Field robot event 2023

1 Task1: navigation

1.1 General description

For this task, the robots are navigating autonomously through a real maize field. Turning must follow adjacent rows for track 1 to 5. From exiting track 5 the robot must follow a given particular turning pattern. This task is all about accuracy, smoothness, and speed of the navigation operation between the rows. Within three minutes the robot navigates between the rows. The aim is to cover as much travelled distance as possible. You find an example field and driving pattern in Figure 1.1.

The first 3 tracks are without intra-row gaps to make it easy for robots to start. The rest of the field – track 4 to 11 – there are intra-row gaps even sometimes on both sides. In the last part – after track 5 – the robot has to follow a particular given turning and row pattern. The pattern may look as: S – 1L – 1R – 3L – 2L – 2R – F. Random stones and pebbles are placed along the path. Therefore, machine ground clearance is required. In order to make it easier for sensors there will be no gaps at the row entries and exits. The ends or beginnings of the rows may not be in the same line. The headland will be perhaps indicated by a fence or ditch or similar.

1.2 Rules for robots

Each robot must start after a starting indication (acoustic signal) within 1 min. The maximum available time for the run is 3 min.

1.3 Points distribution

The distance travelled following the given path during task duration is measured. (As soon as the robot leaves the specified path, the distance measurement will stop.) The final distance will be calculated including especially a bonus factor when the end of the field is reached in less time than 3 min. The final distance including a bonus factor is calculated as: S_{final} [m] = $S_{corrected}$ [m] * 3 [min] / $t_{measured}$ [min]

The corrected distance includes travelled distance and the penalty values. Travelled distance, penalty values and performance time are measured by the jury officials. Crop plant damage by the robot will result in a penalty of 2% of total row length distance in meter per damaged plant. (Example: 10 rows x 10 m = 100 m max. distance, means a penalty of 2 m per damaged plant.)

