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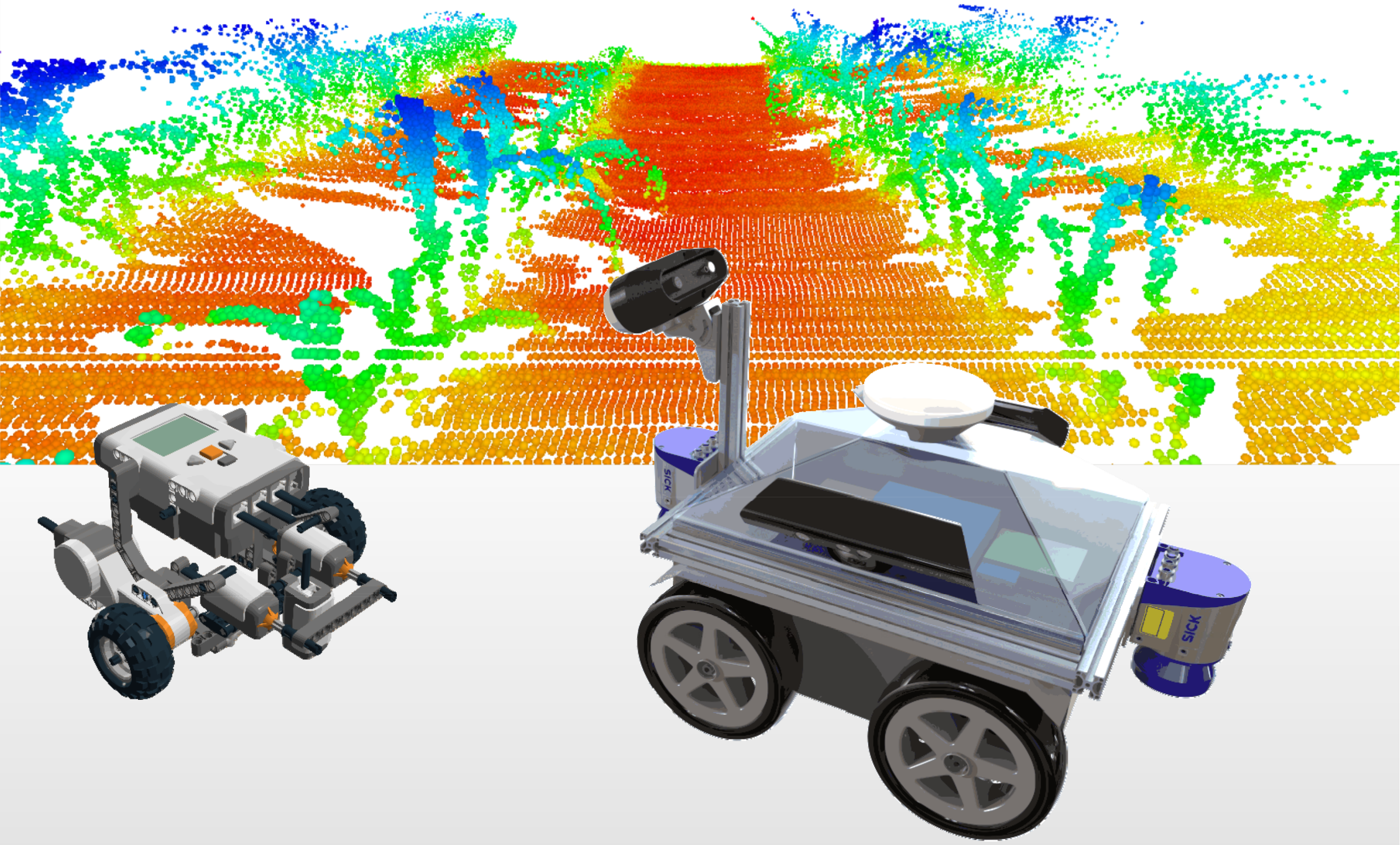
International FRE Field Robot Event

Field Robot Event

Contest + Design + Junior + Demo + Talks 14th edition

14th – 16th June 2016

Program Booklet



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Index

Thanks to all who contributed to the organisation!

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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 to the competition.

Welcome to the Field Robot Event 2016!

The 14th Field Robot Event will take place in Gut Mariaburghausen, Mariaburghausen, Germany from Tuesday June 14th to Thursday June 16th 2016. The FRE 2016 is held in conjunction with the DLG Field Days (DLG-Feldtage) for the second 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 experience and having fun during the contest!

The international Field Robot Event is an annual open-air contest on an agricultural field, where students and their supervisors compete within several tasks in autonomous navigation and other tasks. In 2016 the contest again will be different compared to last years. During the two navigation tasks there will be a stronger focus on autonomous behaviours and in the two application tasks the solutions are expected to be more complex & challenging and hence more realistic. Furthermore, in 2016 there will be for the first time a Robot Design Award donated by an industrial sponsor.

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/

Task Description

Together with the DLG-Feldtage, 14th – 16th June 2016 at the Gut Mariaburghausen, Mariaburghausen, 97437 Haßfurt

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

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 competitive advantage by not allowed technologies. The teams should even provide support to each other in all fairness.

Any observed or suspected cheating should be reported to the chair of the competition 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 be partly in a national language.

Five tasks will be prepared to challenge different abilities of the robots in terms of sensing, navigation and actuation: Basic Navigation, Advanced Navigation, Weeding Application, Seeding Application and Free Style (option).

If teams come with more than one machine the scoring and ranking 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 or development strategies.

In 2016 one of the most significant change is that NO team members are allowed to be in the inner contest area - with maize plants - and close to the robot during the performance of their machine. 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.

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

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

The crop plant in task 1 to 3 is maize (corn) or *Zea Mays*[2]. The maize plants will have a height of 20 - 50 cm.

Damaged plants

A damaged plant is a maize plant that is permanently bended, broken or uprooted. The decision if a maize plant is damaged 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 - 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 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.

During start, the robot is placed at the beginning of the first row. The starting line is located 1 m inwards the first path, which is marked with a white cross line. Any part of robot must not exceed the white line in 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 that task.

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 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.

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

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

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. 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 of 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 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.

In the headland, only rotating of the robot is allowed, no moving or 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 (Seeding) 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), weeding (3), and seeding (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, the robot must have ground clearance of this amplitude at minimum, and the robot must be able to climb over obstacles of max 25 mm height.

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 use STOP button when necessary.

1.4. 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.

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 2016. 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 at 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 in the end of the rows. However, due to circumstances of previous runs by other robots, it is possible that some plants in 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. 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.

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 2016. 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 "Weeding" (3)

3.1. General description

For this task the robots are navigating autonomously. The robots shall detect weeds represented by pink golf balls and spray them precisely. Task 3 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 rules for entering the field, moving the robot, using remote controller etc. are the same as in task 1 and 2.

3.2. Field conditions

The *weeds* are objects represented by pink golf balls[3] randomly distributed between (!) the rows in the soil that only the upper half is visible. Robots may drive across or over them without a penalty. The weeds are located in a centered band of 60 cm width between the rows. No weeds are located within rows and on 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 detection of a weed must be confirmed by an acoustic signal of an official siren[4]. All

[3] The golf balls used are "Nitro Blaster Golf Balls – Pink". The organizer of the competition will send these to the teams after registration, but you can order your own set from Amazon.

