wavy pattern** of rows.
  - There is **no fixed minimum distance** between bushes in the same row. Distinct bushes will be visibly separate.
  - **Row skipping** is permitted. **Examples** of valid strategies include:
    - Double frontal camera setup from adjacent row.
    - One-sided camera with two swipes (back and forth) within the same row.
    - And more...

  - Recognizing the same bush from multiple rows is allowed but not scored multiple times.

- **Detection Requirements:**
  - Robots must indicate whether the bush is on the **right or left side**.
  - For **multi-bush areas**, each bush should be clearly reported (e.g., with steady light, blinking, or voice).
  - **Real-time signaling is encouraged** for public engagement and is the primary criterion for evaluation. However, **optionally**, **post-processed results** are also acceptable as a backup in case of technical issues. In such cases, please provide the results to the judges in CSV format, which can be shared via a **USB stick**. You may include the number of strawberry bushes detected per intra-row and their 2D coordinates (x, y) with respect to the starting point.

- **Execution and Output:**
  - Each task run lasts **3 minutes**.

2.3 Task 3: Fruit Counting

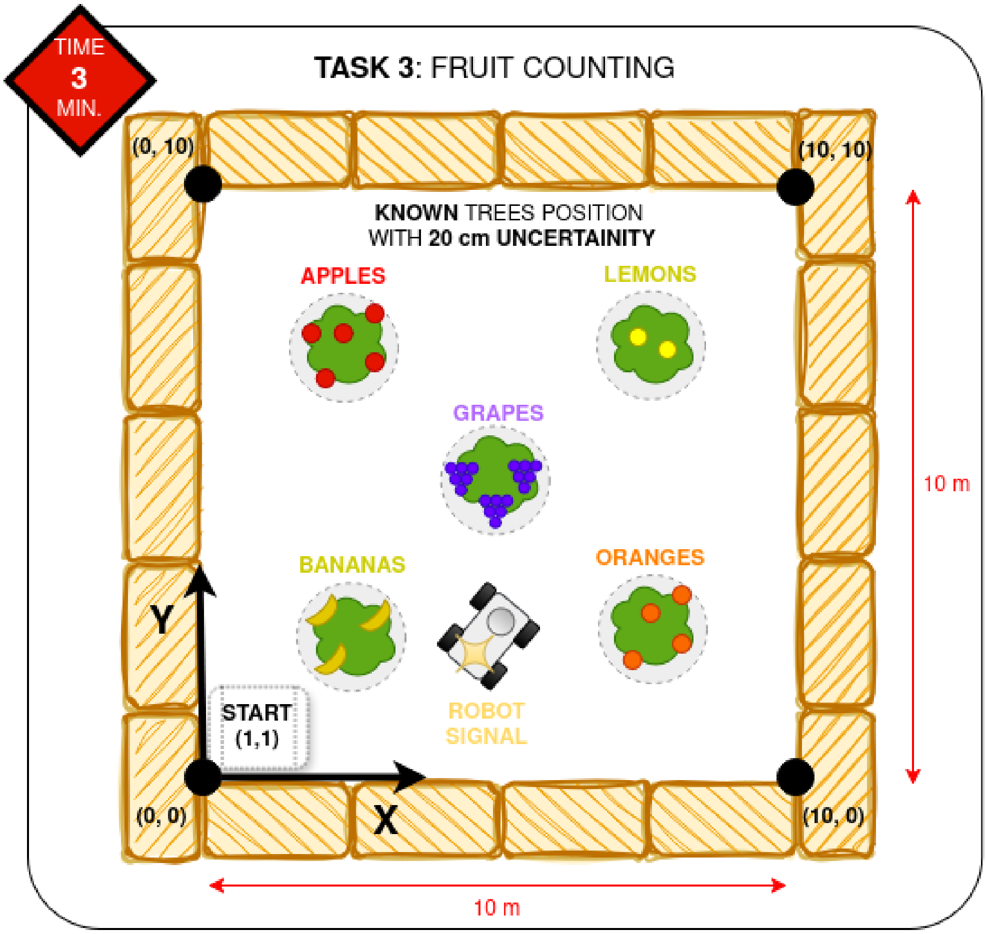

Figure 3: Fruit Couting: The robot navigates an 10×10 meter field delimited by hay bales, mapping the locations of fruit trees.