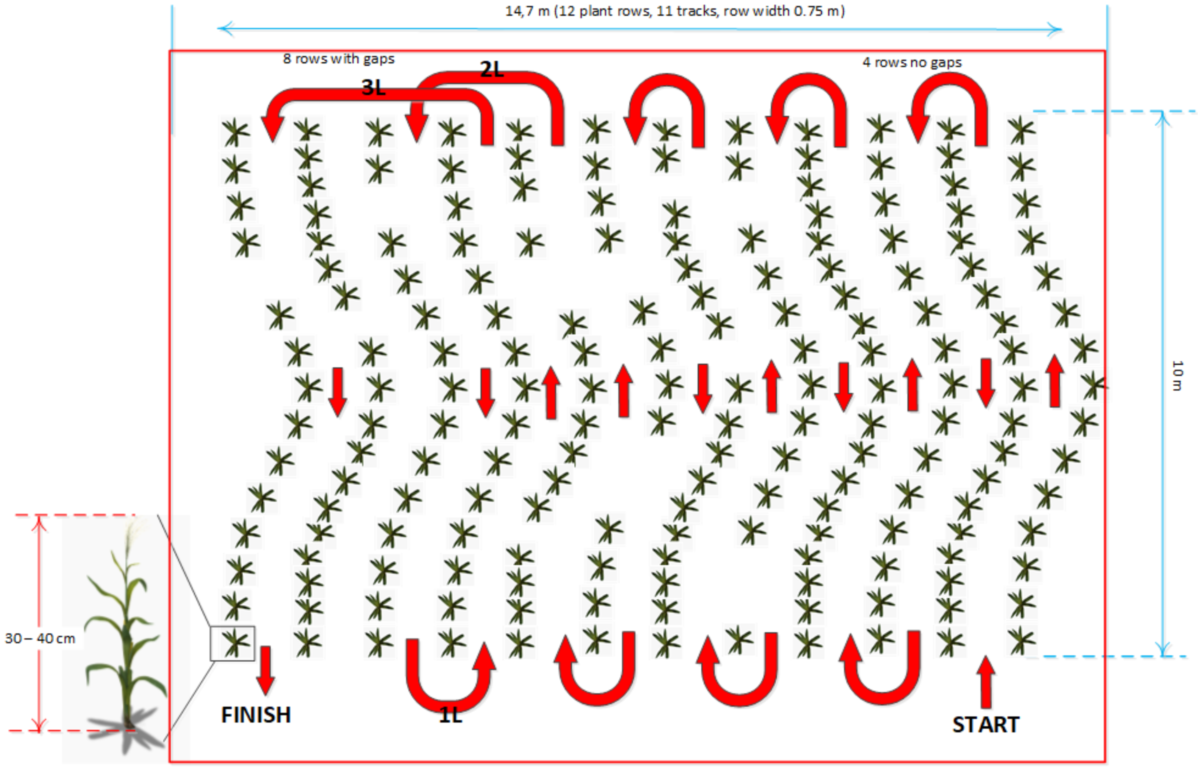

Figure 1.1: Concept of field structure for navigation task (example); Track 1 to 3 with no gaps, track 4 to 11 with gaps. After track 7 on navigation with pattern 2L (second left), 1L (one left) and 3L (third left) as an example. The headlands are 2 m wide.

2 Task2: treating (spraying) the plants

2.1 General description

For this task, the robots are navigating autonomously through a real maize field, like in first part of task 1, but skipping every second row. In addition to this, the robots must treat the plants when the plants are present and stop the treatment, where the plants are not present.

In optimal conditions, the robots should start spraying the plants on their left and right side. If plants are missing on one side, the robot should stop spraying on that side until it does not detect new plants on that side. In addition, the robot should stop spraying when it reaches the end of the row and starts the turning procedure. In real world, the robots might run out of water or might not even have the capabilities to spray. Therefore, the robots must be equipped with two indicators / bright lights, turning on and off in accordance to the presence of plants.

For the contest, the spraying medium will be water.

2.2 Rules for robots

Each robot must start after a starting indication (acoustic signal) within 1 min. The maximum available time for the run is 3 min.

2.3 Points distribution

There will be 10 areas in the field where the plants will be missing approx. 1 m long empty rows, distributed on one or possibly both sides. So, in total, 10 m of plants will be missing. The points will be awarded according to the number of successfully detected empty regions ($S_{missing}$), with a weight set to 1, and the total distance travelled ($S_{travelled}$).

S_{final} [m] = 10 * weight * $S_{missing}$ [m] * + $S_{travelled}$ [m]

A bonus factor will be awarded to the robots, that will actually spray the plants. To evaluate this, water sensitive paper (WSP) will be placed on dry wooden planks and these wooden planks will be placed on the ground where the plants are missing[1]. The WSPs will be positioned one in every 10 cm and based on the number of wet WSPs the weight will be set as follows:

The percentage of all WPS that are dry[2]	Weight
80% or more	2

[1] The wood plank with WPS will be positioned close to the last plant. If this first WSP will be wet, the weights will be applied. If the robot indicates the area with missing plants, but fails to spray (as it pobbrably ran out of water) and the WSPs are all dry, the weight will be set to 1.

[2] Pay attention to drift from the previous rows as it might ruin the results.

60% to 79%	1.75
40% to 59%	1.5
Less than 40%	1.25
0 %, correct indication	1
0 %, false indication	0

where, if needed, the percentage will be rounded to the first integer value.

Crop plant damage by the robot will result in a penalty of 2% of total row length distance in meter per damaged plant. (Example: 10 rows x 10 m = 100 m max. distance, means a penalty of 2 m per damaged plant.)

In case the robot fails to detect the plants in the middle of row where the plants are not missing, evident as the robot will stop spraying and / or the light indicator will turn off, this will result in penalty points as in the case of damaged plants (e. g. one damaged plant per one false positive action)[3].

[3] Some robots might be quite accurate to detect where the plants are and where there are just (small portions) of leaves present. This might result in constant on / off spraying situation in areas where the plants are present. In order to avoid penalty points, the teams are advised to keep spraying / indicator on until the next plant (if present).

3 Task3: sensing and recognizing possible obstacles

3.1 General description

To be successful in the next task, the robots will be tested and evaluated how good they are in recognizing new possible obstacles. Therefore, set of images (one after another) will be placed in front of the robot, each of them from one of the three groups: a deer, a human and something else. The robots must have an acoustic and / or visual indicator that will let the jury / audience know what the robot sees: a human, a deer or unknown.