[4] "Pro Signal S130", which is available e.g. from Farnell (order number 676550), voltage range 6 - 12 V. The FRE organizer will send these to the teams after registration.

robots must use the official siren. The length of the beep may not be longer than 2 seconds.

The robot must spray only the weeds or the circular area around the golf ball with a diameter of 25 cm. Spraying outside this weed circle is counted as false positive, with no true positive scoring.

In the case that the robot is spraying or producing an acoustic signal without any reason, this is regarded as false negative.

3.4. Assessment

The Jury registers the number of true positives, false positives and false negatives:

- True positives (correct spraying with acoustic signal) + (plus) 6 points,
- True positives (correct spraying without acoustic signal) + (plus) 4 points,
- False positives - (negative) 1 point and
- False negatives - (negative) 2 points.

Crop plant damage by the robot will result in a penalty of 2 points 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 2016. Points for the overall winner will be given as described in chapter 0.3 Awards.

4. Task "Seeding" (4)

4.1. General description

The robots perform a seeding operation for an area of 10 m x 1 m = 10 m^2. The robots take wheat seeds from a station and sow them as even as possible on the area. How the robots realize the task is absolutely free.

From the starting point the robot goes to the filling station, stops there and asks to fill the hopper using a wireless command. A provided refill station has to be used. (Instructions given to construct your own mockup see picture 5.) The robot goes to the area and starts and ends the sowing correctly. Furthermore, the seeds need to be distributed as even as possible across the area and covered by soil as good as possible.

4.2. Field conditions

A bare soil area is used for this task with no plants. To provide equal conditions for every team, the soil is harrowed before every run and compacted afterwards with a light manual roller (such that is used in garden to care grass). After every run, the setup is moved to another location.

Red lines of 50 mm wide textile tape will be installed on the ground as a guiding help, see picture 4. They indicate longitudinal start and end as well as transversal center of the seed area.

The red centerline is extended to the start position of about 5 m passing the refill station. The outlet hose location of the refill station is marked with a perpendicular blue line on the ground (50 mm wide) that the robots may utilize in order to stop in the right place. The blue line is located about 3 m from the start and about 2 m from the region.

The team may install temporarily to the field also their own additional visual ground markers in the neighborhood of the blue line, to enable stopping into the accurate place for refill.

These markers must be placed in the field before the start and they may not be touched during the task.

The maximum number of additional markers is three and the maximum size of each is limited to 15 x 15 cm.

4.3. The seeds

Common wheat seeds (*triticum aestivum*) colored in red or blue will be used. The seeds will have a typical 1000-seed-weight of 30-40 g and a bulk density of 740-800 kg/m^3.

On first day each team will get a non-colored sample of 200 g trial seeds. More trial seeds will be available on request during the testing. During the competition the seeds will be provided.

4.4. The refill station

Drawings of the refill station are published well prior the competition (picture 5). Each team may build their own version for practicing, but during the competition only the provided one shall be used.

The body of refill station is located 75 cm beside the red line (picture 4 and 5). This implies the width of the robot may not exceed 75 cm including the accessories for seeding.

The hose where the seeds are delivered is adjustable, each team may adjust the height, and the side offset of the hose prior to the start. No moving of the hose during the task is allowed by any means.

The exit of hose may be adjusted 10-60 cm from the ground level and 5-50 cm offset from the body of the refill station. The hose outer diameter will be 50 mm at a 45 degree angle.

4.5. The seeding

The required seed rate is 500 seeds/m^2. Therefore, the total number of seeds that is metered by the refill station to the hopper is 10 x 500 seeds = 5000 seeds, which equals around 150-200 g.

How to achieve the most even distribution across the 10 m x 1 m area is up to the teams.

The seed rows may not touch the red line physically and should keep a distance of at least 5 cm from the red line.

After sowing, as many seeds as possible should be covered by soil. In other words, the seeds may not be visible on top view.

No other material besides the competition seeds may be distributed to the field.

4.6. Rules for robots

The robot must be equipped with a hopper that can take the required amount of seeds (at least 500 ml). The hopper must be either top open or transparent, for jury members to see smooth emptying during sowing.

A robot must start from the headland, 5 m from actual field to be seeded. The starting point is illustrated in picture 4 with a green dot.

Around 3 m from the start, the refill station is located. The robot must navigate there autonomously using the red line as a reference guide path. The robot must stop there autonomously.

After stopping, the robot must send a command to the refill station, to ask material refill, by using Internet protocol. The refill station is connected to Internet with a public IP, so the team may use their own means to access it through Internet, or to use a local wireless connection. More details of the communication protocol will be announced soon.

If the refill command fails, a team member may push a manual button on the station to ask refill manually. Manual button does not score any points.

The station refills the hopper exactly the amount of seeds required to sow 10 m^2. The refill is completed in 10 seconds from the receiving the command packet, after which the robot may continue.

After refill, the robot continues to the beginning of seeding area (which is marked with a perpendicular red line).

Robot must start sowing immediately after the red perpendicular line and sow until reaching the next red perpendicular line. In other words, the area between the two red lines needs to be sown, not beyond.

4.7. Assessment

Success in various subtasks give the score (speed does not matter as long as reasonable, max. time 6 min).

In this task, the speed is not rewarded at all. However, the maximum time to complete the task is 1+5 minutes (refill + sow).

The emphasis in scoring is more on agronomical correct operation, less on the accuracy of navigation.

In the ideal case, the resulted seeded area after each run would be 10 m^2, which will result in 10 points. If the seeded area is higher or lower than the required 10 m^2, the jury members will measure it. Any deviated area (in decimal m^2) is subtracted from the 10 points.

One of the following achievements give 2 points each:

- navigating and stopping autonomously to the refill station
- commanding refill station to ask seed refill wirelessly
- correct filling of the seeds, all seeds went into the hopper
- navigating from refill station to region
- general navigation and turning

Furthermore, the jury members will assess two qualitative performance criteria by giving points from 0 (insufficient) to 10 (excellent) for each one. These two criteria are:

1. Seed spatial distribution
2. Seed soil coverage

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 2016. 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 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

