Field Robot Event 2022 – The Tasks and Rules

Simulation and Field Contest from 14th to 16th June 2022
Together with the DLG-Field Days, Germany

Remark: The organizers tried to describe the tasks and assessments as good and fair as possible, but all teams should be aware of that we might need to modify the rules before or even during the contest! These ad hoc changes will always be decided by the jury members.

Aim of the Field Robot Event 2022

The aim of the Field Robot Event 2022 is to compare robot programming and behaviors in a modeled and real field. That's why we decided to go for a hybrid format. We will try to minimize the difference between the virtual field and the real field as much as possible. Therefore, it will be a big challenge for the organizers especially to create and adapt the field simulations including crop plants, weeds and other objects.

All task runs in simulation, field performance and awarding will be broadcasted to the internet by the platform DLG connect with access after free registration.

The simulation will be during the morning and the field runs will be during the afternoon. Each task will be conducted for simulation AND for a real field.

Comments for the simulation contest:

A model of a standard robot (Jackal CLEARPATH ROBOTICS, German dealer NEXT company) will be provided for those teams who want a model. Teams can also come with their own machine models. The models must be realistic in function and physics (kinematics, sensing and other abilities). Basic parameters must be considered and respected.

For those teams who are not coming to the event personally, we offer the opportunity that their codes can also be tested in the real field during the afternoon runs.

Teams should inform us about what sensors etc. they want to use. The organizers will decide about if the requested components can be used. After the organizers agreed to the use of a component they will ensure that they can be executed within the composed environments (simulation).

All source codes (models for sensors etc.) should be send to the organizing team and made public before the event. In general, we want to promote the use of open source sensors.

More information on the webpage: https://www.fieldrobot.com/event/

0. Introduction

The organizers expect that a general agreement between all participating teams is that the event is held in an "Olympic Manner". The goal is a fair competition, without any technological or procedural cheating or gaining a competitive advantage by not allowed technologies. The teams should even provide support to each other with all fairness. Any observed or suspected cheating should be made public immediately.

The jury members are obliged to act as neutrals, especially when having relations to a participating team. All relevant communication will be in English. For pleasing national spectators, the contest moderation could partly switch to a national language.

If teams come with more than one machine the scoring, ranking and awarding will always be machine related and not team related.

During the machine runs for each task the team members are not allowed to be in the inner contest area where the maize plants are and close to the robot during the performance. If the robot performance fails, it has to be stopped from outside with a remote switch. To enter the inner contest area is only allowed after (!) the robot has stopped. The control switch activating team member then can go to the machine and manually correct it. When the team member has left the inner contest area only then the robot is allowed to continue its operation. This procedure shall promote the autonomous mode during the contest and make the performance more attractive to spectators.

All participating teams must contribute to the event proceedings with an article describing the machine in more details and perhaps their ideas behind it or development strategies in general. The submission of text is after the event.

0.1. General rules

The use of a GNSS receiver is not allowed except for the Free Style. The focus for the other tasks in terms of localization shall be on relative positioning and sensor-based behaviors.

Crop plants

The crop plants for the tasks is maize (corn) or *Zea Mays*[1] . The maize plants will have a height of approximately 20 - 40 cm. The concrete appearance of the crop plants is depending on the location specific growing conditions and varies from year to year.

Damaged plants

A damaged plant is a maize plant that is permanently bent, broken or uprooted. The decision about a maize plant to be damaged by a machine will be made by the jury members or assistants.

Parc fermé

During the contests, all robots have to wait in the parc fermé from the beginning on. Therefore, no more machine modification to change the machine performance is

[1] Plant density 10 m^2, row width of 0.75 m, plant spacing 0.133 m

allowed during the task runs with regard to fairness. All PC connections (wired and wireless) have to be removed or switched off and an activation of a battery saving mode is recommended. This shall avoid having an advantage not being the first robot to conduct the task. The starting order will be random. When a robot will move to the starting point, the next robot will already be asked by the parc fermé officer to prepare for starting.

Navigation

The drive paths of the robots shall be between the crop rows and not above rows. Large robots or robots which probably partly damage the field or plants will always start after the other robots, including the second chance starting robots. However, damaged plants will be replaced by spare ones, to always ensure the same operation conditions for the robots.

