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Field Robot Event

12th edition

17 - 19 June 2014

Program Booklet

UNIVERSITY OF HOHENHEIM

Field Robot Event 2014 - Task Description

Together with the DLG-Feldtage, 17th – 19th June 2014 at the
International DLG Crop Production Center (IPZ), Bernburg-Strenzfeld, Germany

Remark: We 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 discussed and decided by the jury.

0. Introduction

During the last years the conducted tasks were always related to crop row structures. Again in 2014 we will focus on crop rows. After having sunflowers and rose pots during last two years we will return to maize[1] in 2014 as used already during several previous FRE contests.

Five tasks will be prepared to challenge different abilities of the robots in terms of sensing, navigation and actuation. Traditionally as well as this year task 1 (basic navigation) and task 2 (advanced navigation) require proper sensing in order to achieve accurate and fast navigation between crop rows. In task 3 the agricultural application will be visible by letting the robots detect weed plants and create weed maps using positional information from a GNSS.

For task 4 always two teams will be asked to let their robots work together to show cooperative abilities. With regards to last contests the team or robot cooperation was highly appreciated. In 2014 we will conduct the popular discipline Freestyle as task 5.

In task 4 and 5 the teams are totally free in to present a robot performance based on their own innovative ideas. As during previous contests the general use of a GNSS system is NOT allowed, because the focus shall be on relative positioning and sensor based behaviours. However, in 2014 we will use them in task 3 for weed mapping (absolute positioning) and on team request in task 4 (Collaboration) and 5 (Freestyle).

All participating teams must contribute to the contest proceedings with an article describing the machine (mechanics and hard- & software) and perhaps their ideas behind or development strategies.

0.1. General rules

All machines shall operate in autonomous mode. Therefore, to control or guide them with laptops, specific controllers or other devices is not allowed. Furthermore, no remote hardware or data sources are allowed, only machine on-board systems shall be used. However, one person is allowed to follow the machine to correct it in case undesired performance or when an emergency stop is needed.

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

During the contests all robots have to wait in the parc fermé and no more machine modification to change the machine performance is - with regard to fairness - allowed. 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 the 1st robot will move to the starting point the next robot will already be asked by the parc fermé officer to prepare for starting.

At the starting point the robot must start within one minute. If the robot doesn't 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 ferme. If the robot fails twice, the robot will be excluded for that task.

For task 3 and on request for task 4 and task 5 two battery powered GNSS boxes including antennas will be provided by the organiser. The specifications will be published on the web pages in advance.

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 ensure always the same operation conditions for each run.

0.2. Awards

The performance of the competing robots will be assessed by an independent expert jury. Beside measured or counted performance parameters also creativity and originality especially in tasks 4 (Collaboration) and task 5 (Freestyle) will be evaluated. There will be an award for the first three ranks of each task. The basic (1), advanced (2) and professional task (3) together will yield the overall competition winner. Points will be given as follows:

Rank	1	2	3	4	5	6	7	8	9	etc.
Points	10	8	6	5	4	3	2	1	1	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 three tasks (1, 2 and 3) will be ranked higher.

1. Task "Basic navigation" (1)

1.1. General description

Within three minutes the robot has to navigate through long curved rows of maize plants (*picture 1* at the bottom of this text). The aim is to cover as much distance as

possible. On the headland, the robot has to turn and return in the adjacent row. There will be no plants missing in the rows. This task is all about accuracy, smoothness and speed of the navigation operation between the rows.

At the beginning of the match it will be told whether starting is on the left side of the field (first turn is right) or on the right side (first turn is left). This is not a choice of the team but of the officials. Therefore, the robots should be able to perform for both options. A headland width of 1.5 meters free of obstacles (bare soil) will be available for turning.

1.2. Assessment

The distance travelled in 3 minutes is measured. If the end of the field is reached in less time, this actually used time will be used to calculate a

bonus factor = total distance * 3 minutes / measured time.

The total distance includes travelled distance and the penalty values. Distance and time are measured by the jury officials.