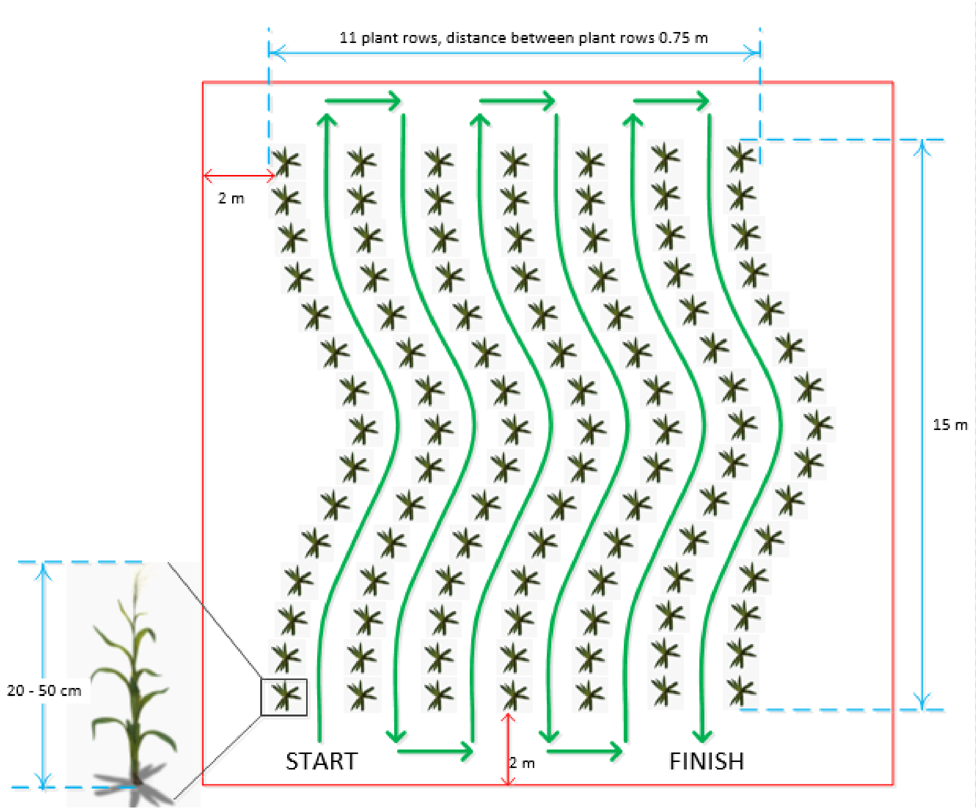
The jury will assess the (i) agronomic idea, the (ii) technical complexity and the (iii) robot performance by giving points from 0 (insufficient) to 10 (excellent) for each.

The total points will be calculated using the following formula:

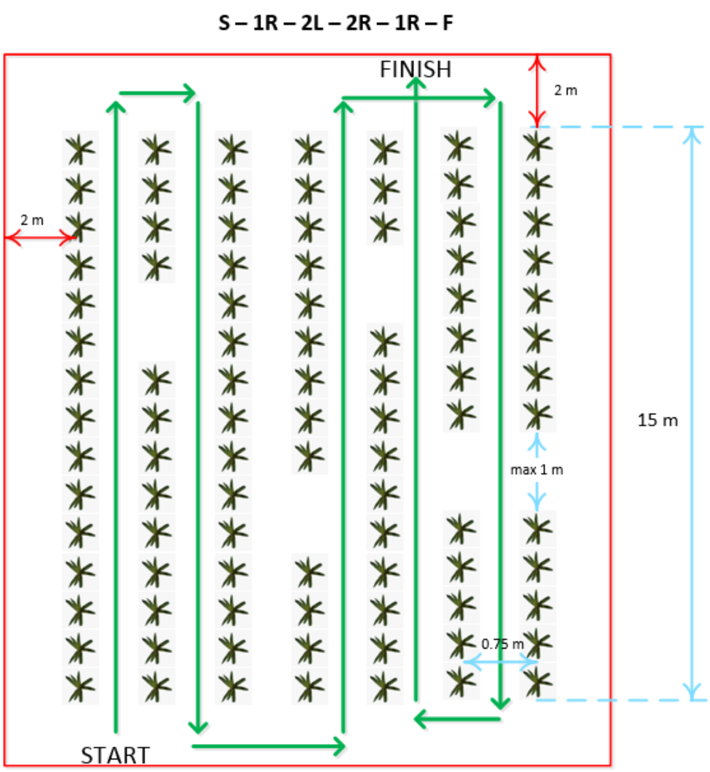
(agronomic idea + technical complexity) * performance.

The task 5 is optional and will be awarded separately. It will not contribute to the contest winner 2016.

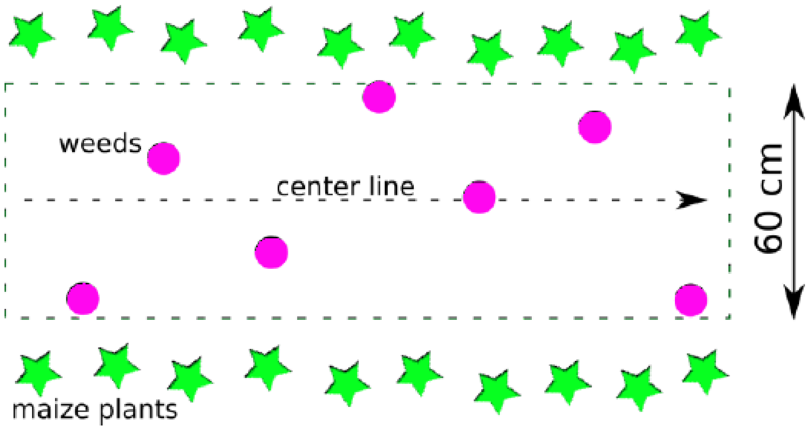
Appendix



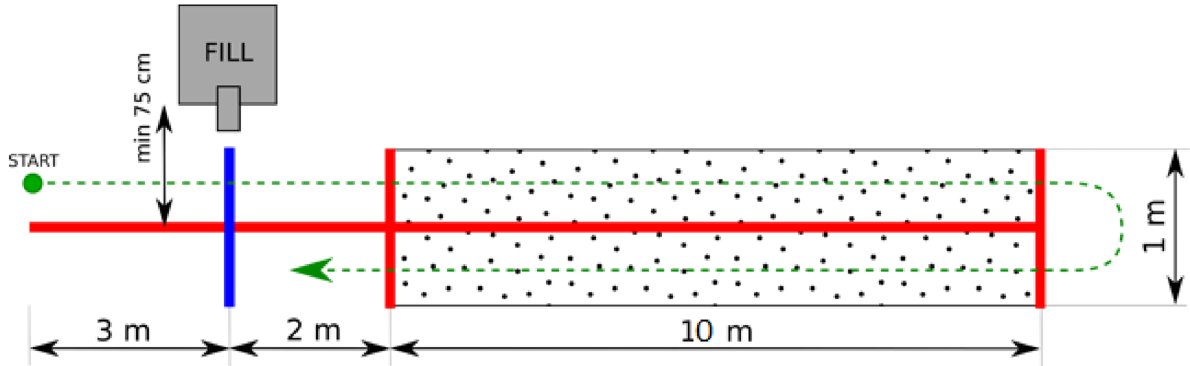
Picture 1 – Dimensions and row pattern for task 1



