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UNIVERSITY OF HOHENHEIM

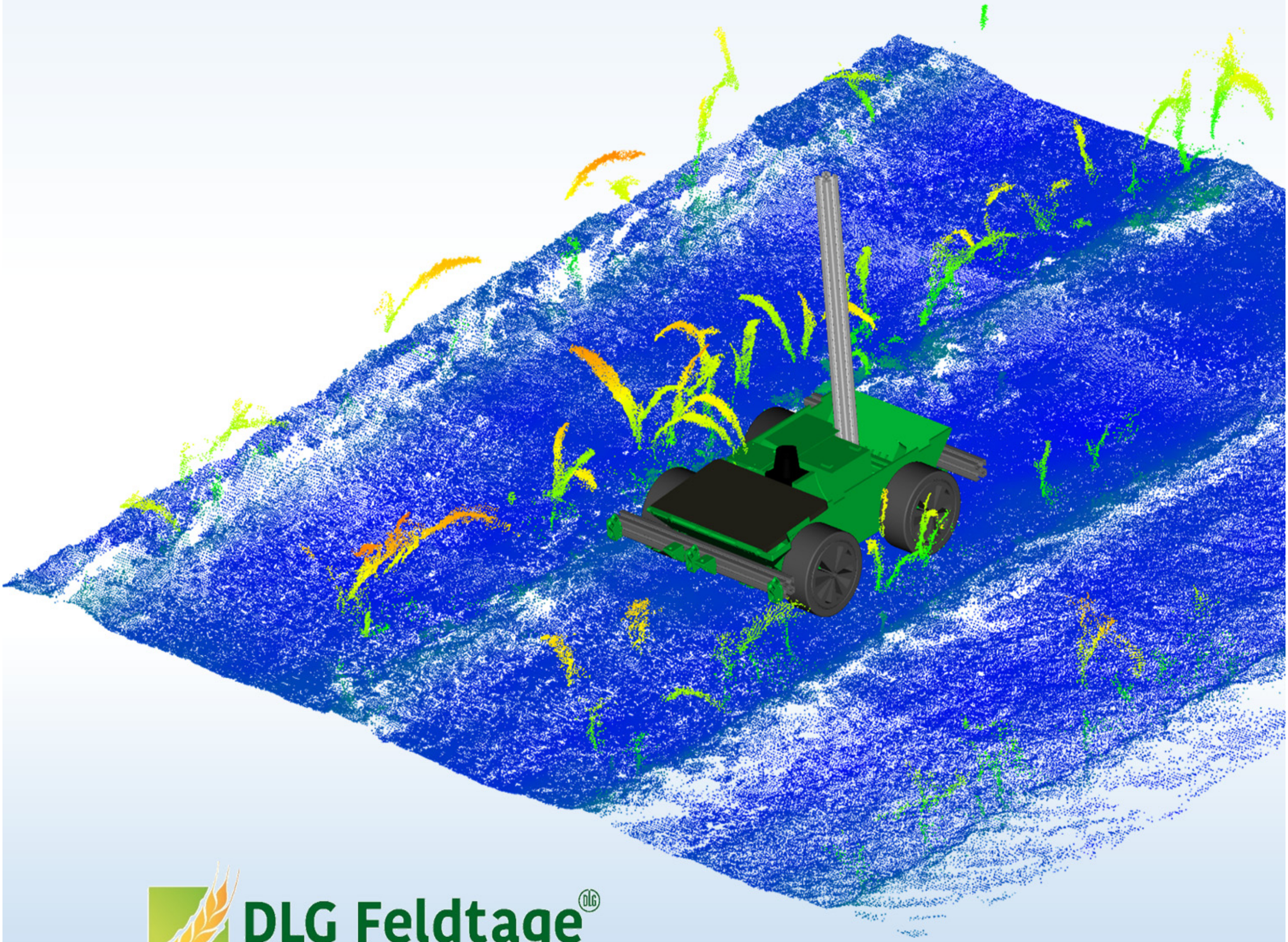
Field Robot Event

Contest + Design + Demo + Talks

16th edition

12th – 14th June 2018

Program Booklet



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Acknowledgements

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Sponsors

We thank all the **sponsors** for their contribution and
their simple and generous support.

Special thanks to **Sylvia Looks** from the CLAAS FOUNDATION for extra
funding of teams coming first time or with a new machine to the competition.

Welcome to the Field Robot Event 2018!

The 16th Field Robot Event will take place at the International DLG Crop Production Center in Bernburg-Strenzfeld, Germany from Tuesday June 12th to Thursday June 14th 2018. The FRE 2018 is held again in conjunction with the DLG-Feldtage for the third time. The DLG Field Days are an international outdoor crop production exhibition organised by the Deutsche Landwirtschafts-Gesellschaft e.V. (DLG).

The FRE has been founded by the Wageningen University in 2003 in order to motivate students to develop autonomous field robots. The agricultural tasks will be challenging for the robots and their students behind them, but beside engineering skills we want to promote meeting international colleagues for exchanging expertise & experience but also having fun during the contest!

The international Field Robot Event is an annual outdoor contest on an agricultural field, where students and their supervisors compete within several tasks in autonomous navigation and other operations. In 2018 the contest again will be different compared to last years. During the two application tasks in weed control the solutions are expected to be complex & challenging and hence more realistic. Furthermore, in 2018 there will be again a Robot Design Award awarded by the international jury.

We wish all teams to have good ideas for solving problems (challenges!), good success in implementation and fun & good luck!

On behalf of the organising team

Hans W. Griepentrog

You find more information on the internet: http://www.fieldrobot.com/event/

Field Robot Event 2018 - Task Description

Together with the DLG-Feldtage, 12th – 14th June 2018 Bernburg-Strenzfeld, 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.

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 connections 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.

In 2018 five tasks will be prepared to challenge different abilities of the robots in terms of sensing, navigation and actuation: Basic Navigation, Advanced Navigation, Sensing, Weeding Control and Free Style (option).

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

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.

During the machine runs for each task no team members are 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.

0.1. General rules

The use of a GNSS receiver is not allowed except for the Free Style in Task 5[1]. The focus for the other tasks shall be on relative positioning and sensor based behaviors.

Crop plants

The crop plant in task 1 to 4 is maize (corn) or Zea Mays2. The maize plants will have a height of approximately 20 - 40 cm. The general appearance of the crop plants is location specific as well as yearly specific.

Damaged plants

[1] If you wish to use a GNSS, you must bring your own.

A damaged plant is a maize plant that is permanently bent, broken or uprooted. The decision that a maize plant is damaged by a machine or not would be made by the jury members.

Parc fermé

During the contests, all robots have to wait in the parc fermé and no more machine modification to change the machine performance is allowed 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 each run.

0.2. General requirements for all robots

Autonomous mode

All robots must act autonomously in all tasks, including the freestyle. Driving by any remote controller during the task 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 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. 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 colours.

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.

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.

While the robot is STOPPED and one team member is allowed to be in the field, besides rotating the robot, the team member is allowed to touch the buttons and other input devices mounted on the robot. Other remote controllers besides START/STOP controller are strictly prohibited to be used at any time.

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 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 within the row, where 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.

In the headland, only rotating to give the robot a new orientation is allowed, no moving or even carrying is allowed at all.

0.3. Awards

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, especially in task 4 and task 5 (freestyle), will be evaluated. There will be an award for the first three ranks of each task. The basic navigation (1), advanced navigation (2), sensing (3), and weeding (4) together will yield the overall competition winner. 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 four tasks (1, 2, 3 and 4) will be ranked higher.

1. Task "Basic navigation" (1)

1.1. General description

For this task, the robots are navigating autonomously. Within three minutes, the robot has to navigate through long curved rows of maize plants (picture 1 at the end 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 2 meters free of obstacles (bare soil) will be available for turning.