> **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), within 3 minutes. The field contains five fruit trees, each representing a different fruit: apples, lemons, bananas, grapes, and oranges. These 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 coordinates $(1, 1)$ meters on a meter-based coordinate system, relative to the origin $(0, 0)$. The origin is defined at the robot's initial position (bottom-left corner of the field), with positive X toward the right (East) and positive Y upward (North). The objective is to generate a 2D map indicating the type and location of each fruit.
>
> 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. 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`.

For each entry, a visual proof of identification must be provided as confirmation to the judges (e.g., 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.
- Manual robot rotation (by an operator) is permitted only to recover from being stuck; strategic use of manual reorientation to improve performance is discouraged and will be monitored.
- 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.
- $P_{\text{Missed}} = -1$ 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.
- Organizers will perform a qualitative visual alignment between reported and actual fruit positions.
- Quantitative comparison of 2D position errors (with the provided ± 20 cm tree-location uncertainty) will only be used to break ties when performances are otherwise similar.

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.

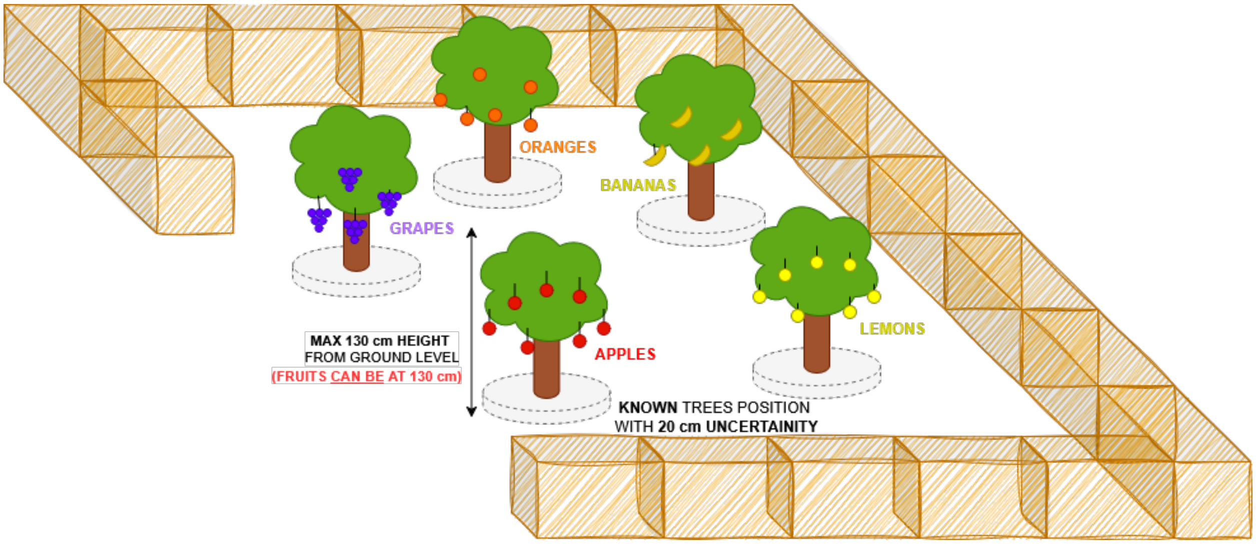

Figure 4: 3D Overview of the fake orchard thats is going to be used during Task 3 for Fruit Counting.

