2. The FRE24 Competition

2.1 Description of the Tasks

2.1.1 Remarks

- There are no plans to offer a virtual participation or a competition in a virtual environment.
- More details will be provided in the next weeks.

2.1.2 REST Communication and Interface

Tasks 2, 3 and 4 require data exchange with a central benchmark and validation server (BVS). The BVS will provide a REST API and its definition will be published as an OpenAPI[1] definition in May. A test BVS will be up and running by midth of May. For the communication, the organising team will provide an access point[2] which has to be fixed on the field robot, e.g. by Velcro band. The field robot has to send its data via ethernet cable to the access point, no additional WLAN is required by the teams. The architecture looks as shown in fig. 2.1.

[1] `https://www.openapis.org`
[2] Similar to the Gl.Inet Mini Smart Router `https://store.gl-inet.com/collections/mini-smart-router`.

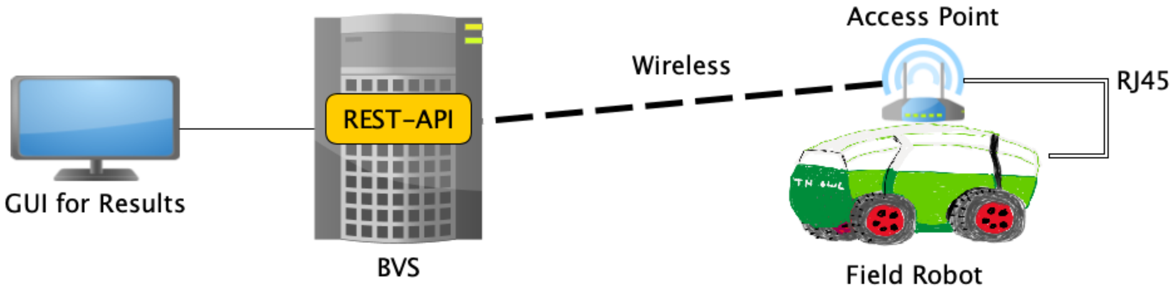

Fig. 2.1: Communication architecture for tasks 2, 3 and 4 including the field robot, an access point and the central benchmark and validation server (BVS).

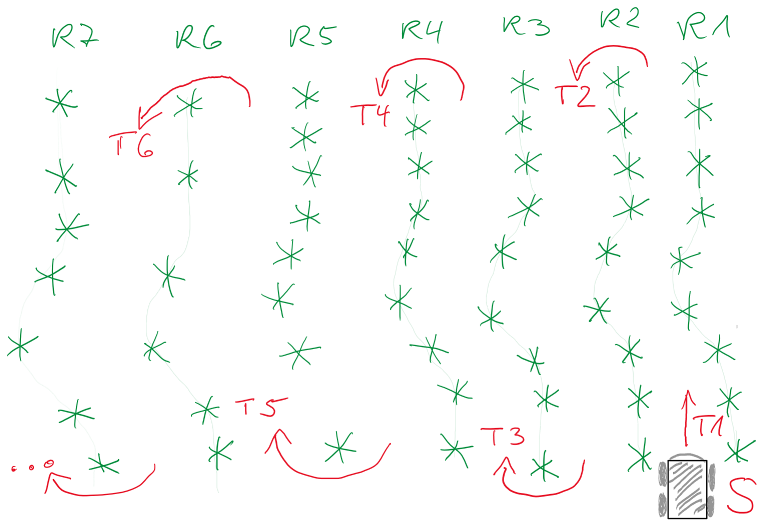

Fig. 2.2: Sketch of the maize area for tasks 1 and 2 with the starting point S (lower right), the rows R_i of maize and the Tracks T_j.

2.1.3 Task 1: Navigation in a Maize Field

General Description

In this task, robots navigate autonomously through a maize field (see fig. 2.2) starting at the starting location S. Turning has to follow adjacent rows for tracks T_1 to T_n, e.g.
$S \Longrightarrow T_1 \Longrightarrow T_2 \Longrightarrow T_3 \Longrightarrow T_4 \Longrightarrow T_5 \Longrightarrow T_6 \Longrightarrow \ldots$
The distance between adjacent rows will be 0.75 m. 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 approx. 0.3 - 0.4 m.

Rules for the Robots

Each robot has to start within 1 min. after the signal for the start. The maximum time is 3 min. for every field robot beginning with the individual start.

Scoring

The scoring P includes the travelled distance, the number of damaged plants causing a penalty and a bonus distance if the fied robot finishes before the 3 min time slot has ended:

$$P_{Pask1} = P_{Distance} - P_{Penalty} + P_{Bonus} \tag{2.1}$$

2.1.4 Task 2: Object Detection and Counting in a Maize Field

General Description

Task 2 is essentially an extension of task 1. In addition to the first task, the field robots have to count the number of plants in each row and present the results row by row immediately after finishing the individual rows by providing the data using the REST API. In addition to the plant counts for each row, a JSON logfile has to be provided immediately at the end of the task using an USB stick.

Rules for the Robots

Each robot has to start within 1 min after the signal for the start. The maximum time is 3 min. for every field robot beginning with the individual start.