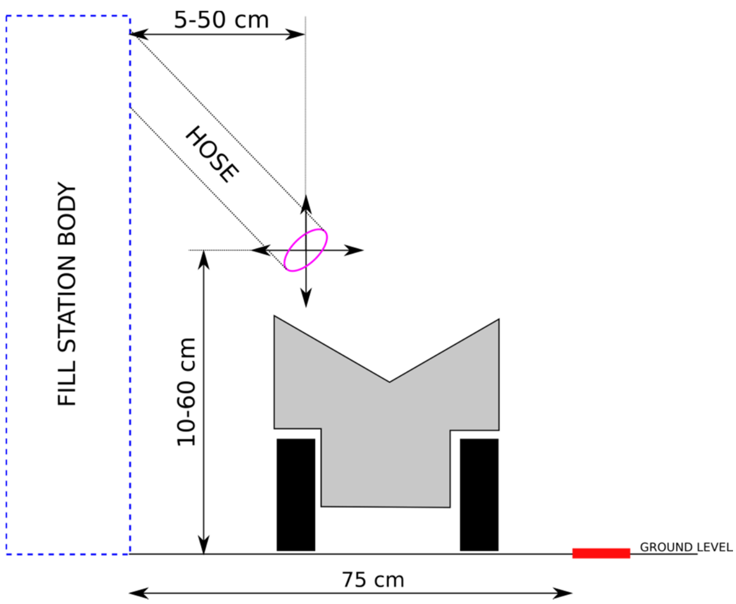
Picture 2 – Dimensions and example (!) row pattern for task 2



Picture 3 – Possible locations of the weeds for task 3.



Picture 4 – Illustration of task 4 "Seeding".



Picture 5 – Dimensions and range of adjustment of the hose for task 4.

Robot Design Award

Beside the task awards this year the exclusive and invited industrial sponsor BOSCH Deepfield Robotics will donate the robot design award. BOSCH Deepfield Robotics will evaluate the robots by reading the booklet, reading pre-written proceedings articles, examining the robots during practice and by interviewing the teams during the competition and comparing to state-of-the-art within robotics.

BOSCH Deepfield Robotics will assess the robots in relation to the technological solution, the design, the robustness, the reliability and the general presentation. The performance of the robots during the competition shall NOT be included in the assessment, because the competition will cover this already with awards. The functionality will also be evaluated, but not specifically.

BOSCH Deepfield Robotics will hand out noncash awards to the three best robots during the main awarding ceremony. BOSCH Deepfield Robotics will also contribute to the event as a normal sponsor.

BOSCH Deepfield Robotics, Robert Bosch Start-up GmbH

Dr. Bojan Ferhadbegovic

Benzstraße 56, 71272 Renningen, Germany

Email: bojan.ferhadbegovic@de.bosch.com

Program (short version)

Monday, June 13

12:00 – 18:00 Arrival and team registration (all day)
12:00 – 18:00 First testing in the test field
18:30 Dinner at Accommodation Site

Tuesday, June 14

09:00 – 12:00 **Field Robot Demo**
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 Dinner at Accommodation Site

Wednesday, June 15

09:00 – 12:00 **Robot Talks**
Presenting the Teams & Testing
14:00 – 17:00 **Contest Task 3 (Weeding)**
Contest Task 4 (Seeding)
& Awarding
18:00 – 22:00 Final Contest Awarding, Robot Design
Award & BBQ party

Thursday, June 16

09:00 – 10:00 Robot Testing
10:00 – 11:30 **Contest Task 5 (Free style)**
11:30 – 12:00 Awarding Task 5
Farewell to the students

13:30 – 14:00 Welcome to **Field Robot Junior**
14:00 – 17:00 Task 1, task 2 and freestyle
17:00 – 17:00 Awarding Field Robot Junior

Field Robot Demo

BOSCH Deepfield Robotics, Germany
BoniRob

The BoniRob is an agricultural robot that can conduct autonomously repeating phenotyping tasks for crop stands and even for individual plants. Furthermore, it can be used as a carrier, supplier and base for multiple BoniRob-Apps. Current apps are (i) phenotyping, (ii) penetrometer and (iii) precision spraying.

Naïo Technologies, France
Oz 440

Oz is a standalone tool that combines efficiency and ecology, it is able to assist growers in the most arduous tasks: mechanical weed control and charge transport at harvest. It is small, so it operates directly between the rows for precision work. Oz is able to run on all your fields, regardless the type of soil and it can weed between the rows and on the row of crops, thanks to its precision tools and to the regularity of its work. With Oz you save time and weeding is no longer a constraint or a tedious task.

Bayerische Landesanstalt für Landwirtschaft (LfL), Germany
i-LEED

The i-LEED optimises the feeding of cattle on pastures and the management of the pasture through introduction and fusion of innovative tools like a mulcher and seeder as well as the necessary sensors for pasture care. The pasture robot shows stable movement even under difficult terrain conditions.

Hohenheim University - Phoenix

The Phoenix is an electro-powered robot designed for agricultural use like scouting, mapping and weeding. Furthermore, in research it is used as an autonomous sensor platform to develop new sensing systems. A special 3D-frame attached to the machine allows plant individual treatments within crop management according to Precision Farming principles.

University of Applied Sciences, Germany
HV-100 Harvest Automation

The gardening robot HV-100 is designed to perform material handling tasks in unstructured, outdoor environments such as those typically found in commercial growing operations. The robots require minimal training to operate.

Field Robot Talks

Ag Robots on the way to the market!?

Since a long time the idea of field robots for agricultural applications has led to dreams and innovations, however, swarms of autonomous systems are still science fiction, aren't they ? Since 2003 the International Field Robot Event is looking ahead to future applications. Is it just playing around or is the gap between research and commercial products decreasing? Having a look at recent activities of several companies and research institutions as well as at international fairs, supports this view.

The Field Robot Talks reflects this situation and looks ahead. The program is as follows:

1. First part:
   Research institutions which participate in the contest present their ideas, research applications and their robot ideas within their research and for the future. This should give a good picture of some public international research activities.
2. Second part:
   Guests from industry are invited to present their products, research and ideas but also contribute to the discussion about the future of field robotics. The companies have already entered field robotics, either in research or close-to-the-market steps.
   Speakers will be:
   – Benno Pichlmaier from AGCO / FENDT
   – Tobias Mugele from BOSCH Deepfield Robotics
   – Julien Laffont from NAIO Technologies
3. Third part:
   A common discussion of all participants will complete the Field Robot Talks.