1.2. Field Conditions

Random stones are placed along the path to represent a realistic field scenario. The stones are not exceeding 25 mm from the average ground level. The stones may be small pebbles (diameter <25 mm) laid in the ground and large rocks that push (max 25 mm) out from the ground, both are installed. In other words, abilities as defined by machine ground clearance and to climb over small obstacles are required.

A red 50 mm wide textile tape is laid in the field 2 m from the plants.

1.3. Rules for robots

For starting, the robot is placed at the beginning of the first row without exceeding the white line.

If the robot is about to deviate out from the path and hit maize plants, the team member with the remote controller must press STOP button immediately. The STOP button must be pressed before the robot damages stems of the maize plants. The team is responsible to monitor the behavior of the robot and to use the STOP button when necessary.

1.4. Assessment

The distance travelled in 3 minutes is measured. 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:

Final distance = corrected distance * 3 minutes / measured time.

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 1 meter per plant.

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, 3 and 4, contributes to the overall contest winner 2018. Points for the overall winner will be given as described under chapter 0.3 Awards.

2. Task “Advanced navigation” (2)

2.1. General description

For this task, the robots are navigating autonomously. Under real field conditions, crop plant growth is not uniform. Furthermore, sometimes the crop rows are not even parallel. We will approach these field conditions in the second task.

The rules for entering the field, moving the robot, using remote controller etc. are the same as in task 1.

No large obstacles in the field, but more challenging terrain in comparison to task 1.

The robots shall achieve as much distance as possible within 3 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 in row entries.

The robot must drive the paths in given order. 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. 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 - 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. Field conditions

Random stones are placed along the path, to represent realistic field scenario where the robot should cope with holes etc. The stones are not exceeding the level of 35 mm from the average ground level in the neighborhood. The stones may be pebbles (diameter <35 mm) laid in the ground and large rocks that push (max 35 mm) out from the ground, both are installed. In other words, the robot must have ground clearance of this amplitude at minimum, and the robot must be able to climb over obstacles of max 35 mm high. No maize plants are intentionally missing at the end of the rows. However, due to circumstances of previous runs by other robots, it is possible that some plants at the end of the rows are damaged. The ends of the rows may not be in the same line, the maximum angle in the headland is ±15 degrees.

No large obstacles in the field and all rows are equally passable. A red 50 mm wide textile tape is laid in the field 2 m from the plants.

2.3. Assessment

The distance travelled in 3 minutes is measured. 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:

Final distance = corrected distance * 3 minutes / measured time.

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 1 meter per plant.

The task completing teams will be ranked by the results of resulting total distance values. The best 3 teams will be rewarded. This task 2, together with tasks 1, 3 and 4, contributes to the overall contest winner 2018. Points for the overall winner will be given as described under chapter 0.3 Awards.

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 "Selective Sensing" (3)

3.1. General description

For this task, the robots are navigating autonomously. The robots shall detect weed patches represented by red and blue golf tees. You can find further details regarding the tees at the end of this document (Appendix B). Task 3 is conducted on the area used in task 2 with straight rows. Nevertheless, simple row navigation is required and the robot has to turn on the headland and return in the adjacent row. There will be nine (9) weed patches in total with three patches on each of the first three between row spacing. The end of the third row spacing is the finish line for this task 3.

The rules for entering the field, moving the robot, using remote controller etc. are the same as in task 1 and task 2.

3.2. Field conditions

The weeds are objects represented by blue and red golf tees distributed between the rows in the soil. The weeds are placed as weed patches in a squared area of 25 cm × 25 cm. The total number of weeds is 10 per weed patch but there are different combinations regarding the number of the red and the blue tees. The tees are in the soil with only the head or upper part visible (ca. 1 to 2 cm). The weed patches are located in a centered band of 25 cm width between the rows. Robots may drive across or over them without a penalty. No weeds are located within the rows and on the headlands. A possible example is illustrated in picture 3.

3.3. Rules for robots

Each robot has only one attempt. The maximum available time for the run is 3 minutes. The robot should detect the weed patches. The detection of the weed patch with a higher number of red tees shall be indicated by one (!) loud acoustic signal while the detection of the weed patch with a higher number of blue tees must be confirmed by two (!)

consecutive and loud acoustic signals. The length of each acoustic signal may not be longer than 1 second.

3.4. Assessment

The jury registers and assesses the signaling as follows:

- True positives (correct signals, correct detection) + / plus 6 points,
- False positives (wrong signals, but weed detection) + / plus 2 point
- False negatives

(No signals with weeds or signals with no weeds) - / negative 2 points.

Crop plant damage by the robot will result in a penalty of 1 point per plant.

The total travelled distance will not be assessed. The task completing teams will be ranked by the number of points as described above. The best 3 teams will be rewarded. This task 3, together with tasks 1, 2 and 4, contributes to the overall contest winner 2018. Points for the overall winner will be given as described in chapter 0.3 Awards.

4. Task "Soil-engaged weeding" (4)

4.1. General description

For this task, the robots are navigating autonomously. The robots shall remove weeds from three (3) weed patches represented by red golf tees (Appendix B). Probably a soil engaged active tool is needed to succeed in this task. In order to minimize the used energy the tool should be active only on the weed spots. Furthermore, the amount of soil moved away from the spots shall also be minimized. Task 4 is conducted on the area used in task 2 with straight rows. Nevertheless, no specific path sequence will be given as in task 2 and the robot has to turn on the headland and return in the adjacent row. The three weed patches will be placed one on each of the three first row spacing. Thus, the end of the third row spacing is the finish line for this task.

The rules for entering the field, moving the robot, using remote controller etc. are the same as in task 1, 2 and 3.

4.2. Field conditions

The weed patches are objects represented by red golf tees distributed between (!) the rows in the soil like in task 3. The weeds are placed as weed patches in a squared area 25 cm × 25 cm (10 red tees per weed patch). Only the upper part of the tees is visible (ca. 1 to 2 cm). The weed patches are located in a centered band of 25 cm width between the rows. Robots may drive across or over them without a penalty. No weeds are located within rows and on headlands. A possible example is illustrated in picture 4.

4.3. Rules for robots

Each robot has only one attempt. The maximum available time for the run is 5 minutes. The robot shall remove the red tees from the weed patch. Each tee removed from the weed patch counts, each tee moved to the headland outside the crop area counts more and each tee collected on the robot and transferred to the end of the third row spacing counts most. Tillage outside the weed patches will be punished..

4.4. Assessment

The Jury registers and assesses the number of weeds (tees) where they are remaining after the run:

- Tees that are stored and transferred to the finish line + / plus 4 points/tee
- Tees delivered to the headlands + / plus 2 points/tee
- Tees cleared and removed from weed patches + / plus 1 point/tee.

Tilled travelled distance between the rows and outside the patches will be punished with 1 negative point per meter even in an intermittently mode. A tolerance of 10 cm for tillage before and after the weed patches will not be punished. The jury will assess the cleanliness of the tees, means the amount of soil picked up with the tees and hence transported away from the spots (0 to 10 points penalty).

Crop plant damage by the robot will result in a penalty of 1 point per plant.

The total travelled distance will not be assessed. The task completing teams will be ranked by the number of points as described above. The best 3 teams will be rewarded. This task 4, together with tasks 1, 2 and 3, contributes to the overall contest winner 2018. Points for the overall winner will be given as described in chapter 0.3 Awards.