To make the competition as fare as possible, each of the teams will provide 3 images before the start of the tasks. A random selection will then be made where one of these 3 images will be used in the final set (so if they are 15 teams competing, the set will consist of 15 images). All images will then be printed (each) on a white A3 sheet of paper and place in random order in front of the robot at a distance of 1.5 m. The robots then have a 5 sec time frame to make a detection, recognize it and indicate what they see.

For this task, the robots will be place in the beginning of the field between the two plant rows, but will not move / drive during this task. Instead, the robots will focus on what is placed in front of them and make a classification. Only one classification per obstacle can be made and cannot be changed (only the first counts).

3.2 Rules for robots

Each robot must start the detection after a starting indication (acoustic signal) within 1 min. The maximum available time for sensing is 5 seconds per obstacle. There can be up to 10 seconds long window to change the pictures by the jury (by first removing the previous picture and placing the new). Once a detection is made, it cannot change in next 5 seconds. Only the first detection counts.

3.3 Points distribution

The jury assesses the detection and classification during the run:

Detected object and right category (true positive)	5 points
Detected object wrong category (false positive)	-5 points

4 Task4: static and dynamic obstacles

4.1 General description

This task is all about safety. The robots will drive through the field as in task 1, but without skipping the rows. In addition, they will have to detect static and dynamic obstacles that might / will come in its path. If the obstacle is dynamic, the robot will stop and make an acoustic sound and / or visual indication (eg. bright flashes) and the obstacle will move in 5 seconds, which means that the robot can continue the driving. If the obstacle is static, it will not move, and the robot must drive back and continue in to the next row.

As in task 3, the robots might encounter an obstacle, but now while driving. For this task there will be 5 obstacles on the field; 3 of them dynamic, and 2 of them static. For dynamic obstacles, a picture of a human will be placed and removed once a clear indicator (audio or visual sign) will be given by the robot. If no indication will be made, the obstacle will remain in its path and the robot will have to move backwards and continue into the next row and this will count as a false positive. For static obstacles, an image of a deer will be placed on the path of the robot and will not be removed, where the robot must give a clear indication what it recognized. If the robot gives a wrong indication it will count as a false positive.

In contrast to the previous task, the pictures of the obstacles will be provided to the teams before the event.

Crop plant damage by the robot will result in a penalty of 2% of total row length distance in meter per damaged plant. (Example: 10 rows x 10 m = 100 m max. distance, means a penalty of 2 m per damaged plant.)

4.2 Rules for robots

Each robot must start after a starting indication (acoustic signal) within 1 min. The maximum available time is 5 min.

4.3 Points distribution

The jury assesses the detection and classification during the run:

Path travelled	x*0.5 points
Successful detection of a static / dynamic obstacle (true positive)	10 points
Unsuccessful detection of a static / dynamic obstacle (false positive)	-10 points

5 Task5: Freestyle

5.1 Description

Teams are invited to let their real robot perform freestyle on the event venue. The explanation as well as the performance must be shown to the jury and the spectators. The team must explain the idea and the machine. Comments during the robot's performance are also welcome.

Creativity and fun are required for this task as well as an application-oriented performance. The freestyle task should be related to an agricultural application. Teams will have a time limit of five minutes for the presentation including the robot's performance.

5.2 Points distribution

The jury will assess by points P the

- P1 : agronomic idea (originality)
- P2 : technical complexity
- P3 : robot performance

Points P will be given from 0 (insufficient) to 10 (excellent) for each criterion (P1, P2 and P3). The total points will be calculated using the following formula:

final points = P1 + P2 + P3

6 End results

The teams will collect their points by combining the results of first 4 tasks. For each of the tasks the team can get up to 25% of the points for the overall assessment and the percentage for each of the task will calculated based on the point they won divided by points won by the winning team of that task. To avoid possible negative points, all points will be subtracted by the lowest points achieved in that task. So, the final scores will be calculated as follows:

$$Overall_{points}(x) = \sum_{n=1}^{4} \frac{points(n,x) - \min(task(n))}{4 * (\max(task(n)) - \min(task(n)))}$$

where x is the number of the team, points(n,x) represent the points for team x in task n, and task(n) and a vector of all the points for that specific task (n).