Participating Machines & Teams

1. Agrifac Bullseye

Team members:	Frenk-Jan Baron, Koen van Dinther, Wim-Peter Dirks, Roel Dohmen, Jari van der Stok, Marco de Theije, Anthony Vermue, Arjan Verduijn		
Team captain:	Wim-Peter Dirks		
Instructor(s):	dr.ir. JMM (Joris) IJsselmuiden, ing. SK (Sam) Blaauw, Thijs Ruigrok		
Institution:	Wageningen University		
Department:	Farm Technology Group (FTE)		
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Street / Number:	Spelstraat 2	Spelstraat 2	6707 ER
Email:	Robatic.bullseye@gmail.com		
Webpage:	http://www.robatic.nl		

THE MACHINE			
W x L x H (cm):	40x110x50	Weight (kg):	35
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Direct drive	Turning radius (cm):	15
Battery type / capacity (Ah):	LiPo 5 (5000 mAh)	Total motor power (W):	600
Sensor(s) type(s) used:	Laser scanner, RGB-cameras, IMU		

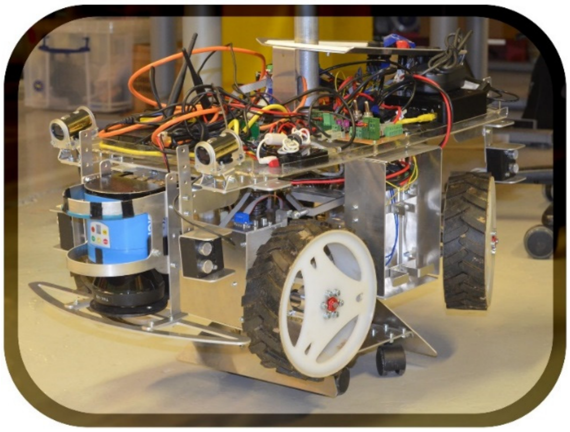
Controller system software description (sensor data analysis, machine control etc.)
The core of the software is based on the Robot Operating System (ROS), which is programmed in Python. For image analysis, build-in packages of OpenCV are used.

Controller system hardware description (motor controller, computer etc.)
The software is controlled by a Gigabyste GA-B75N, Intel Core i7 3770T. All four wheels of the robot are driven and can be steered independently.

Short strategy description for navigation and applications
Task 1 – Basic navigation: The rows are scanned with a laser scanner, the robot navigates on a route calculated based on a particle filter. **Task 2 – Advanced navigation:** The rows are scanned with a laser scanner, the robot navigates on a route calculated based on a particle filter. On the headlands, the rows are counted with the information from laser scanner. **Task 3 – Weeding:** RGB-cameras pointing downwards capture images of the ground. Using OpenCV these are processed and the position is determined relative to the nozzles. Based on the speed of the robot, the nozzles spray at the right time. **Task 4 – Seeding:** RGB-cameras capture images in front of and to the right of the robot. Using OpenCV, the tape is detected and the robot is steered accordingly. The sowing machine can be lowered into the ground and an electrical dosing unit is used to equally distribute the seeds over four sowing pipes. **Task 5 – Freestyle:** The robot will drive along a number of storage crates. They will be detected, scanned and ordered.

These are the commercial team sponsors & partners (if there are)
Agrifac, Kverneland, Precision Makers, Steketee, Dacom

2. AGRONAUT



Team members:	Miika Ihonen, Mikko Ronkainen, Robert Wahlström, Robin Lönnqvist, Aleksi Turunen, Ali Rabiei, Mikko Perttunen, Aatu Heikkinen, Jori Lahti
Team captain:	Miika Ihonen
Instructor(s):	Timo Oksanen, Teemu Koitto, Mikko Hakojärvi, Jari Kostamo
Institution:	Aalto University & University of Helsinki
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City:	Espoo
ZIP Code	FI-02150
Email:	timo.oksanen@aalto.fi
Webpage:	http://autsys.aalto.fi/en/FieldRobot2016

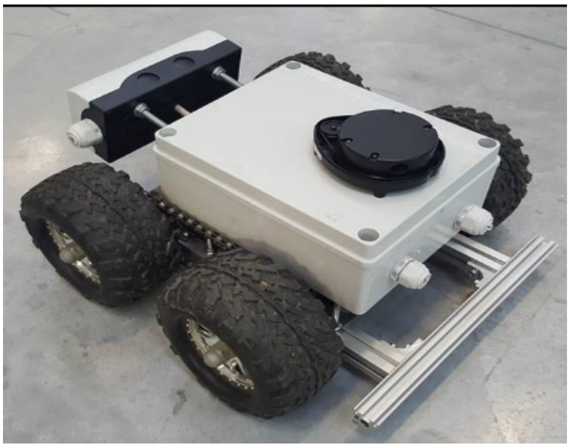
THE MACHINE		
W x L x H (cm):	390 x 750 x 560 (mm)	Weight (kg): 20 kg without batteries and trailer
Commercial or prototype:	Prototype	Number of wheels: 4 (+2 with trailer)
Drivetrain concept / max. speed (m/s):	~2.5 m/s	Turning radius (cm): ~40 cm
Battery type / capacity (Ah):	Li-Po, 15 Ah	Total motor power (W): 500W (with powered trailer)
Sensor(s) type(s) used:	Ultrasound & infrared rangers, LIDAR, gyroscope, rotary encoders, web cameras, GPS (optional)	

Controller system software description (sensor data analysis, machine control etc.)
Signal processing of eight ranging sensors and laserscanner using various self made algorithms in Matlab. Machine vision for three cameras using OpenCV. Signal processing, positioning and navigation algorithms developed in Matlab Simulink and code generation to C++ is utilized. The runtime over .NET / C# & DLL platform, in two onboard computers running WinCE & Win7.

Controller system hardware description (motor controller, computer etc.)
There are two PC computers onboard the robot, a weaker one mostly dedicated for time critical communications and control, and a more powerful one which decodes the data from both the laser scanner and the cameras. The rest of the functionality is provided by a suite of microcontrollers, one in each add-on device and axle module. These all communicate through the CAN bus. The robot is driven by two self-contained axle modules of two wheels each, which contain a brushless DC motor equipped with hall sensors, a rotary encoder, a motor controller, a turning servo and a microcontroller. All drive systems such as the gear reductions, servo mechanics and wheels are implemented with them.

Short strategy description for navigation and applications
Active Four Wheel steering in row navigation. Active Four Wheel steering in headland. Two way driving. Trailer for sowing. Additional hardware for freestyle.

3. BANAT



Team members:	Nicolae Patru, Mihai Pop, Paul Negirla, Stefania Hergane, Paul Calescu, Catalin Almasan		
Team captain:	Mihai Pop		
Instructor(s):	Sorin Nanu, Sorin Bungescu, Dumitru Tucu		
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:	sobungi@yahoo.com / enikototh4@gmail.com		
Webpage:	-		

THE MACHINE			
W x L x H (cm):	30x50x30	Weight (kg):	10kg
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	1.5m/s	Turning radius (cm):	60cm
Battery type / capacity (Ah):	NiMH-72V-3600mAh	Total motor power (W):	-
Sensor(s) type(s) used:	Lidar, Laser range sensor, Gyro, rotary encoders		

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

Task 1 & 2

- Acquisition and computation of the 3 sensors one Lidar, one laser range sensor and one Gyro.
- Send a prescription to the motors on a serial output based on state machine design with the following states: "Start", "Drive", "End of row", "Obstacle", Turn left", "Turn right", "Stop"

Task 3

- Image processing using Pixy CMUcam. When the learnt object is detected, the system performs the following actions: stop the motors, start the siren (part B) or spray the object using a pump for 2seconds (part A)

Task 4
- Image processing using Pixy CMUcam to detect the filling station and the start of seeding zone

Controller system hardware description (motor controller, computer etc.)
The robot uses a UDOO Quad board as its brain. First, we use the UDOOs Atmel SAM3X8E ARM Cortex-M3 controller to make the data acquisition from 3 sensors: one Lidar, one laser range sensor and one Gyro. Next, we sent the information to the UDOOs microprocessor where we process the data and send a prescription to the motors on a serial output. Also, the software that runs on the UDOO microprocessor is designed around a state machine. The states are “Start”, “Drive”, “End of row”, “Obstacle”, Turn left”, “Turn right”, “Stop” and are taken into consideration when calculating the prescription to the motors. The motors are controlled by an atmega328p microcontroller which uses as input two sets of data: the prescription from the UDOO board and the readings from two rotary encoders. The two sets of data are thrown in a control loop whose exit is the PWM signal for the motors.