5. Task "Freestyle" (5)

5.1. Description

Teams are invited to let their robots perform a freestyle operation. Creativity and fun are 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

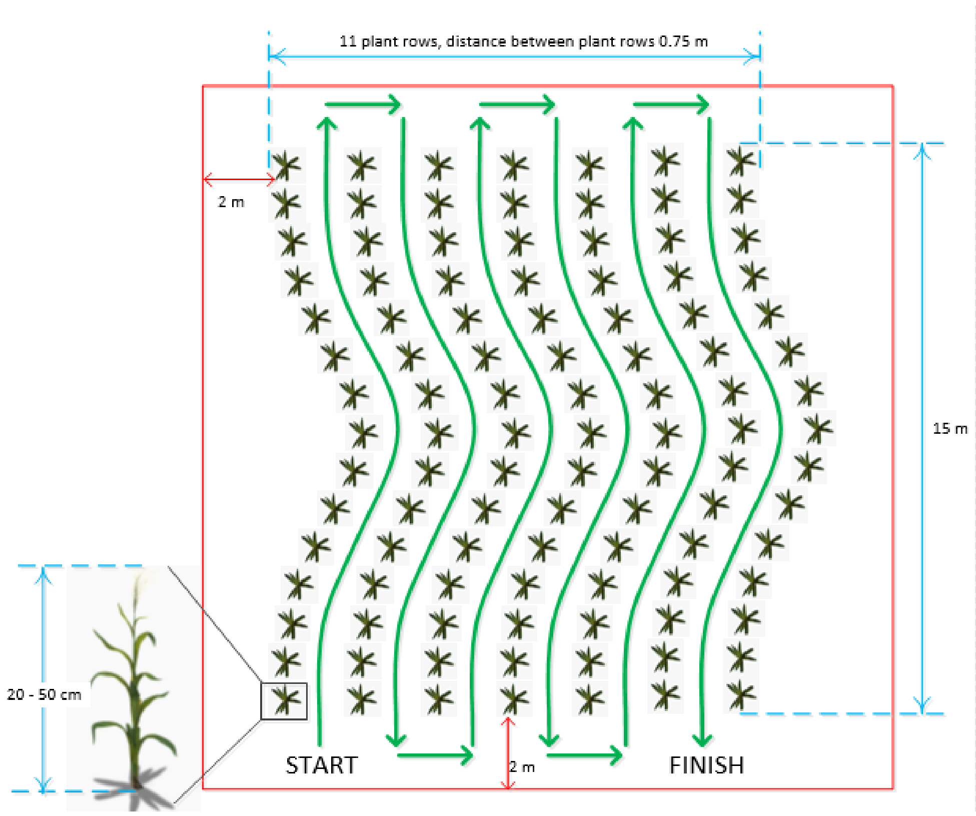
The jury will assess the (i) agronomic idea, the (ii) technical complexity and the (iii) robot performance by giving points from 0 (insufficient) to 10 (excellent) for each.

The total points will be calculated using the following formula:

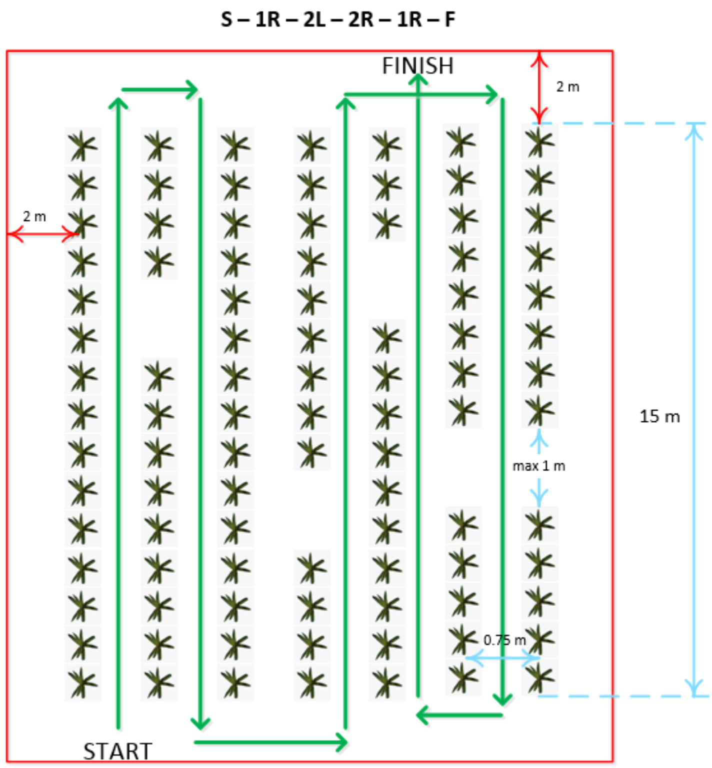
Final points = (agronomic idea + technical complexity) * performance.

The task 5 is optional and will be awarded separately. It will not contribute to the contest winner 2018.