Errata Corrige 3: Fruit Counting

- **Coordinate System and Ground Truth**
  - The origin is defined at the robot's initial position (bottom-left corner of the arena image); **The robot begins at (1, 1) on a meter-based coordinate system**.
  - The coordinate axes are defined with positive X toward the right (East) and positive Y upward (North).
  - Absolute alignment is not required; participants can use their own reference frame and apply a roto-translation.
  - Only the relative correctness of the reported fruit positions in 2D is evaluated. Organizers will perform a qualitative visual alignment with ground truth; quantitative comparison is going to be done in case of similar performance.
- **Tree and Fruit Information**
  - Artificial trees have stems and are approximately 150 cm in height.
  - Fruits are located between 80 cm and 130 cm from the ground.
  - All fruits on a given tree are of the same type.
  - Fruits may appear both hanging from and placed around the tree.
  - Tree positions are provided with an uncertainty of $\pm$20 cm, primarily for navigation aid.
  - Only the 2D positions of the fruits are required for submission.
- **Autonomous Mode Policy**
  - Manual robot rotation is permitted to recover from being stuck.

- Strategic use of manual reorientation to improve performance is discouraged and will be monitored.

- **Fruit Counting Rules**
  - Trees may contain zero or more fruits, but all trees being empty is ruled out.
  - Duplicate fruit detections are penalized as false positives.
  - The exact number of fruits per tree is not disclosed and may change among each team run to discourage hard-coded results based on previous competitors environments.

- **Environmental Constraints**
  - Minimum navigation clearance between obstacles (trees, hay bales) is 75 cm.
  - Tree diameter is less than 1 m.
  - Hay bales are expected to be approximately $100 \times 45 \times 35$ cm (L×W×H).
  - Hay bale dimensions are the same in Tasks 3 and 4.

- **Logistics and Setup**
  - Final tree positions will be announced approximately 1 hour before the task.
  - There are no restrictions on robot or sensor height. The sensors must rely on relative perception without introducing andy absolute reference frame such as a GPS.
  - CSV file can be provided via USB stick.