Manual intervention during the within field operation will result in a distance penalty of 3 meter per touch. During headland turning – after exiting the rows - to help the robot finding the right row will be punished with a penalty of 5 meters. The number of interventions (touches) will be counted by the officials.

Crop plant damage by the robot (e.g. bended, broken or uprooted plants) will result in a penalty of 1 meter per plant. The officials will decide whether a plant is damaged or not.

The task completing teams will be ranked by the results of resulting total distance values. The best 3 teams will be rewarded. This task 1, together with tasks 2 and 3, contributes to the overall contest winner 2014. Points for the overall winner will be given as described under chapter 0.2 Awards.

2. Task "Advanced navigation" (2)

2.1. Description

Under real field conditions crop plant growth is not uniform and even obstacles may occur. Furthermore, sometimes the crop rows are not even parallel. We will approach these field conditions in the second task.

The robots shall achieve as much distance as possible within 5 minutes while navigating between straight rows of maize plants, but the robots have to follow a certain predefined path pattern across the field (*picture 2* at the end of this text). Additionally at some locations plants will be missing (gaps) at either one or both sides with a maximum length of 1 meter. There will be no gaps at row entries.

In order to challenge the robots' abilities to navigate 2 obstacles - e.g. traffic cones - will be placed at not published positions between some rows and will block the path for the robot. The robot has to reverse and to continue in the described path pattern. The coded pattern takes blocked paths into account.

A headland width of not more than 1.5 meters will be available for turning.

The code of the path pattern through the maize field is done as follows: S means START, L means LEFT hand turn, R means RIGHT hand turn and F means FINISH. The number before the L or R represents the row that has to be entered after the turn and the single

number 0 means return in the same path. Therefore, 2L means: Enter the second row after a left-hand turn, 3R means: Enter the third row after a right hand turn. The code for a path pattern for example may be given as: S - 3L - 0 - 2L - 2R - 1R - 5L - F.

The code of the path pattern is made available to the competitors 15 minutes before putting all robots into the parc fermé. Therefore, the teams will not get the opportunity to test it in the contest field.

2.2. Assessment

The distance travelled in 5 minutes is measured. If the end of the field is reached in less time, this actually used time will be used to calculate a

bonus factor = total distance * 5 minutes / measured time.

The total distance includes travelled distance and the penalty values. Distance and time are measured by the jury officials.

Manual intervention during the within field operation will result in a distance penalty of 3 meter per touch. During headland turning – after exiting the rows - to help the robot finding the right row will be punished with a penalty of 10 meters. The number of interventions (touches) will be counted by the officials.

Crop plant damage by the robot (e.g. bended, broken or uprooted plants) will result in a penalty of 1 meter per plant. The officials will decide whether a plant is damaged or not.

The task completing teams will be ranked by the results of resulting total distance values. The best 3 teams will be rewarded. This task 1, together with tasks 2 and 3, contributes to the overall contest winner 2014. Points for the overall winner will be given as described under chapter 0.2 Awards.

The *picture 2* shows an example of how the crop rows and the path tracks could look like for task 2. Be aware, the row gaps and the path pattern will be different during the contest!

3. Task "Professional Application" (3)

3.1. Description

The third task is based on a realistic scenario within precision farming. Five weed plants will be randomly placed within crop rows. These will be yellow golf balls placed on tees on the ground in line with the crop plants on the soil surface. During the run the weeds have to be indicated and mapped. By using an RTK GNSS system an absolute geo-referenced weed map has to be generated. A suitable device[2] as a battery powered receiver with antenna and interface cable will be provided by the organiser. The specifications will be published in advance (size, weight, interface and data protocol). A testing box will be available for testing purposes the day before the contest. The submitted final map must consist of coordinates of the individual weed plants. The robot has 5 minutes to complete the run.

It will be a combined task consisting of three robot performance skills that need to be performed simultaneously during the run.