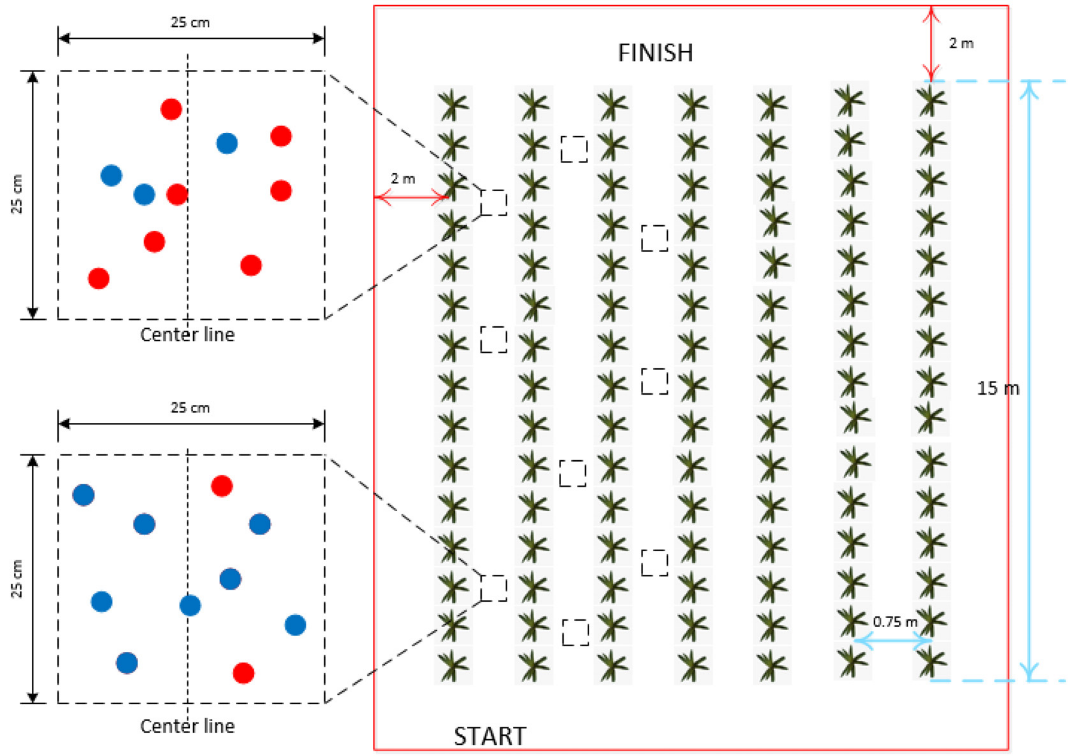
Appendix



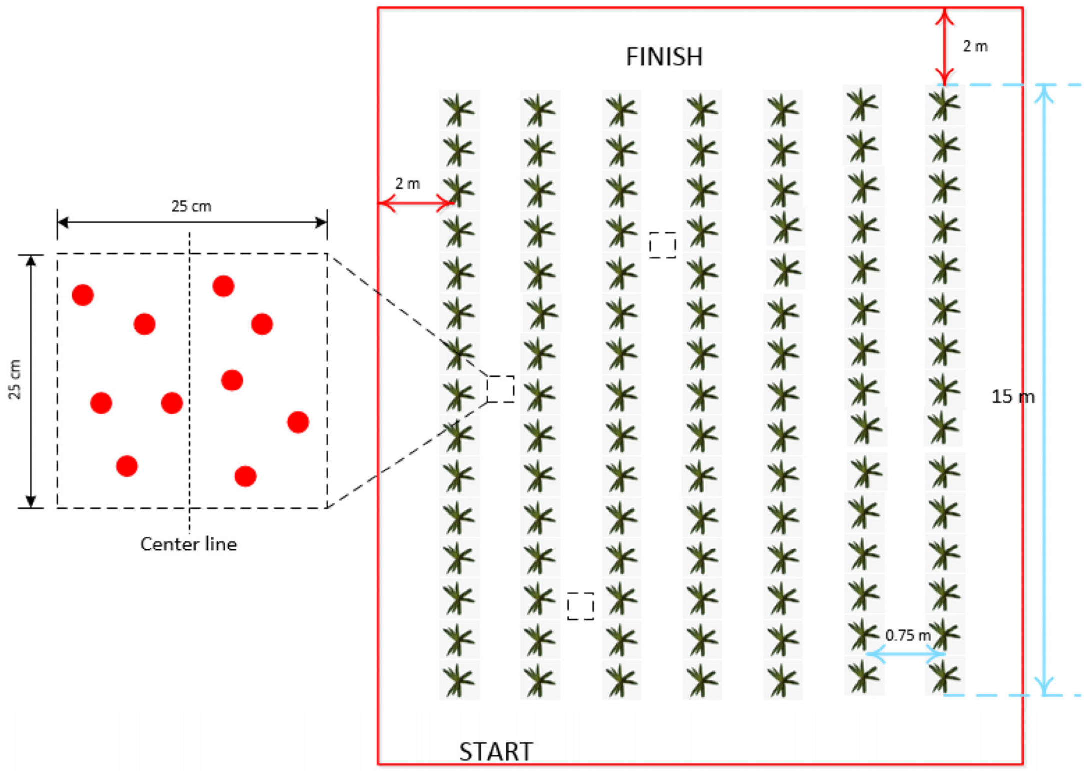
Picture 1 – Dimensions and row pattern for task 1



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



Picture 3 – Possible locations of the weeds for task 3. Two zoom areas of 25 cm x 25 cm of two weed patch (with different combinations of blue and red weeds) are also indicated.



Picture 4 – Possible locations of weed patches for task 4. The zoom area of 25 cm × 25 cm of one weed patch (with ten red weeds) is also indicated.

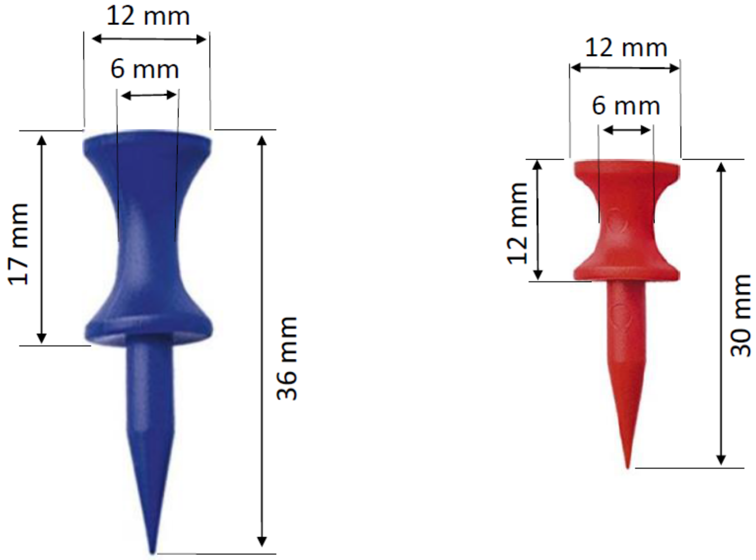
Appendix B

Red tees

https://www.amazon.de/40-Plastic-Step-Tees-Abstandtees-Stufentees-Eisen/dp/B00TE28HT6/ref=sr_1_1?s=sports&ie=UTF8&qid=1523354524&sr=1-1&keywords=Stufentees+rot

Blue tees

https://www.amazon.de/40-Plastic-Step-Tees-Abstandtees-Stufentees-Hybride/dp/B00TE2HOJA/ref=pd_sim_200_1?_encoding=UTF8&psc=1&refRID=MEZEVTJC768PYQTZM0JP



HWG & DP 2018.04.16

Robot Design Award

Beside the task awards this year the exclusive and invited sponsor partner **top agrar** will donate the robot design award. **top agrar** will evaluate the robots by reading the booklet, examining the robots during practice and by interviewing the teams during the competition and comparing to state-of-the-art within robotics.

top agrar will assess the robots in relation to the technological system solution in terms of the theoretical potential for navigating on agricultural fields and conducting applications. The performance of the robots during the competition shall NOT be included in the assessment, because the competition will cover this already.

Criteria will be e.g.:

- Appearance
- General chassis and drive concept
- Control and sensor concept
- Functionality potential
- Reliability potential, Robustness
- Energy concept
- Material, Weight
- Costs (for machine without sensors)

top agrar will hand out the noncash award to the team with the best design during the main awarding ceremony. **top agrar** contributes to the event as a regular sponsor.

Field Robot Event 2018
top agrar Design Award

Field Robot Demo

Phoenix (University of Hohenheim)

The Phoenix is an electro-powered robot designed for agricultural use. Typical applications are scouting, monitoring and several operations e.g. mechanical weeding. Furthermore, in research it is used as an autonomous sensor platform to develop new sensing systems and in teaching to allow project work with autonomous vehicles. For flexible machine balancing of various operations the drive chassis with the crawlers can longitudinally be shifted. The machine was developed by University of Hohenheim and University of Southern Denmark (SDU).

There will be probably more robots participating in the demo.

Field Robot Talks

Wednesday, June 13th, 10.00 – 11.00, FRE Awarding Tent

Agriculture of the future: The era of small field robots?

While the development of small autonomous field robots has been in the focus of the "International Field Robot Event" from the beginning in 2003, commercially available agricultural machines have become even larger. Thus the "autonomation" of larger existing machines and the development of smaller field robots seem to be alternative technological concepts for a sustainable future agriculture.

Smaller robots from companies - such as Xaver, NAIO or BoniRob presented at the Field Robot Event 2016 (DLG Field Days) - are now approaching the market and initiate questions, as for example:

- Is this the starting point of a new era of small and very small agricultural machinery?
- What makes small robots better than large agricultural machines?
- Are they more precise or more flexible, what are most promising first applications?
- Will new – digitally focused – companies take over the business of today's machinery industry?

These and other questions about the "era of small field robots!?" will be discussed at the "Field Robot Talks 2018" by experienced members of the "International Field Robot Event" community:

Sam Blaauw (Wageningen University, The Netherlands)
Hans W. Griepentrog (University of Hohenheim, Germany)
Timo Oksanen (Aalto University, Finland)
Jurij Rakun (University of Maribor, Slovenija)
Ole Ravn (Technical University of Denmark/Lyngby)
Arno Ruckelshausen (University of Appl. Sciences Osnabrück, Germany)
Jan Schattenberg (Technical University Braunschweig, Germany)
Sam Wane (Harper Adams University, Great Britain)

Participating Teams

1. Bullseye

Team members:	Anna Lisa Nooren, Alexander van Tuyll van Serooskerken, Cor Feitsma, Harmen van der Vliet, Jaap Weerheim, Jan Morssink, Merel Arink, Michiel Mans, Robert van de Ven, Ronald Konijn, Stef Wesselink		
Team captain:	Dana Vernooji		
Instructor(s):	Ing. SK (Sam) Blaauw, Thijs Ruigrok		
Institution:	Wageningen University and Research		
Department:	Farm Technology Group (FTE)		
Country:	Netherlands	City:	Wageningen
Street / Number:	Bornsesteeg 48	ZIP Code	6708 PB
Email:	robatic.bullseye@gmail.com		
Webpage:	www.robatic.nl		

THE MACHINE			
W x L x H (cm):	40 x 110 x 53	Weight (kg):	35
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	1.3	Turning radius (cm):	0
Battery type / capacity (Ah):	2 x 5000 mAh	Total motor power (W):	222
No. sensors internal / external: Sensor(s) type(s):	1 x 2D LiDAR sensor: Sick LMS-111-10100 2 x IMU: Xsens Mti-300 AHRS 1 x USB 3.0 color industrial camera: DFK 33UX174 4 x Maxon motors 2 x Arduino		

Controller system software description (sensor data analysis, machine control etc.)
The software runs in Robot Operating System (ROS) Kinetic on Ubuntu 16.04LTS and is programmed in Python and C++.