0.2. General requirements for all robots

Autonomous mode
All robots must act autonomously in all tasks except for the freestyle. In the freestyle a full autonomous mode would be perfect but perhaps hard to realize. Driving by any remote controller during the other tasks is not allowed at any time. This includes steering, motion and all features that produce movement or action at the machine. Stopping and starting function for manual corrections of the machine is the only exception.

During start, the robot is placed at the beginning of the first row. The starting line is marked with a white cross line. Any part of the robot must not exceed the white line in the start. For signaling the start and end of a task there will be a clear acoustic signal. After the start signal, the robot must start within one minute. If the robot does not start within this time, it will get a second chance after all other teams finished their runs, but it must - after a basic repair - as soon as possible brought back into the parc fermé. If the robot fails twice, the robot will be excluded from the task starting list.

Start & Stop Controller
All robots must be equipped with and connected to one wireless remote START/STOP controller. Additional remote displays are allowed but without user interaction, e.g. notebook or laptop.

Preferably, the remote controller is a device with two buttons clearly marked START and STOP. Alternatively, the coding may be done with clear green and red colors.

It is allowed to use a rocker switch with ON/OFF position with hold, if the ON and OFF are clearly marked with text in the remote controller.

Any button of the remote controller may not be touched for more than one second at a time. In other words, a button, which has to be pressed all the time, is not allowed.

The remote controller may contain other buttons or controls than the required/allowed START/STOP inputs, but no other button may be used at any time during any task.

Before the start of any task, the remote controller must be placed on the table that is located at the edge of the field. One member of the team may touch the START and STOP inputs of the remote controller. The possible remote display must be placed on the same table too.

The remote controller must be presented to the Jury members before the run. A jury member will watch the use of the START/STOP remote controller during the task execution. Other remote controllers besides START/STOP controller are strictly prohibited to be used at any time.

In each task, the robot must be started by using the remote controller START input, not pressing any buttons on the robot itself.

During any task, while the robot is stopped in the field by using the remote controller, it is allowed to use any buttons of the robot itself, e.g. to change the state of the navigation system.

Implementation note: If using Logitech Cordless Gamepad or equivalent as a remote controller, the recommended practice is to paint/tape one of the push button 1 green and push button 2 red, to mark START and STOP features.

Manual correction of the robot
One team member is allowed to enter the field after the same (!) team member has pressed the STOP button of the remote controller and the robot has completely stopped (no motion). It is recommended to install some indicator onto the robot to see that the robot is in STOP mode before entering the field in order to avoid disqualification.

The START/STOP operator is also responsible for the eventually manual robot corrections. Due to the fact that it can be difficult for him/her to monitor the robot's behavior from a large distance, another team member can be inside the 2 m area between a red textile tape and the crop plant area (see picture 1 and 2 at the end of this document). This second team member could give instructions to the operator, but this supporting person is only an observer and is not allowed in any case to enter the crop plant area or interact with the robot.

After leaving the remote control on the table, the operator is allowed to rotate - not to move - the robot in the field. The only exception for moving is when the robot may need to get back to the path if a wheel or track of the robot has collided stem of maize plant, to avoid further damage of plants. Carrying the robot is only allowed after significant navigation errors in order to bring it back (!) to the last correct position and orientation.

0.3. Awarding and Prizes
The performance of the competing robots will be assessed by an independent expert

jury committee. Beside measured or counted performance parameters, also creativity and originality (freestyle) will be evaluated. There will be an award for the first three ranks of each task. All tasks together will yield two overall competition winners: one for simulation and one for the field competition. Points will be given as follows:

Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	etc.
Points	30	28	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	etc.

Participating teams result in at least 1 point, not participating teams result in 0 points. If two or more teams have the same number of points for the overall ranking, the team with the better placements during all tasks will be ranked higher.

1. Task 1 “Navigation”

1.1. General description

For this task, the robots are navigating autonomously through a modeled and real maize field. Turning has to follow adjacent rows for track 1 to 7. From exiting track 7 the robot has to 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 the Appendix.