Short strategy description for navigation and applications
- Field mapping using the Lidar sensor - Image processing using Pixy CMUcam to detect weeds and to spray them - State machine based algorithm - Remote control to start/stop the motor - Inter modules communication for acknowledge and commands

4. Beteigeuze

Team members:	45		
Team captain:	Tobias Loritz, Lennart Nachtigall		
Instructor(s):	-		
Institution:	Karlsruher Institut für Technologie		
Department:	-		
Country:	Germany	City:	Karlsruhe
Street / Number:	Rintheimer Querallee 2	ZIP Code:	76131
Email:	mail@kamaro-engineering.de		
Webpage:	www.kamaro-engineering.de		

THE MACHINE			
W x L x H (cm):	50x70x30	Weight (kg):	30 Kg
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	4x4 / 3,05 m/s	Turning radius (cm):	~ 40 cm
Battery type / capacity (Ah):	Li-Po/10.000 mAh	Total motor power (W):	250 W
Sensor(s) type(s) used:	Camera, Bosch IMU, Sonar, Laser, Mechanical Sensor		

Controller system software description (sensor data analysis, machine control etc.)
Low-Level Controllerboards programmed in C API for hardware abstraction written in C++ Main Computer Software written in Java in combination with ROS

Controller system hardware description (motor controller, computer etc.)
Main Computer: Mini ITX Mainboard, x86 Components Controllerboards: Diverse ARM Based Chips Mechanics: Custom Kamaro Design

Short strategy description for navigation and applications
Simple in row navigation by searching for the direction with largest free space in front of the robot. SLAM outside of rows.

5. CORNSTAR

Team members:	Peter Berk, Peter Bernad, Ziga Brinsek, Matic Cebe, Janez Cimerman, Miran Lakota, Jurij Rakun, Zan Vajngerl		
Team captain:			
Instructor(s):	Miran Lakota, Jurij Rakun, Peter Berk		
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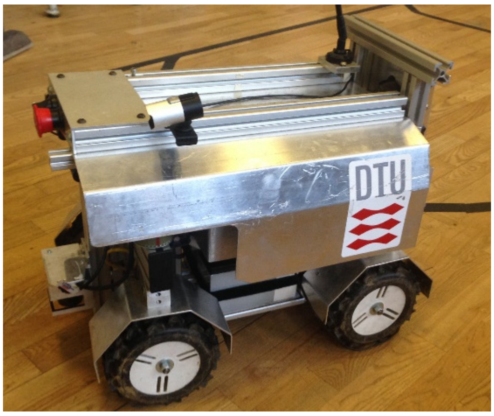
THE MACHINE			
W x L x H (cm):	42 x 60 x 45	Weight (kg):	15
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	4 WD, 3 m/s	Turning radius (cm):	150
Battery type / capacity (Ah):	LiPo 2S 4000 mAh LiPo 3S 4000 mAh	Total motor power (W):	
Sensor(s) type(s) used:	LIDAR (Sick TIM 310), Camera (TIS, DFK31AG03)		

Controller system software description (sensor data analysis, machine control etc.)
ROS with custom software; based on the readings from the LIDAR sensor, the software adjusts the path of the robot. In addition, it uses the camera for the 3rd task to follow the red line and to control the seeding process.

Controller system hardware description (motor controller, computer etc.)
Raspberry pi 3 + custom developed expansion board that controls the servos, the motor and power outputs.

Short strategy description for navigation and applications
Robot moves based on location of closest corn and IMU data

6. DTUni-Corn



Team members:	Sigurd Engvik Rasch, Jose Gregorio, Marie Claire Capolei, Adrien Gato, Christian Hoffgaard, Henning Si Høj, Oliver Topp, Raphaël Viards, Jonas Jørgensen, Martin Aaman.		
Team captain:	Marie Claire Capolei		
Instructor(s):	Nils Axel Andersen, Ole Ravn.		
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Department:	Automation and Control		
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Webpage:	http://www.iau.dtu.dk/~fre/		

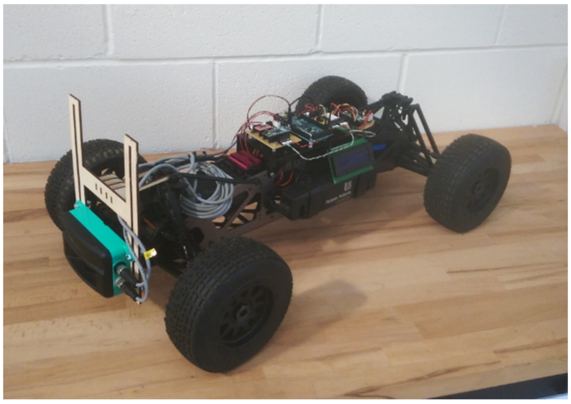
THE MACHINE			
W x L x H (cm):	37 x 82 x 47	Weight (kg):	~20
Commercial or prototype:	Commercial	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Ackerman steering 3.6 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	14	Total motor power (W):	150W
Sensor(s) type(s) used:	Laser, Gyroscope		

Controller system software description (sensor data analysis, machine control etc.)
The operating system is “Mobotware” and it is programmed in SMR-CL via. ethernet communication.

Controller system hardware description (motor controller, computer etc.)
Maxon motor controller, Zotac motherboard.

Short strategy description for navigation and applications
Complete as much as possible of the tasks at suitable speed, as autonomous as possible, without hitting any of the maize plants.

7. ERIC



Team members:	Joe Allin, Tom Lindley, Ali Taylor, Josh Matthews		
Team captain:	Joe Allin		
Instructor(s):	Ianto Guy		
Institution:	Harper Adams University		
Department:	Engineering		
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Street / Number:		ZIP Code:	TF10 8NB
Email:	iguy@harper-adams.co.uk		
Webpage:	http://www.harper-adams.ac.uk/		

THE MACHINE			
W x L x H (cm):	45 x 70 x 25	Weight (kg):	5
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	4WD / 8m/s	Turning radius (cm):	90
Battery type / capacity (Ah):	2x 11.1V LiPo / 7Ah	Total motor power (W):	
Sensor(s) type(s) used:	2D laser scanner, PIXY CMU Cam5, Rotary encoder, Magnetic compass		

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 and control 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.

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 drilling navigation mark detection.