Controller system hardware description (motor controller, computer etc.)
Rhe 2D Sick LMS-111 laser scanner data is processed by an MSI Z871 motherboard running an Intel Core i7-4770T processor. To control the 4 independently driven and steered wheels, 4 Maxon Motors are used. EPOS2 controllers are used for propulsion and 4 Motion Mind Rev2 controllers for steering. Two additional Arduinos are used to operate the emergency stop and the pick up system. The whole system is powered by tow 22.2 V 6S 20C 5000mAh Li-Po batteries.

Short strategy description for navigation and applications
The Maize rows are scanned with the laser scanner fracing forward. With these measurements combined with the odometry data from the motorcontrollers and the IMU a map is generated. Within this map lines are found for determining the place of the maize rows. Then the robot can navigate between them. Once the headland is reached the robot will use the same map for determining its position and the amount of rows it has passed since entering the headland. For tee detection an USB 3.0 industrial color camera is used, together with vision software.

These are the commercial team sponsors & partners (if there are)
Main sponsor: Steketee Sponsors: Agrifac, Livestock robotics, Kverneland, Xsens Can still increase

2. Carbonite

Team members:	Marcus Bolter; Junus Hirner; Jacob Schupp		
Team captain:	Jacob Schupp		
Instructor(s):	Lukas Locher		
Institution:	Schuelerforschungszentrum Südwürttemberg		
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Email:	locher@gymueb.de		
Webpage:	http://www.sfz-bw.de/		

THE MACHINE			
W x L x H (cm):	45x67x27	Weight (kg):	ca. 13
Commercial or prototype:	prototype	Total no. of wheels / no. driven wheels:	4/4
Drivetrain concept / max. speed (m/s):	4-Wheel-Drive,Front- and rear differential gear/ 2.5 m/s	Turning radius (cm):	65
Battery type / capacity (Ah):	Lipo/16Ah	Total motor power (W):	250
No. sensors internal / external: Sensor(s) type(s):	1 gyroscope/ 2 Sick laser scanners, one camera		

Controller system software description (sensor data analysis, machine control etc.)
Nodes from Robot-Operating-System (ROS) supplemented with our own ROS Nodes written in C++
Controller system hardware description (motor controller, computer etc.)
Brushless DC-Motor controller, 4 digital Servos from Dynamixel, Intel NUC PC with Ubuntu Linux, 2 Stm32F0 Microcontrollers (Odometrie and Signal-Sound)
Short strategy description for navigation and applications

Pending on environmental effects, navigation by laser scanner or camera. Recondensing of drive way by laser scanner or camera.
These are the commercial team sponsors & partners (if there are)
Schülerforschungszentrum Südwürttemberg, Landesstiftung Badenwürtemberg (Mikro Makro Mint), Wilhelm Stemmer Stiftung

3. BANAT

Team members:	Paul Calescu, Daniel Neamtiu, Iulia-Eliza Crisan, Silviu Batranut, Catalin Almasan		
Team captain:	Paul Calescu		
Instructor(s):	Sorin Nanu, Sorin Bungescu		
Institution:	"Politehnica" University and Banat University of Agricultural Sciences and Veterinary Medicine Timisoara		
Department:	Automation and Applied Informatics and Machinery and Equipment for Agriculture and Food Industry		
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Email:	Paul.calescu@gmail.com / sobungi@yahoo.com		
Webpage:	-		

THE MACHINE			
W x L x H (cm):	30 x 50 x 60	Weight (kg):	10
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	1.5 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	3x NiMh - 7.2V 3600 mAh	Total motor power (W):	2 x 80 (160)
Sensor(s) type(s) used:	Lidar, Compass		

Controller system software description (sensor data analysis, machine control etc.)

Task 1 & 2:

- Position and orientation relative to the plants is controlled by LIDAR running a python controller on a Chromebox PC
- Orientation and speed are controlled by PID controller on ATMega2560 controller based on direct acquisition of global orientation from Compass and relative direction prescribed by LIDAR
- At the end of the row, the LIDAR counts how many rows the robot passes by until returning and reports back to Mega controller.

Task 3:

- Image processing using Pixy CMUcam. Direction is held straight by above mentioned mechanism and Pixy Camera command a buzzer when desired pattern is detected.

- Pixy Camera is linked to Arduino Uno controller completely independent of the rest of the robot. Task 4: - No clear strategy yet;

Controller system hardware description (motor controller, computer etc.)
Two entities live inside the robot: - An ATMega2560 controller responsible for software regulators (PID direction control / Engine speed control) and various state machines (Remote control, safe stop, automatic control, automatic row navigation, automatic row turn) - A Chromebox PC as a middle-man between the Mega controller and the LIDAR. Its job is to read the LIDAR data and provide the Mega with a clear direction to navigate. Mega controller will then assume the new orientation with help from the Compass as a differential measure. - The robot uses an HC-05 Bluetooth adaptor for remote control and the “ControlJoystick” application commonly found on Google Play Store running on an Android Device. - An HM55B Hitachi compass for the Global orientation regulator Scanse LIDAR

Short strategy description for navigation and applications
The robot will navigate the rows holding a steady distance with the use of a LIDAR device and an electronic compass. The LIDAR dictates the new orientation and by reading the compass, the said orientation is achieved very quickly. The LIDAR will detect the end of the row, the place where the robot needs to turn. It also helps by counting the rows it passes by. To turn, we use the compass again and after re-entry, we switch back to LIDAR.

These are the commercial team sponsors & partners

4. The Great Cornholio

Team members:	Johannes Barthel, Sebastian Böhm, Benedict Hadi, Steffen Hellermann, Mathias Igelbrink, Alexander Kemeter, Julius Kirfel, Julian Klose, Andreas Linz, Thomas Ludemann, Jannik Redenius, Jan Roters, Lars Schilling		
Team captain:	Thomas Ludemann		
Instructor(s):	Andreas Linz		
Institution:	University of Applied Sciences Osnabrück		
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Email:	Thomas.ludemann@hs-osnabrueck.de		
Webpage:	https://www.hs-osnabrueck.de/de/field-robot-team/		

THE MACHINE			
W x L x H (cm):	47x80x42	Weight (kg):	25
Commercial or prototype:	Prototype, based on Fraunhofer Volksbot design	Number of wheels:	4/4
Drivetrain concept / max. speed (m/s):	Differential drive / 1.4 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	2x Lead Acid Battery/ 14,4 Ah (24V)	Total motor power (W):	2x 150 (300)
Sensor(s) type(s) used:	1/4, rotary encoder, laser scanner, camera module, inertial measurement unit (IMU)		

Controller system software description (sensor data analysis, machine control etc.)
The basic framework used inside Cornholio is ROS. It helps us to handle different sensor information in a convenient way and feed these into our algorithms. We use several ros-nodes for all kinds of sensors and actuators to control our robot.

Controller system hardware description (motor controller, computer etc.)
The heart of Cornholio is a fanless pokini-i computer. It uses an i7 processor and has an SSD hard disk. The motors/motor controller included in our system are produced by maxon. Cornholio has two of these motors to achieve the differential driving. Each one controls one side of the robot.

Short strategy description for navigation and applications
The navigation is based on the free space approach using laser scanner data. The turning at the end of the rows uses the IMU sensor to perform a turn into the next row and heads back into the field. Apart from that we use external cameras and deep learning techniques to detect the golftees. For picking up that golftees we use a rake like construction. Its design has the advantage that Cornholio does not have to dig into the ground.