1.2. Virtual and Field Environment

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 7 – the robot has to follow a particular given turning and row pattern. This pattern will be made available 15 minutes before the contest starts for the real-world contest. In the simulation, the pattern is made available in the ‘driving_pattern.txt’ file in the `map` folder of the `virtual_maize_field` package of the robot container. The content of this file may look as an example like:

S – 1L – 1R – 3L – 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.

1.3. Rules for robots

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

1.4. Assessment

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. (This year example 10 tracks x 10 m = 100 m max. distance, means a penalty of 2 m per damaged plant.)

2. Task 2 “Sensing, Mapping and Object Removal”

2.1. General description

The robots shall detect objects as weeds (5 dandelions) and beer cans (5 objects as examples for waste) and map or geo-reference them. The coordinate system shall be locally in horizontal field dimensions. Good row navigation is required. There will be ten (10) objects in total distributed across the virtual and real field.
The robot has to generate a file (pred_map.csv) with detected objects and their coordinates relative to the given reference points (pillars with QR code). The reference point of the coordinate system (0,0) is in the center of the field. Each line in the submitted file shall represent an object together with the coordinates x and y in horizontal plane in meters with 3 decimal points. Extra points can be obtained for object classification of weed or litter also indicated in the file. The file layout as an example is:

```
X,Y,kind
1.412,2.301,weed
-2.352,3.321,litter
1.873,-1.322,weed
etc...
```

After the run, this file should be given to the jury immediately on a USB-stick from the organization. In the simulation, this file should be saved in the `map` folder of the `virtual_maize_field` package in the robot container. The removal of waste to headlands gains also extra points, see below.

2.2. Virtual and Field Environment

Objects are realistic weeds and cans e.g. of beer with different brands and colors. The objects will be placed randomly across the field. No objects are located on the headlands. The reference point of the relative coordinate system will be in the center of the field and not marked. The pillars show a QR code with the name of that pillar. The relative coordinates of the pillars will be provided to the teams on forehand in the field contest. In the simulation, the coordinates of the pillars will be provided in the markers.csv file in the map folder of the ‘virtual_maize_field’ package.
In the field, the robot should be able to make two different loud distinct sounds when it detects a weed or can. Both sounds should be different in order to indicate which kind of object was found. In the simulation, when the robot detects an object, it should publish the object type (‘weed’ or ‘litter’) to the ‘/fre_detections’ topic. This will spawn a marker in the simulation above the robot position.

2.3. Rules for robots

The maximum available time for the mapping run is 3 min, but if the robot successfully moves an object to the headline it will gain 1 min of time. This is to promote the waste removal and not to get punished for this useful action.

2.4. Assessment

The jury calculates and assesses the accuracy of the provided and mapped objects:

- Detected object and right category (true positive)	5 points
- Detected object wrong category (false positive)	minus 5 points
- Mapped object position to true position	points = f (distance error)

$$\text{Points} = f(x_{error}) = \begin{cases} 15 \quad if\ x \leq 2\ cm \\ 15.56 - 0.2817 * x \quad if\ x\ \leq 37.5\ cm \\ -5 \quad if\ x\ > 37.5\ cm \end{cases}$$

with x_{error}: distance error or Euclidean distance

Crop plant damage by the robot will result in a penalty of 4 points per plant.

2.5. Additional task for the field runs – Removal of waste objects

The robot can remove the 5 waste objects and place them outside the crop area on the headlands. The Jury or the simulator registers and assesses the number of objects where they are remaining after the run:

- Object picked up	3 points per object
- Object delivered to headlands	6 points per object AND a time bonus of 1 minute

The robot is allowed to push the object to the headland, but without a clear act of picking up, it will only earn points for the delivery. Crop plant damage by the robot will result in a penalty of 4 points per plant. The total travelled distance will not be assessed.