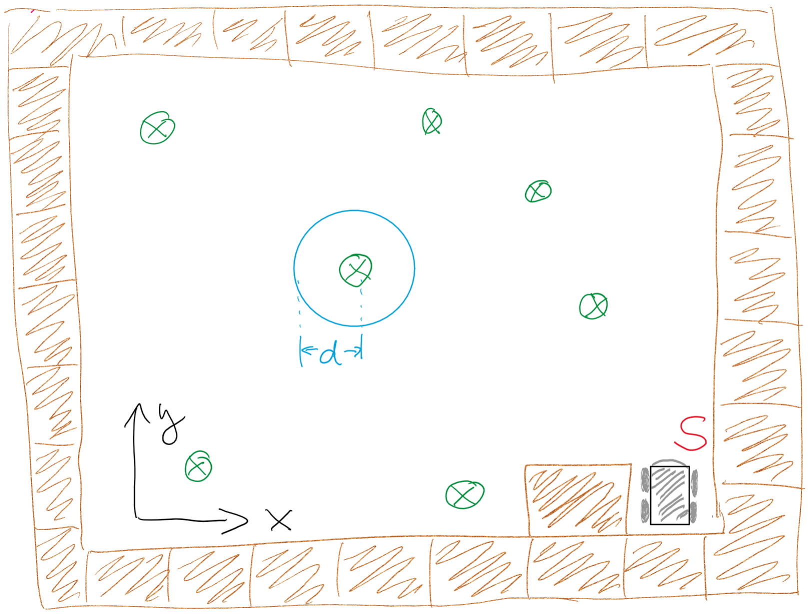

Fig. 2.3: Sketch of the grassland area for tasks 3 and 4 with the starting point S (lower right), the orientation of the coordinate system and possible locations of the weed.

Scoring

The scoring in this task depends on the fraction of correct plant countings. Only data from rows which have been completed are accepted.

$$P_{Task2} = \sum_{i=1}^{k} \left[1 - \frac{N_{i,correct} - N_{i,counted}}{N_{i,correct}} \right] - P_{Penalty} \tag{2.2}$$

with the number $N_{i,correct}$ of plants existing in row i and the counted number of plants $N_{i,counted}$ in row i. Note that the first row is the one on the right hand side of the field robot when it starts. A penalty $P_{Penalty}$ will be applied for robots damaging maize plants.

2.1.5 Task 3: Mapping in a Grassland Area

General Description

In this task, the field robots have to work in a grassland area, see fig 2.3. The task is to find and map any weeds in the area. In order to support the localisation within the grassland area, it will be enclosed by a side fence, e.g. straw bales or something similar with a height of at least 0.3 m. The result data consisting of (x,y) data sets has to be provided by the field robot by using the above mentioned REST interface (see section 2.1.2). Additional obstacles might be present in the grassland area. The weed will be represented by small artificial flowers[3] placed on the ground. The dimensions of the grassland area are approx. 8 m x 8 m.

Rules for the Robots

Each robot has to start within 1 min after the signal for the start in the starting area. The maximum time is 3 min. for every field robot beginning with the individual start. There is no predefined track. The direction of x and y will be defined by the starting area and the initial orientation of the field robot.

[3] See, e.g. https://www.amazon.de/-/en/artificial-sunflowers-flowers-decorative-decoration/dp/B08SWGFLQS/ref=sr_1_2?crid=3TS5QB5RDBNUP

Scoring

The score depends on the number of correctly mapped weed plants. The required accuracy d is 0.15 m for the distance between real and mapped location.

$$P_{Task3} = \frac{N_{correct}}{N_{total}} \tag{2.3}$$

with $N_{correct}$ being the number of correctly mapped weed positions and N_{total} the total number of weed plants in the grassland area. If the distance l between real location and measured location is greater than the required accuracy d, the location of the weed will not contribute to $N_{correct}$.

2.1.6 Task 4: Application in a Grassland Area

General Description

In task 4, the locations of the weed will be available via REST at the beginning of the individual field robot run and has to be downloaded by every field robot. The weed and the grassland area are the same as in task 3. The field robot has to move to the locations of the weed and apply any weed control. There is no predefined mechanism for the application, but the application has to be verifyable by the jury members and removing the weed by driving over it will not result in any scoring points.

Rules for the Robots

Each robot has to start within 1 min after the signal for the start in the starting area. The maximum time is 3 min. for every field robot beginning with the individual start . There is no predefined track. The direction of x and y will be defined by the starting area and the initial orientation of the field robot.

Scoring

The scoring contains contributions $a_{i,distance}$ for reaching the weeds (distance < 0.5 m: 1 point, distance < 0.15 m: 2 points) and $a_{i,application}$ for the application of the weed control (non-visible: 0 points, visible: 1 point, clearly visible: 2 points) for each of the k weeds:

$$P_{Task4} = \sum_{i=1}^{k} \left(a_{i,distance} + a_{i,application}\right) \tag{2.4}$$

2.1.7 Task 5:Free Style

General Description

In the last task the teams are encouraged to present ideas and their implementations for self-chosen topics. Each team has to present the idea and explain the solution. Any ideas with a strong agronomic motivation is welcome.

Rules for the Robots

There are no specific rules for this task.

Scoring

Scoring is based on the number of points $r_{agronomic}$ for the agronomic idea, $r_{techn.complexity}$ and for the field robot's performance $r_{performance}$ with $r_x = 0 \ldots 5$.

$$P_{Task5} = r_{agronomic} + r_{techn.complexity} + r_{performance} \tag{2.5}$$

2.1.8 Overall Result

For the overall result, the teams will get points according to their individual performance in each task. i.e. for n teams, the best team in a task will get n points, the second one $n-1$ etc. and the last one 1 point. The sum of the team's results will be divided by the number N of teams multiplied by 4:

$$R_{overall} = \frac{R_{Task1} + R_{Task2} + R_{Task3} + R_{Task4}}{4 * N} \tag{2.6}$$