8. FloriBot

Team members:	Benedict Bauer, Constantin Dresel, Björn Eistel, Judith Gehring, Michael Gysin, Torsten Heverhagen, Dennis Hoch, Kai Krieg, Carolin Nowak, Sandra Reitinger, Lisa Schäfer, Stefan Walz, Jürgen Withopf		
Team captain:	Benedict Bauer		
Instructor(s):	Prof. Torsten Heverhagen		
Institution:	Heilbronn University		
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Email:	benedict.bauer@hs-heilbronn.de, torsten.heverhagen@hs-heilbronn.de		
Webpage:	www.hs-heilbronn.de, www.floribot.de		

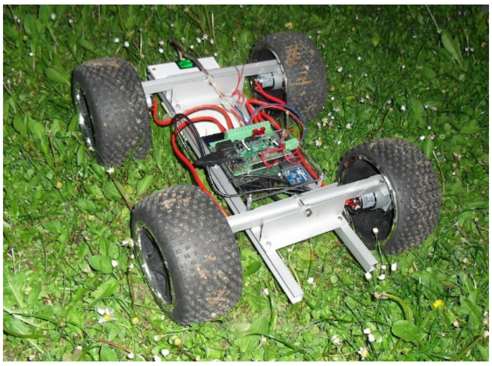
THE MACHINE			
W x L x H (cm):	55 x 60 x 50	Weight (kg):	25 kg
Commercial or prototype:	prototype	Number of wheels:	2
Drivetrain concept / max. speed (m/s):	Differential wheeled / 2 m/s	Turning radius (cm):	60 cm
Battery type / capacity (Ah):	LiPo / 18 Ah	Total motor power (W):	180 W
Sensor(s) type(s) used:	Laser ranger, web cams, high precision encoders,		

Controller system software description (sensor data analysis, machine control etc.)
ROS Nodes generated from Simulink models in conjunction with various ROS drivers

Controller system hardware description (motor controller, computer etc.)
Sabretooth 2x25, Motherboard with 1.86GHz Intel Atom Dual Core Processor and 4GB DDR3 RAM, Lynxmotion SSC-32 Servo Controller

Short strategy description for navigation and applications
Precision > speed. The in row navigation is based on the potential field method.

9. Fredl



Team members:			
Team captain:	Bernhard Mayer		
Instructor(s):			
Institution:	JECC		
Department:			
Country:	Germany	City:	Künzing
Street / Number:	Girchinger Str. 17A	ZIP Code:	94550
Email:	bernhard-mayer@gmx.net		
Webpage:	http://www.jecc.de		

THE MACHINE			
W x L x H (cm):	40x60x30	Weight (kg):	8
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Gear motor / 1.2 m/s	Turning radius (cm):	20
Battery type / capacity (Ah):	LiPo 4s / 5000 mAh	Total motor power (W):	60
Sensor(s) type(s) used:	Laser distance sensor, compass, odometer, camera		

Controller system software description (sensor data analysis, machine control etc.)
Realtime functions (Motor control) on Microcontroller. Sensor analysis and decision making on raspberry Pi

Controller system hardware description (motor controller, computer etc.)
Motorcontroller with TI DRV8432 and STM32F4 connected to Raspberry Pi 3 via USB; Sensors directly connected to Raspberry Pi

Short strategy description for navigation and applications
Task 1 & 2: find a free path with the laser distance sensor. If no more obstacles around, the robot has passed the first line unduses compass and odometer to enter the next line. Task 3: Navigation like task 1. Camera detects weed via optical analysis. Task 4: Navigation with camera along the red line.

10. HELIOS / FREDT

Team members:	Matthias Kemmerling, Christopher Sontag, Mohammed Alzoubi, Andrii Kostrysia, Christian Schaub, Christopher Prange, Henrik Wulferding, Sven von Höverling, Tom Schröder, Luke Schneider		
Team captain:	Christopher Sontag, Matthias Kemmerling		
Instructor(s):	Dipl.- Ing. Till- Fabian Minßen		
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Webpage:	www.fredt.de		

THE MACHINE			
W x L x H (cm):	35cm x 66cm x 42cm	Weight (kg):	20kg
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	permanent 4-wheel drive, power distributed via central differential and differentials in front and rear axles	Turning radius (cm):	75cm
Battery type / capacity (Ah):	NiMH 4.5Ah	Total motor power (W):	220W
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.)
Robotic Operating System (ROS) Indigo on a Ubuntu 14.04LTS Machine

Controller system hardware description (motor controller, computer etc.)
- Gigabyte Barebone with i7-4770R, 16GB RAM, 256 GB SSD - self-made electronics on µController basis - component communication via CAN-Bus

Short strategy description for navigation and applications
- navigation: find row middle and stick to it - weeding: drive slowly and once weed is found, adjust the sprayer, drive above the weed and spray precisely - seeding: navigate along the red line, seeding will be done by an extra module

11. Innok TX

Team members:	Benedict Bauer, Constantin Dresel, Björn Eistel, Judith Gehring, Michael Gysin, Torsten Heverhagen, Dennis Hoch, Kai Krieg, Carolin Nowak, Sandra Reitinger, Lisa Schäfer, Stefan Walz, Jürgen Withopf		
Team captain:	Benedict Bauer		
Instructor(s):	Prof. Torsten Heverhagen		
Institution:	Heilbronn University		
Department:	Faculty of Mechanics and Electronics		
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Webpage:	www.hs-heilbronn.de, http://www.innok-robotics.de/en/products/tx		

THE MACHINE			
W x L x H (cm):	56 x 56 x 37	Weight (kg):	16 kg
Commercial or prototype:	commercial	Number of wheels:	6
Drivetrain concept / max. speed (m/s):	6-WD (All-Wheel-Drive) / 10 m/s	Turning radius (cm):	60 cm
Battery type / capacity (Ah):	LiPo / 5 Ah	Total motor power (W):	2000 W
Sensor(s) type(s) used:	Laser ranger, web cams, high precision encoders,		

Controller system software description (sensor data analysis, machine control etc.)
ROS Nodes generated from Simulink models in conjunction with various ROS drivers

Controller system hardware description (motor controller, computer etc.)
6 x 120 MHz ARM Cortex-M3 microcontroller, On-Board PCs

Short strategy description for navigation and applications
Precision < speed. The in row navigation is based on the potential field method.

These are the commercial team sponsors & partners (if there are)
Innok Robotics GmbH: http://www.innok-robotics.de/

12. Plants with Benefits

Team members:	Jarno Meijer, Jesse Bax, Stefan Bruekers, Stefan Sweerts, Patrick van Broekhuijsen, Joris Willers		
Team captain:	Joris Willers		
Instructor(s):	F. van Gennip		
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Department:	FHTenL		
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Email:	j.willers@student.fontys.nl		
Webpage:	-		

THE MACHINE			
W x L x H (cm):	40 x 67 x 30	Weight (kg):	20
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):		Turning radius (cm):	0
Battery type / capacity (Ah):	6 x 5,8 LiPo	Total motor power (W):	160W
Sensor(s) type(s) used:	Sick TIM 351		