[2] Coordinates will be in UTM (NMEA $PTNL, PJK string), output frequency 5 Hz

Subtask 1: Autonomous navigation between curved crop rows of maize plants each second row (!), not adjacent rows!

Subtask 2: The weed plants have to be indicated to the jury by very clear optical, acoustical or other signals while the machine is passing the weed.

Subtask 3: The weed plants have to be mapped with absolute coordinates by using the GNSS system. Immediately after the run the team has to deliver a text file[3] consisting of the values of the five coordinate pairs.

3.2. Assessment

For this task the robot shall of course navigate autonomously. Therefore, each manual correction will result in a penalty of 0.10 points. The total travelled distance will not be assessed.

Crop plant damage by the robot (e.g. bended, broken or uprooted plants) will result in a penalty of 0.20 points per plant. The officials will decide whether a plant is damaged or not.

The number of correctly indicated weed plants will be counted by the jury and points will be given for each correctly indicated weed (max. 5 points). The reference point on the machine must be visible e.g. by an indicator. Each wrongly indicated weed will be punished by 0.20 point value.

The generated map consisting of coordinates (x, y values in meters) of the weed plants will be analysed. If the error (distance between true and mapped weed coordinate) is less than 0.75 meter a point will be given as correctly mapped weed (max. 5 points). If teams have the same number of points then the mean error of all coordinates will be used for the ranking (the smaller the better). Files with more than 5 coordinate pairs will not be assessed. After the run the text file must be delivered to the parc fermé officer e.g. file saved on a USB stick.

Before the run of each team the GNSS-box will be checked concerning the RTK fix status[4].

The task completing teams will be ranked by the number of points for correctly indicated weeds (max. 5) and correctly mapping weeds (max. 5 and perhaps mean error). The best 3 teams will be rewarded. This task 3, together with tasks 1 and 2, contributes to the overall contest winner 2014. Points for the overall winner will be given as described in chapter 0.2 Awards.

4. Task "Cooperation" (4)

4.1. Description

Two-team groups will conduct a cooperative task. The groups are free to define their tasks as long as it is a task with two robots working together. For this purpose there has to be a somehow communication between the robots. However, the robots could also "communicate" via pressure sensors or vision etc. Everything is possible in this task as

[3] Including team name, date and time stamp, data pairs of number of detected weed and coordinates (easting and northing in meters with 3 decimal points). There shall be no further information in the text files. An example file will be on the FRE 2014 webpage on the download flag.
[4] The robot is welcome to also indicate GNSS mode status.

long as it is cooperative. The communication could also be done by Wi-Fi and / or ISO 11783 protocol. Nevertheless every other way of communication is allowed and we are open for good ideas. This is a nice step forward in technology because communication between field robots will be very important in the future.

In 2014 we are allowing to use the 2 available GNSS systems. Therefore, two collaborating machines can base their performance on absolute positioning. The organisers must be informed in advance if teams want to go for this option.

The teams have to indicate their participation during the contest registration. For the contest they will be chosen by the organizer and will be pronounced as early as possible. Team groups will have a time limit of five minutes for conductance.

4.2. Assessment

The jury will assess the (i) underlying idea, the (ii) technical challenge and the (iii) robot performances by giving points from 1 (fair) to 10 (excellent) for each. The three criteria will be weighted by factors 1, 1 and 2. The teams will be ranked by highest points.

The task 4 is optional and will be awarded separately. It will not contribute to the contest winner 2014.