3. Task 3 “Freestyle”

3.1. General description

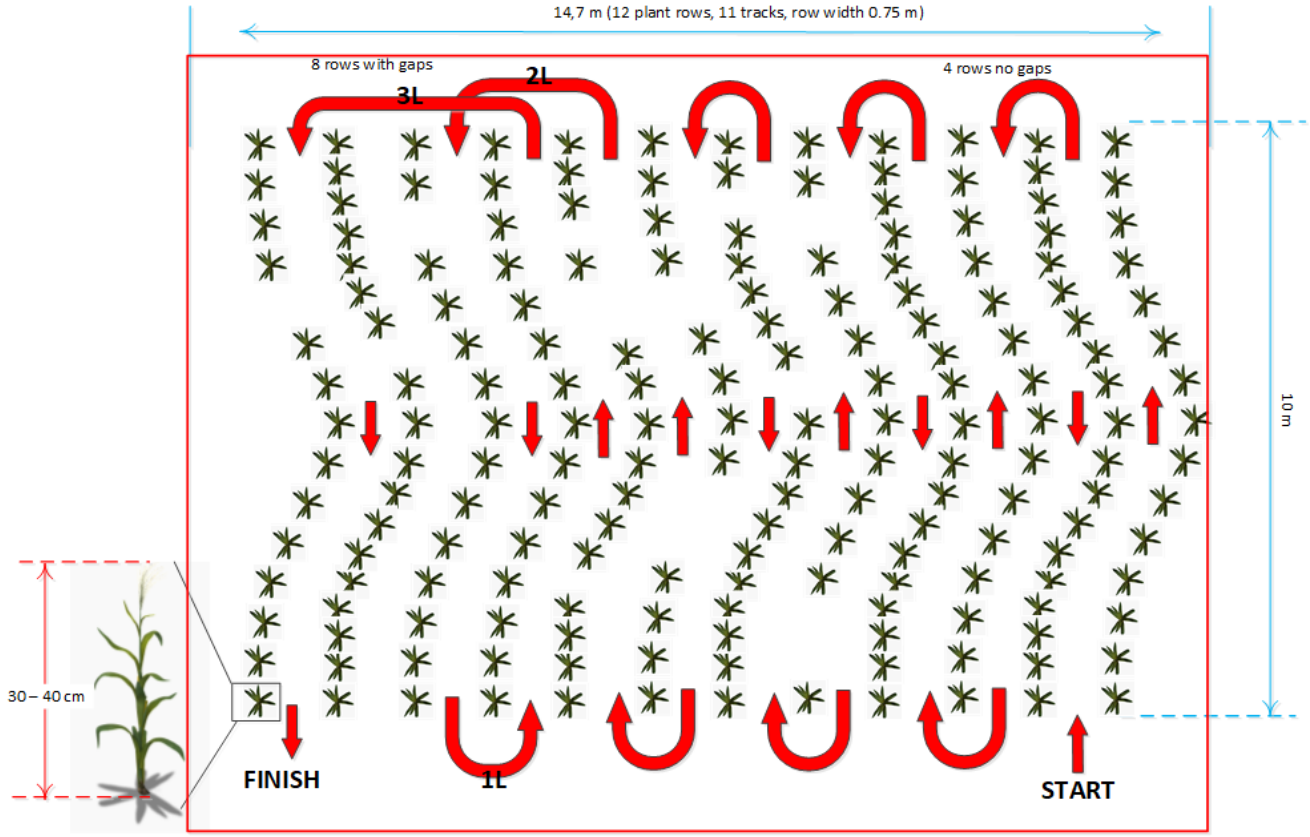
Teams are invited to let their virtual and real robot perform a freestyle operation at their home institution or in the virtual environments or on the events venue. The explanation as well as the performance shall be transmitted online via internet to the jury and the spectators. The team has to explain 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.

3.2. Assessment

The jury will assess by points P the
P_1 : agronomic idea (originality)
P_2 : technical complexity
P_3 : robot performance
Points P will be given from 0 (insufficient) to 10 (excellent) for each criterion (P_1, P_2 and P_3). The total points will be calculated using the following formula:
P_{final} points = $P_1 + P_2 + 2\ P_3$ (double weighing on performance)