2.4 Task 4: Bioluminescent Fungi Discovery

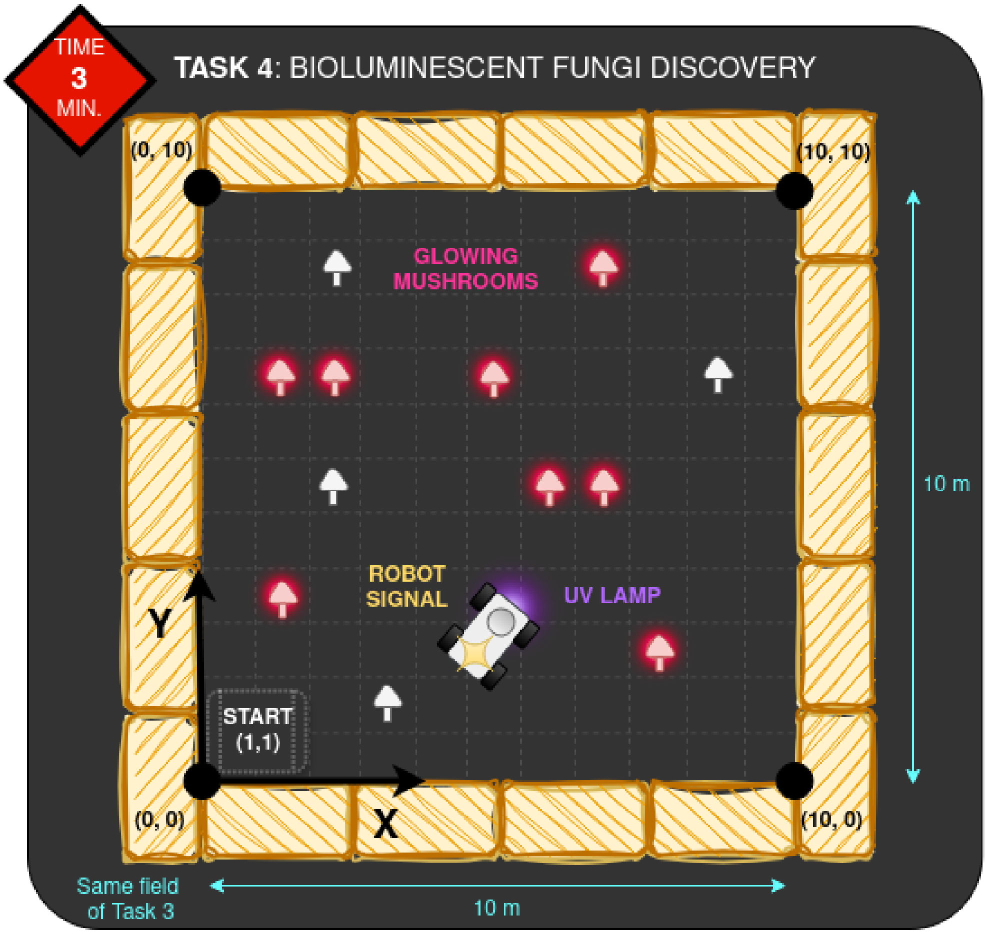

Figure 5: Bioluminescent fungi discovery: The robot navigates an 10×10 meter field at night to locate glowing mushrooms using a UV lamp.

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), starting at position (1, 1) in meter-scale coordinates, the robot must operate under nighttime conditions and complete the task within 3 minutes. The robot may carry a UV lamp to reveal glowing mushrooms (which fluoresce red under UV), but use of UV illumination is not enforced. Mushrooms (glowing or not) are scattered on the floor in a regular grid with minimum inter-mushroom spacing of 1 meter.

The robot's objective is to locate as many glowing mushrooms as possible while avoiding collisions that destroy them (running over with wheels is prohibited; slight contact of the frame without damage is allowed). Non-glowing mushrooms must not be mapped—reporting them incurs a penalty. At the end of the task, the team must submit a CSV file listing the discrete grid-cell indices of detected glowing mushrooms, using zero-based (x, y) coordinates:

`x_cell, y_cell`.

A soft scoring mechanism allows slight errors in cell indices (adjacent or two-cell offsets) without harsh penalty.
The task duration is limited to 3 minutes, and the robot must finish within this time.

Rules for the Robots

- Navigate autonomously within the 10×10 m field.
- Mushrooms must not be destroyed by the robot: collisions that damage or run over mushrooms incur a penalty.
- Frame contact without damage is allowed.
- UV or any illumination may be used; glowing mushrooms fluoresce red under UV, and only their tops are painted.
- Do not map non-glowing mushrooms.
- Submit at task end a CSV file with rows:

  `x_cell, y_cell`.

- Complete the task within 3 minutes.

Scoring

The score P_{Task4} is computed as

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

where:

- P_{Detected}: points for glowing mushrooms detected by cell proximity:
  - +3 pts for correct cell,
  - +2 pts for adjacent cell,
  - +1 pt for two-cell offset.
- $P_{\text{Missed}} = -2$ pts per glowing mushroom not reported.
- $P_{\text{Destroyed}} = -5$ pts per mushroom (glowing or not) destroyed by collision.
- $P_{\text{FalsePositive}} = -3$ pts per non-glowing mushroom mapped.

Output Assessment

- Compare submitted CSV to ground truth grid.
- Apply soft scoring on cell indices as above.
- Penalize reported non-glowing mushrooms as false positives.
- Mushrooms destroyed by collision incur the destruction penalty.

This encourages careful navigation and accurate differentiation between glowing and non-glowing mushrooms.