5. Task "Freestyle" (5)

5.1. Description

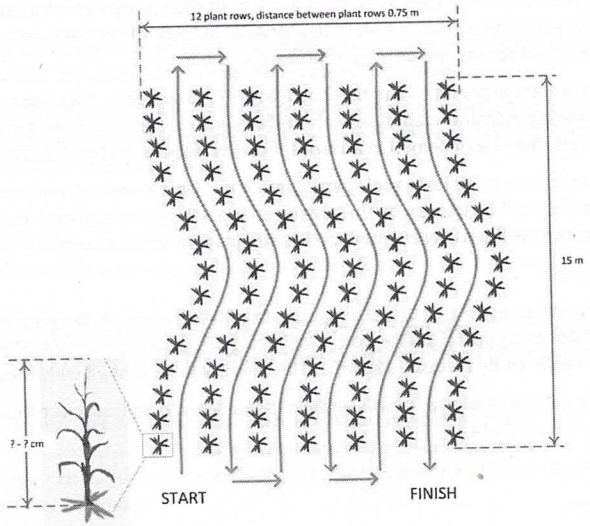
Teams are invited to let their robots perform a freestyle operation. Creativity and fun is required for this task as well as an application-oriented performance. One team member has to present the idea, the realization and perhaps to comment the robot's performance to the jury and the audience. The freestyle 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. Assessment

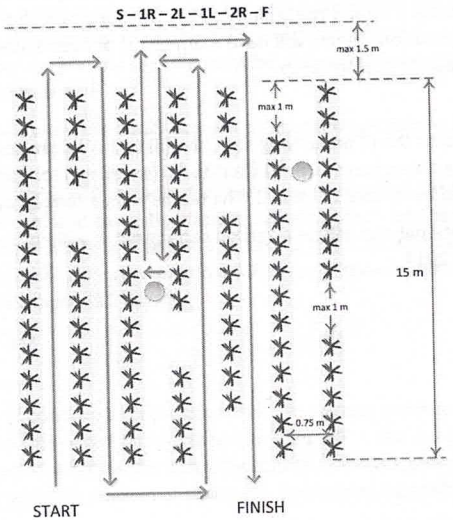
The jury will assess the (i) underlying idea, the (ii) technical challenge and the (iii) robot performance by giving points from 1 (fair) to 10 (excellent) for each. The three criteria will be weighted by factors 1, 1 and 2. The teams will be ranked by highest points.

The task 5 is optional and will be awarded separately. It will not contribute to the contest winner 2014.

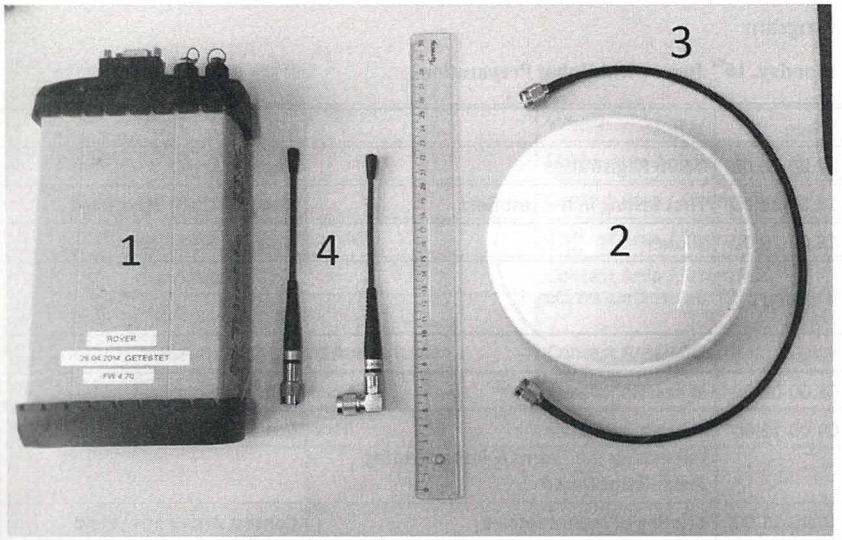
Appendix



Picture 1 – Dimensions and row pattern for task 1



Picture 2 – Dimensions and example (!) row pattern for task 2



Picture 3 – GNSS system (Trimble AgGPS RTK Base 450): (1) receiver, (2) antenna Trimble AG25 GNSS with magnetic base, (3) cable for connecting the satellite antenna to the receiver and two options regarding the (4) radio antenna for RTK correction signal. No power supply is required due to built-in battery.