These are the commercial team sponsors & partners (if there are)
AMAZONE, IOTEC, IBS, SICK, MÄDLER, XSENS, ELECTRONIC ASSEMBLY

5. Beteigeuze

Team members:	Thomas Friedel, Hao Gong, Friedolin Gröger, Philip Kiehnle, Carsten Naber, Manuel Muth, Anton Schirg, Erik Wustmann		
Team captain:	Erik Wustmann		
Instructor(s):	mechanics: Sebastian Blickle electronics: Friedolin Gröger software: Anton Schirg organisation: Nicolas Kessle		
Institution:	Kamaro Engineering e.V. at Karlsruher Institut für Technologie		
Department:	MOBIMA/ FAST		
Country:	Germany	City:	Karlsruhe
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Email:	mail@kamaro-engineering.de		
Webpage:	www.kamaro-engineering.de		

THE MACHINE			
W x L x H (cm):	50 x 100 x 65	Weight (kg):	40
Commercial or prototype:	Prototype	Number of wheels:	4/4
Drivetrain concept / max. speed (m/s):	4-Wheeldrive/ 2m/s	Turning radius (cm):	50
Battery type / capacity (Ah):	6 cell LiPo/ 10 Ah	Total motor power (W):	220
Sensor(s) type(s) used:	LIDAR SICK LMS100, LIDAR SICK TIM551, 2x absolute encoder Pepperl&Fuchs CSS36M, 2x stereo camera Intel Realsense R200, fisheye camera, IMU BOSCH BNO055		

Controller system software description (sensor data analysis, machine control etc.)
The robot software is implemented on top of the ROS Software Stack. This means that the software is separated in so called nodes which solve small parts of the overall problem. There is a crawl row node keeping the robot in the middle between two rows of corn, a turn node which manages the switching between the rows and a localisation node providing the first two nodes with an accurate localisation to assist them. The localisation as well as a detection node using

opencv empower the robot to detect golf balls. A state machine orchestrates the nodes to achieve the correct interplay for the given tasks.

Controller system hardware description (motor controller, computer etc.)
Mechanical: In order to full fill the requirements of a robot driving in a field the drive chain was designed as a 4-Wheeldrive with a single, central electric motor which can provide a torque up to 9Nm per wheel. The power transmission flows on two self-designed differentials in the front and in the back of the robot. Each axle mounting has its own suspension ensuring a smooth ride in rough terrain. Front and back axis can be steered independently therefore also diagonal movements are possible. Electrical: The central computing unit is a desktop computer mainboard in the mini-itx format with a Intel i5 quadcore processor and 8 Gb of ram. Low level hardware interaction and motor control via CAN-Bus is done on a ARM Cortex M4 Board. The microcontroller communicates with the computer via USB.

Short strategy description for navigation and applications
We will use the LIDAR installed at the front to navigate between the rows of corn plants. For the weeding task we use a camera for detecting the golf balls and a 3D-printed construction for spraying. As our freestyle task we are planning to analyse the condition of the plants. We will use the stereo cameras to create a point cloud to measure their height or at least to differentiate the heights of different plants. Further we want to try to determine the health situation of the plants.

These are the commercial team sponsors & partners (if there are)
Companies: SICK, Dunkermotoren, Schaeffler, Nozag, Igus, CONEC, Pepperl+Fuchs, Ganter Griff, Eurocircuits Institutes at the KIT: MOBIMA/FAST, WBK

6. Volcano

Team members:	Breksam Khaled Morsi Ali Khallaf -Mohamed Abdellatif Aly Ibrahim Elsabbagh-Ahmed Salah Elmaghawri Sayed Ahmed		
Team captain:	Breksam Khaled Morsi Ali Khallaf		
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Email:	egyptianroboticsacademy@gmail.com		
Webpage:			

THE MACHINE			
W x L x H (cm):	30 x 30 x 30	Weight (kg):	2
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Ability to track signals as fast as 360 pulses per sec	Turning radius (cm):	7
Battery type / capacity (Ah):	NiMH (7.2v-3000mAh)	Total motor power (W):	
Sensor(s) type(s) used:	2 sensors ultrasonic sensor-LDR sensor		

Controller system software description (sensor data analysis, machine control etc.)
Arduino is preferred here than raspberry pi because Arduino is open source, offer same required features with less cost. Type of Arduino will be used is mega because Number of analog and digital pins are greater than other types of Arduino . It has 54 digital input/output pins, 16 analog inputs and memory large enough as 8KB SRAM, 256KB flash. The Mega has four hardware serial ports, which means maximum speed.

Controller system hardware description (motor controller, computer etc.)
We will use in our project:

▪ DC motor: will be used in motion of the body of the car robot, because Speed control, quick starting, stopping, reversing and acceleration. ▪ High Torque. ▪ Servo motor: will be used in motion of Ultrasonic because controlled movement is required. ▪ Control rotation angle, speed, position and synchronism.

Short strategy description for navigation and applications
ultrasonic sensor: • ultra sonic sensors are characterized by their readability as it can do most complex tasks as object detection. LDR sensor: • An LDR is a component that has a variable resistance that changes with the light intensity that falls upon it.

7. Maize Runner

Team members:	Raffaele Barucci, Thomas Thuesen Enevoldsen, Carsten Dalacker, Ramon Buchaca Tarragona, Alejandro García-Vaquero Velasco, Sarah Ellinor Engell		
Team captain:	Raffaele Barucci		
Instructor(s):	Henning Si Høj, Nils Axel Andersen		
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Email:	hsih@elektro.dtu.dk		
Webpage:	http://www.aut.elektro.dtu.dk		

THE MACHINE			
W x L x H (cm):	33 x 55 x 44	Weight (kg):	30
Commercial or prototype:	Prototype	Number of wheels:	4/2
Drivetrain concept / max. speed (m/s):	2 m/s	Turning radius (cm):	50
Battery type / capacity (Ah):	12V lead acid / 14	Total motor power (W):	200
Sensor(s) type(s) used:	6/2 Gyroscope, wheel encoders, camera and lidar.		

Controller system software description (sensor data analysis, machine control etc.)
The robot will be running the newest version of Mobotware, DTU's own plug-in-based software platform for robots, which will be used for basic navigation and dealing will the given tasks of the competition.

Controller system hardware description (motor controller, computer etc.)
The main computing hardware is an Intel NUC. Furthermore, the embedded electronics for the low-level interface has an ARM microprocessor running on a custom PCB.

Short strategy description for navigation and applications
Navigation: The lidar is used to follow the path within the plants. When the robot reaches the end of the rows, the turning maneuver uses odometry. Tee detection: A camera will be used to detect the golf tees. The image processing will be running on software based on OpenCV. Tee collection:

A trolley containing the collection mechanism will be attach at the rear part of the robot. The design is based on a rotary cylindrical mechanism with transversal aluminum bars.

These are the commercial team sponsors & partners (if there are)
The CLAAS Foundation has provided us with 1500€ to overhaul the internal electronics.

8. ERIC

Team members:	Alex Fisher, Megan Platt, Rhys Thomas		
Team captain:	Alex Fisher		
Instructor(s):	Ianto Guy / Sam Wane		
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Webpage:	http://www.harper-adams.ac.uk/		

THE MACHINE			
W x L x H (cm):	45 x 80 x 50	Weight (kg):	11
Commercial or prototype:	Prototype	Number of wheels:	4 /4 WD
Drivetrain concept / max. speed (m/s):	4WD / 8m/s	Turning radius (cm):	90
Battery type / capacity (Ah):	2 x 11.1V LiPo / 6 Ah	Total motor power (W):	30
Sensor(s) type(s) used:	4 x 2D Lidar laser scanner (external), 2 x PIXY CMU Cam5 (external), 1 x Rotary encoder (internal), 1x Magnetic compass (external)		

Controller system software description (sensor data analysis, machine control etc.)
Arduino software on-board Eric and the remote base using Processing. Modular structured code run on distributed hardware, using sensor inputs to determine program flow.