Errata Corrige 4: Bioluminescent Fungi Discovery

- **Mushroom Interaction and Penalties**
  - Any collision with mushrooms, glowing or not, will incur a penalty.
  - Mushrooms must not be destroyed by the robot. Slight contact is acceptable, but running over them with wheels is prohibited.
  - Contact with the robot's frame that does not cause damage is generally allowed.
- **Mushroom Characteristics**
  - All glowing mushrooms will fluoresce red under UV light.
  - The tops of the mushrooms are entirely painted with UV-reactive red paint.
  - Paint may be applied to both red and brown mushroom types.
  - Only the tops of the mushrooms are painted.
  - The actual mushroom size is approximately 6.5 cm in diameter and up to 7.2 cm in height (excluding mounts).
  - Consider that there may be red mushrooms that do not glow.
- **Sensing and Illumination**
  - While UV light is recommended to reveal glowing mushrooms, its use is not enforced.
  - Participants may use any illumination source; mushrooms are designed to reflect UV light, but detection methods are open-ended.
- **Coordinate Reporting and Scoring**
  - Participants should report mushroom locations using discrete (x, y) grid cell indices, starting from $(0, 0)$.
  - Scoring is based on visual comparison to ground truth. "Soft scoring" is applied to allow slight inaccuracies.
  - Metric accuracy is not required; submissions will be evaluated qualitatively.
- **Mushroom Spacing and Data Access**
  - Minimum distance between any two mushrooms is 1 m.
  - CSV file can be provided via USB stick.
- **Materials and Updates**
  - The official paint color is fluorescent red, despite earlier documentation errors linking to blue products.
  - Due to shortages, some tasks may employ alternative mushroom models, which are harder to crush:
    * https://amzn.eu/d/gcAcV0B
    * https://www.amazon.com/dp/B0CM27RMNF
  - All relevant task updates and rule clarifications will be compiled and finalized after the registration deadline.

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.

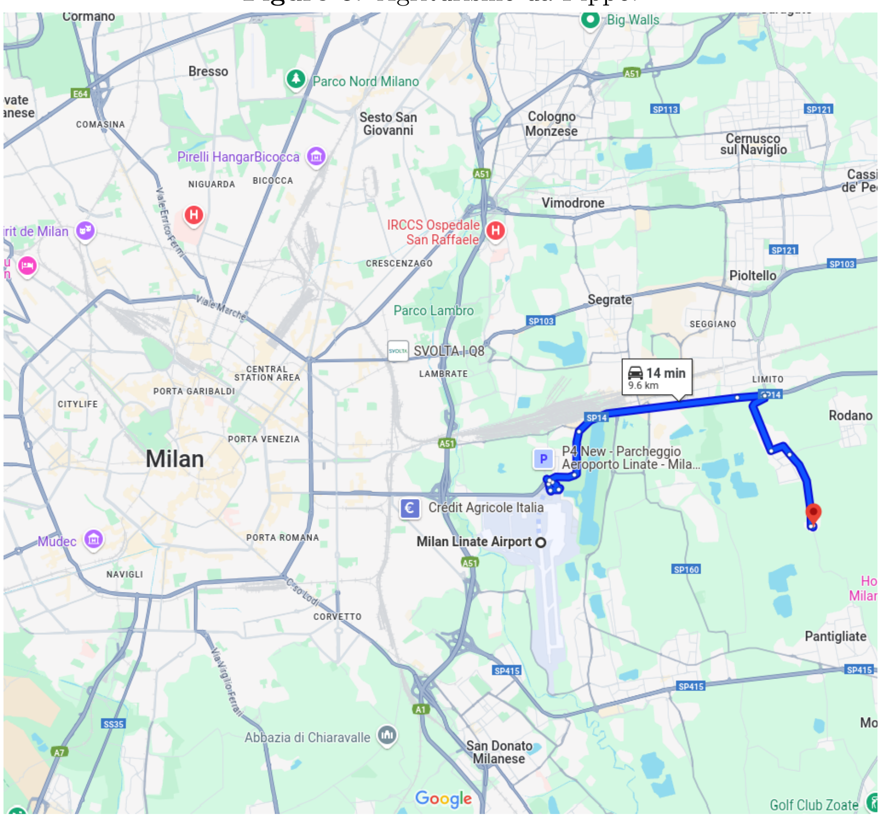

Figure 7: Google Maps location with respect to Milano Linate Airport.

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.