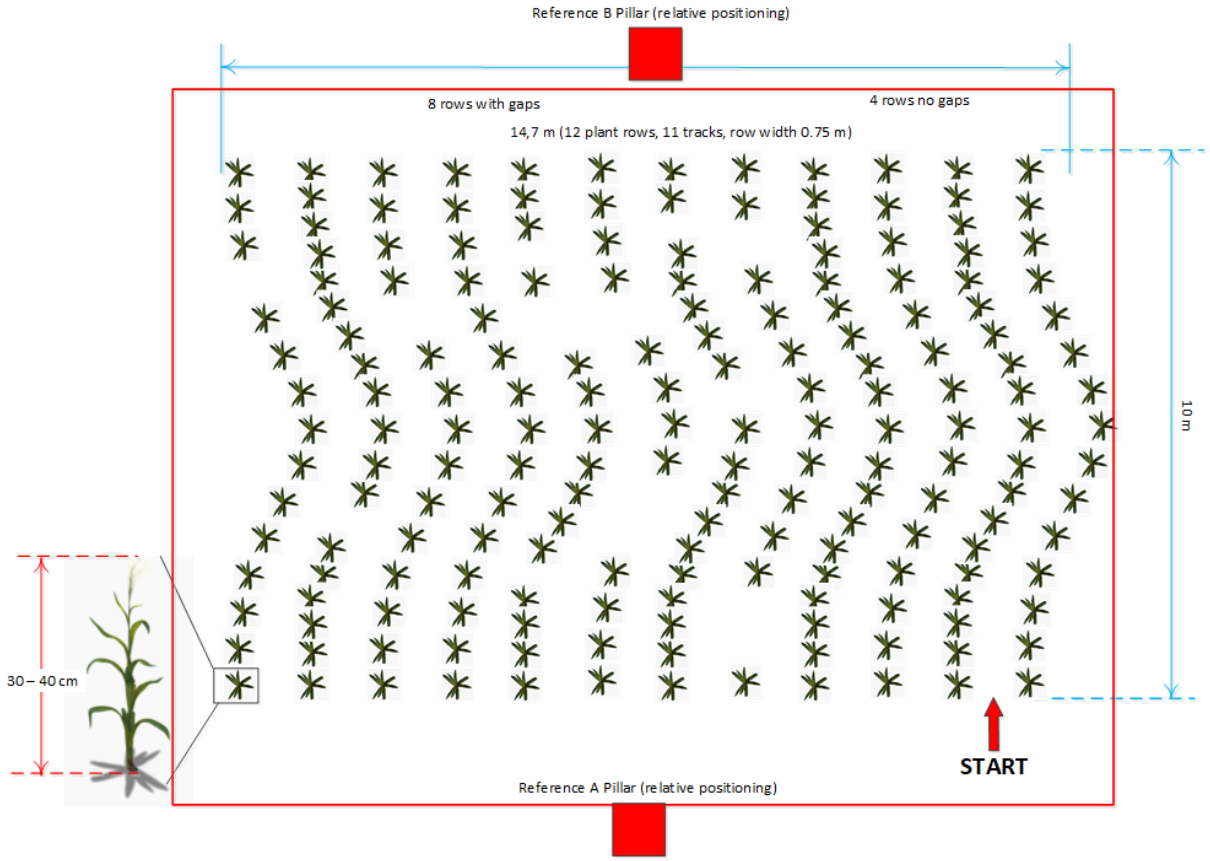
Appendix

Concept of field structure for task 1 (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.

Concept of field structure for task 2



Track 1 to 3 with no gaps, track 4 to 11 with gaps. The 10 objects (5 weeds and 5 cans) will distributed randomly within the field, but not on headlands. The reference point of the coordinate system is in the center of the field (0,0). The pillars will have coordinates as (Xpillar1,Ypillar1) for the upper one and (Xpillar2,Ypillar2) for the lower one.

These artificial dandelions will be used in the task 2. There will be 5 dandelions and 5 cans as litter within the field. There will be variations within the 5 dandelions in number of blossoms (0 to 5). At least one can will be damaged.

German provider of the dandelions:

https://www.seidenblumen-ross.de/search?sSearch=l%C3%B6wenzahn

You find them – the same company! - also at Amazon:

https://www.amazon.de/L%C3%B6wenzahn-Kunstpflanzen-k%C3%BCnstliche-Pflanzen-Kunstblumen/dp/B083LQFCPT/ref=sr_1_6?crid=2JKPWL2S45HT7&keywords=kunstblume+l%C3%B6wenzahn&qid=1650638823&sprefix=Kunstblume+l%C3%B6wenza%2Caps%2C86&sr=8-6&language=en_GB

Hans W. Griepentrog, Sam Blaauw, Rick van Essen 07.06.2022