Controller system hardware description (motor controller, computer etc.)
Laptop for remote monitoring through XBee. On board control hardware consists of Arduino Micros for sensor processing and chassis control; motor controller for speed; servos for steering; and Arduino Mega for vehicle control through I2C bus. Simple Controller for Stop/Go functions.

Short strategy description for navigation and applications
Using feedback from the 2D laser scanners to determine route through navigation courses. Headland turning assisted by compass and rotary encoder. PIXY cameras used for weed detection and to help control robotic arm with weed removal.

These are the commercial team sponsors & partners (if there are)
The Team are sponsored by The Douglas Bomford Trust, Syngenta and Pepperl + Fuchs GB ltd.

9. FloriBot

Team members:	Marlon Augustin; Benedict Bauer; Lukas Eberle; Michael Gysin; Torsten Heverhagen; Markus Joos; Benjamin Lauf; Andreas Pister; Philipp Rösner		
Team captain:	Benedict Bauer		
Instructor(s):	Prof. Torsten Heverhagen		
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Email:	benedict.bauer@hs-heilbronn.de		
Webpage:	www.floribot.de		

THE MACHINE			
W x L x H (cm):	55 x 78 x 70	Weight (kg):	20
Commercial or prototype:	Prototype	Number of wheels:	3 / 1
Drivetrain concept / max. speed (m/s):	Differential wheeled / 2 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	Li-Ion 25.2 V / 18	Total motor power (W):	200
Sensor(s) type(s) used:	Laser scanner / 1, Motor Encoder / 2, IMU / 1, Temperature / 1, Camera / 2		

Controller system software description (sensor data analysis, machine control etc.)
We are running the robot operating system based on Ubuntu Linux. For the programming of machine control and sensor data analysis, we are mainly using Matlab/Simulink with the robotics system toolbox.

Controller system hardware description (motor controller, computer etc.)
Our computer is based on an Intel i5 processor with 16GB RAM and an SSD HD. Communication with sensors and actors is done with USB and RS232. Sensors are laser scanner, camera and wheel encoders. Actors are servomotors and a pan-tilt-unit.

Short strategy description for navigation and applications
Our strategy is to extract a line feature out of the plants and to navigate according to the extracted line. At the end of the row, the robot drives a circle until it recognizes the row again.

The tees are recognized using a camera and collected using a kind of a fork in combination with the pan-tilt-unit.

These are the commercial team sponsors & partners (if there are)
Claas Foundation Servo motors are sponsored by ebm-papst

10. FarmBEAST

Team members:	Aljaz ZAJC, Benjamin ZALOZNIK, Erik RIHTER, Gasper FRIDRIH, Jakob SAFARIC, Jernej MLINARIC, Kristijan POLOVIC, Luka SELIH, Marcos MIZERIT, Matic RASL, Peter BERNAD, Rok FRIS, Zan MONGUS		
Team captain:	/		
Instructor(s):	Prof. dr. Miran LAKOTA doc. dr. Jurij RAKUN		
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THE MACHINE			
W x L x H (cm):	52,7 x 65 x 50	Weight (kg):	35
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	0.5	Turning radius (cm):	75
Battery type / capacity (Ah):	6	Total motor power (W):	800
Sensor(s) type(s) used:	5 LIDAR (single and multi channel),2 x camera, IMU		

Controller system software description (sensor data analysis, machine control etc.)
Linux Ubuntu, Robot Operating System

Controller system hardware description (motor controller, computer etc.)
Raspberry Pi 3 Model B (low level computer) + Intel NUC 7i7BNH (high level computer)

Short strategy description for navigation and applications
Custom infield navigation algorithm based on LIDAR and IMU readings.

These are the commercial team sponsors & partners (if there are)
SMT, CLAAS, EMSISO

11. HELIOS

Team members:	Mohammad Al Zoubi, David Bernzen, Tobias Lamping, Steffen Lohmann, Constantin Ruhe, Christian Schaub, Enrico Schleef, Christopher Sontag, Timo Timm, Sven von Höveling		
Team captain:	David Bernzen, Christian Schaub, Christopher Sontag		
Instructor(s):	Tobias Blume		
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THE MACHINE			
W x L x H (cm):	35 x 70 x 42	Weight (kg):	25
Commercial or prototype:	Prototype	Number of wheels:	4 / 0
Drivetrain concept / max. speed (m/s):	4 WD with ackermann steering / 2.7	Turning radius (cm):	75
Battery type / capacity (Ah):	NiMH 4.5 Ah	Total motor power (W):	250
Sensor(s) type(s) used:	- camera: 2x Allied Vision Prosilica GC - gyroscope: Analog Devices ADIS16300 - laserscanner: SICK LMS 100, SICK TiM 310		

Controller system software description (sensor data analysis, machine control etc.)
We are using ROS in version kinetic, an open source environment for controlling robotic platforms.

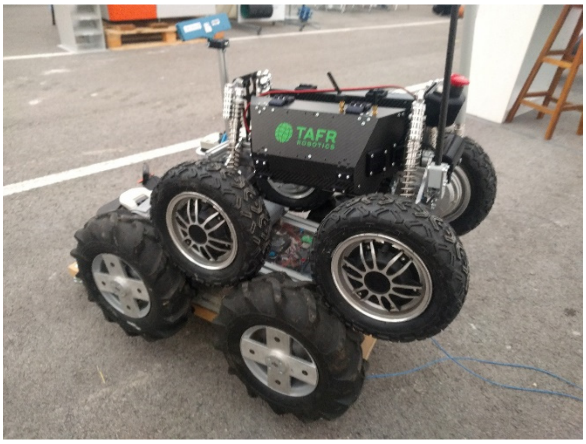
Controller system hardware description (motor controller, computer etc.)
Computer: Barebone mit i7-4770R ,16GB RAM, 256 GB SSD in combination with self-made electronics and CAN-Bus

Short strategy description for navigation and applications
Global and local path planner using laser scan data and odometry. Simultaneous synchronised real-time map generation.

Application will be done through a modified Pick up for collecting Tees.

These are the commercial team sponsors & partners (if there are)
Associated Friends of the IMN

12. TAFR



Team members:	Janez Cimerman, Žiga Brinšek, Tim Kambič, Martin Debevc, Gal Pavlin, Iza Burnik, Matej Avšič, Andrej Šenk, Rok Avšič, Vida Katarina Vidovič, Martin Turk, Pavel Remic-Weiss		
Team captain:	Janez Cimerman		
Instructor(s):	/		
Institution:	Zavod 404 (Institute 404)		
Department:	TAFR Team		
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Webpage:	tafr.si/en/index.html		

THE MACHINE			
W x L x H (cm):	55 x 60 x 40	Weight (kg):	35
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	3	Turning radius (cm):	0 (differential drive)
Battery type / capacity (Ah):	Lipo 10Ah	Total motor power (W):	2000
Sensor(s) type(s) used:	Lidar, encoders, imu, battery capacity, camera		

Controller system software description (sensor data analysis, machine control etc.)
We are working on ROS mainframe on Kubuntu Linux. Our main strategy for detecting rows of corn is to detect clusters of lidar data and extrapolate the rows direction from that. We orient according the calculated direction and go forward with the speed of 1.5m/s. Detection of weeds is done via color detection with the help of OpenCV software.

Controller system hardware description (motor controller, computer etc.)
Motors are inside the wheels and are run by open source VESCs. Central computer is Intel NUC i7, 8GB Ram, 64 SSD. We have some custom electronics that take care of correct startup of the robot, safety buttons, screens and running peripheral devices.

Short strategy description for navigation and applications
Our main navigation sensor is Lidar for driving between the corns, but we rely heavily on imu,

camera and odometry when turning and counting rows. The main sensor for detecting weeds is our realsense 3d camera.

These are the commercial team sponsors & partners (if there are)
Zavod 404, EPILOG d.o.o., Mestna občina Ljubljana (Municipality of Ljubljana), RLS, LTFE.

13. VOLTAN

Team members:	Hugo Antonio Fernandez, Norberto Cuapantecatl Garrido, Armando Reyes Amador, Luis Gerardo Ruiz González		
Team captain:	Armando Reyes Amador		
Instructor(s):	Dr. Noe Velazquez Lopez		
Institution:	Chapingo Autonomous University		
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Webpage:			

THE MACHINE			
W x L x H (cm):	53 x 78 x 50	Weight (kg):	30
Commercial or prototype:	Prototype	Number of wheels:	4 / 4
Drivetrain concept / max. speed (m/s):	Skid Steer/ 1.7	Turning radius (cm):	0
Battery type / capacity (Ah):	12V / 12A / h	Total motor power (W):	490 WX2
Sensor(s) type(s) used:	1 / 6, Inertial Measurement Unit(IMU), Absolute encoder, ultrasonic sensors, web cam		

Controller system software description (sensor data analysis, machine control etc.)
An algorithm was developed using OpenCV for the autonomous navigation. We are working to pass everything to ROS. The algorithm consists of detecting the two rows of maize that are aside the vehicle. Then we calculated the center of mass of these two rows which happened to be the exact center of the row. Finally, through serial communication the main computer sends signals to the Arduino for motor control

Controller system hardware description (motor controller, computer etc.)
We are using a Dell notebook with intel core I7 processor, 16 GB RAM and 250GB Hard disk, two Arduino MEGA 2560, a Logitech c920 webcam, an absolute encoder, Inertial Measurement Unit(IMU-9250) and due to its low cost and power capabilities a couple of electric motors used in Power Wheels toys vehicles were selected. To control the motors two drivers IBT-3 were used.

This driver is designed to control speed (PWM) and turning direction and meets the requirements of the current consumption of the motors (2-50A)

Short strategy description for navigation and applications
We are using mainly computer vision for navigation. We are using ultrasonic sensors combine with computer vision to detect the end of the row, the turn is being measured using the IMU. We are developing an algorithm to count the number of “weeds” and discriminate by colour. Finally we are designing an implement to take the weeds.

14. Sparrow

Team members:	Nils Lüling, Lucas Jahn, David Reiser, Michael Steppich, Robin Löffler, Matthias Schlötterer, Georg Feyrer, Daniel Riehle, Grischka Ulrich		
Team captain:	David Reiser		
Instructor(s):	David Reiser		
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Webpage:	www.uni-hohenheim.de		

THE MACHINE			
W x L x H (cm):	40 x 50 x 75	Weight (kg):	10
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	12	Turning radius (cm):	0
Battery type / capacity (Ah):	7	Total motor power (W):	300
Sensor(s) type(s) used:	5/2, IMU(Acceleration, Gyroskop, Height), 2xEncoders / LIDAR, Camera		

Controller system software description (sensor data analysis, machine control etc.)
Linux ROS; Modecontroller

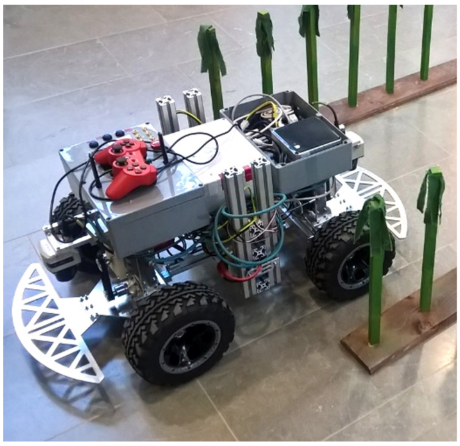
Controller system hardware description (motor controller, computer etc.)
A tablet, connected to all necessary devices with a USB 3.0 Port, controlled the whole robot. The Tablet had an integrated battery with a runtime of 8 hours. It is using an Atom x5 1.44 GHz processor, 4 GB RAM and a 64 eMMC high speed storage. The touchscreen works with 1280x 800 pixels (10”). As motor controller the Roboteq SDC2130 (Roboteq, Scottsdale, USA) was used. This dual channel motor controller is able to power up to 30 V and 2x 20 A maximum, sufficient for the used motors. The motors at each side were connected to each other, so that they turned always in the same direction. In addition, the encoders were attached directly to the motor controller and the update

signals were sent to the control tablet. For the remote control and direct user interaction a standard X-Box Joystick Logitech F710 (Logitech, Lausanne, Switzerland) was connected to the computer with a Bluetooth dongle. For activating the magnetic valves and the siren, four USB driven relays were used. The IMU used a RS232 protocol for communication, while the laser scanners worked with TCP/IP over Ethernet with an attached adapter. For remote control a hotspot was integrated, enabling to control the computer tablet with SSH and remote desktop connection via WLAN.

Short strategy description for navigation and applications
The tablet runs with Ubuntu Mate 16.04., including ROS as basic software structure for programming, visualization and user interface. For competing at the field robot event, the most important task of the robot is the autonomous row following of the system. To set up this structure, a mode changer was implemented (Blackmore et al., 2002). This included one mode for navigation inside the row and one mode for headland turning. It was possible to overwrite the autonomous mode with a user joystick input and to separate the program code to different tasks. In general, three modes were used: ▪ User Mode ▪ Headland Turn ▪ In Row navigation For each mode, the motor controller subscribed to a separate speed message, provided by the joystick, the laser scanner or the odometry with a point-to-point navigation. The ROS Middleware was used to set up the programs of the robot (Quigley et al., 2009). The whole programming was performed in using C/C++ and Python packages and nodes.

These are the commercial team sponsors & partners (if there are)
Balluff; Gigatronik; Bosch; Sick; Linak; Mädler

15. LAZER MAIZER



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Webpage:	http://autsys.aalto.fi/en/FieldRobot2018		

THE MACHINE			
W x L x H (cm):	50 x 80 x 120	Weight (kg):	15
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	4WD & 4WD 2 m/s	Turning radius (cm):	75
Battery type / capacity (Ah):	5	Total motor power (W):	200
Sensor(s) type(s) used:	2 lidars, imu, cameras		

Controller system software description (sensor data analysis, machine control etc.)
System based on PC which runs C#/C++ program. C++ code generated from Matlab/Simulink, for sensor fusion, positioning and navigation, C# for drivers.

Controller system hardware description (motor controller, computer etc.)
Intel PC, VESC motor controllers, SICK lidars, communication with Ethernet/USB/Serial ports

Short strategy description for navigation and applications
Four wheel steering allows agile movement both in rows and in headland. Two way driving.

These are the commercial team sponsors & partners (if there are)
AGCO/Valtra, SICK Finland, Koneviesti

Program (short version)

Monday, June 11th

12:00 – 18:00	Arrival and team registration (all day)
12:00 – 18:00	First testing in the test fields
18:30	Common dinner

Tuesday, June 12th

09:00 – 12:00	**Field Robot Demo & Talks** Team registration, presenting the teams & robot testing
10:00 – 11:00	Briefing of team captains
13:30 – 14:00	Welcome note
14:00 – 17:00	**Contest Task 1 (basic navigation)** **Contest Task 2 (advanced navigation)** & awarding
18:30	Common dinner

Wednesday, June 13th

09:00 – 12:00	**Field Robot Demo & Talks** Presenting the teams and testing
14:00 – 17:00	**Contest Task 3 (weed detection)** **Contest Task 4 (weed control)** & awarding
18:00 – 22:00	Final contest awarding Robot Design Award & BBQ party

Thursday, June 14th

09:00 – 10:00	Robot testing
10:00 – 11:30	**Contest Task 5 (free style)**
11:30 – 12:00	Awarding Task 5 Farewell
14:00 – 16:00	**Field Robot Demo & Talks**

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