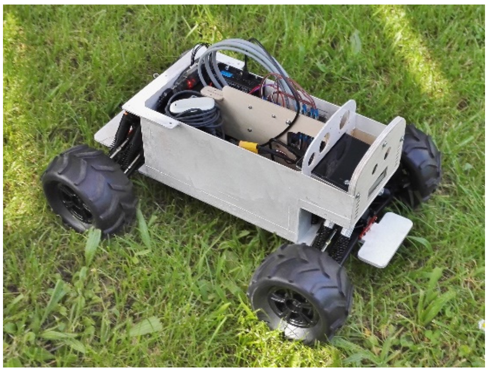
Controller system software description (sensor data analysis, machine control etc.)
I2C, PWM, SPI, Serial

Controller system hardware description (motor controller, computer etc.)
BMS(Battery Management Systems), Arduino Mega, IPC2 PC

Short strategy description for navigation and applications
Lane Detection, Path Planning, Drive

These are the commercial team sponsors & partners (if there are)
Fontys, Sick

13. Soifakischtle (Soapbox car)



Team members:	Johannes Bier, Julian Mock, Andreas Schmyrin, David Lippner, Christoffer Raun		
Team captain:	Samuel Layer-Reiss		
Instructor(s):	Lukas Locher		
Institution:	Schülerforschungszentrum Überlingen		
Department:	Robotics		
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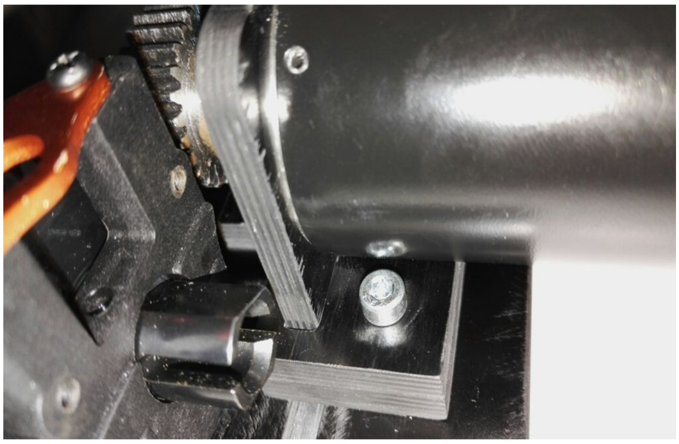
Email:	locher.l@t-online.de		
Webpage:	sfz-ueb.de		

THE MACHINE			
W x L x H (cm):	45x79x35	Weight (kg):	20 kg
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	5 m/s	Turning radius (cm):	85
Battery type / capacity (Ah):	LiPo 16 Ah	Total motor power (W):	150W
Sensor(s) type(s) used:	2 Sick Laser-Scanner, Gyro+Accelerometer+Compass from a Pixhawk flight controller, Allied Vision GigE camera Manta 235		

Controller system software description (sensor data analysis, machine control etc.)
For obstacle detection and navigation in the corn rows we are using two Sick Laser-scanners (one in the front and one in the back). On the software side we are using the Robot Operating System (ROS) and Ubuntu-Linux on an Intel Nuc PC. We hope, that we can use the drive-encoder-data from the Maxon motor and the gyro, accelerometer and compass data from the Pixhawk flight controller and the position-feedback of two digital steering servos for some rude odometric position calculations, helping for navigation in the headlands. The Maxon-Drive is controlled with a Maxon EPOS2 Controller. There is a maxon API for Linux Computers to get access to the EPOS-Controller.

Controller system hardware description (motor controller, computer etc.)
We are using two steerable axes from a model car 1:8 and one Maxon motor. We hope to reach a velocity of up to 5 m/s.

The cardan shafts of the differential gears of the two axes are driven from a third central differential gear. As our milling machine is to weak to shape aluminium, we milled and glued carbon-plates to fit the drive with this center differential gearbox.



This milling machine is not only weak, it is also a very small milling machine. That's why we are planing to manufactor our chassis of many small overlapping pieces of plywood, sticked together with epoxyresin and glasfibres. By this means we hope to finalize with a construction, compareable to a soap box car, called “SOIFAKISCHTLE” in the swabian dialect of our region. For the steering of the robot, we are using digital Dynamixel servos. For further small parts like the mountings of the laser scanners, we plan to use parts manufactured from a 3D-printer and constructed with CAD-Software CATIA.

Short strategy description for navigation and applications
At the time of this writing, our hope is, that we can master to assemble the robot in the remaining time. So far we milled and glued our ground plate and our drive assembly. Most parts are delivered and some long sessions with milling, drilling, glueing, planning and wirering are scheduled for the next days of our two week school holidays. We all are hoping, that strategical (software) ideas will come soon, when the robot is able to drive. But before the crucial hacks can be tested, the maize plants have to sprout through the ploughed soil first and before we can see any germs on the surrounding maize fields there is no reason to panic.... As you can see from the rendered picture our CAD-expert has designed a separate trailer for the seeding task. Mayhap, that this trailer will be printed in 3D. Another idea is to modify a camera based pan-tilt-controller from a former robot-project for detecting and spraying the weed in the weeding task. But lets do it like the famous soccer pros and think from game to game. And before we have to play against the “Task1 opponents” we first have to play against some “assembly, constructions and software opponents” the next days...

14. Talos

Team members:	David Reiser, Daniel Riehle, Javier Martín; Max Staiger; Olimjon Tuychiev, Tobias Schleker		
Team captain:	David Reiser		
Instructor(s):			
Institution:	University Hohenheim – Institute of Agricultural Engineering		
Department:	Instrumentation and Test Engineering		
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Webpage:	www.uni-hohenheim.de/einrichtung/fg-mess-und-prueftechnik		

THE MACHINE			
W x L x H (cm):	50 x 110 x 60	Weight (kg):	40
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Static motor / 0.8	Turning radius (cm):	0
Battery type / capacity (Ah):	2 x 48 Ah	Total motor power (W):	200
Sensor(s) type(s) used:	LIDAR, encoder, IMU, Camera		

Controller system software description (sensor data analysis, machine control etc.)
Ubuntu 14.04, ROS-Indigo, Lidar based RANSAC line detection algorithm

Controller system hardware description (motor controller, computer etc.)
i3-Quadcore processor with 3.3 GHz, 4 GB RAM and SSD Hard drive, 2 x 12V/48Ah batteries, 2 x motor controllers (Roboteq, SDC2130), IMU (VN- 100), 2 x Sick TIM LMS 571 2D- LIDAR, Raspberry Pi 3, Kinect V2

Short strategy description for navigation and applications
The Robot navigate himself in the row with a calculated vector. This Vector apparent from a Point cloud analysed by an RANSAC algorithm. At the End of the row the robot drives to the next by constantly checking the encoder values combined with the IMU. In addition the Robot is equipped with a Kinect V2 Camera to analyse the ground. Analysing this Information with a Circle Hough Transform algorithm, will identify foreign objects and provide the basis of completing Task three.

These are the commercial team sponsors & partners (if there are)
SICK

15. The Great Cornholio (The Normal One)

Team members:	Fabian Ellermann, Jan Roters, Tristan Igelbrink, Matthias Igelbrink, Thomas Ludemann, Florian Wasmuth, Heiko Wilms, Aditya Kapur, Ivan Zaytsev, Olga Merzliakova, Steffen Hellermann		
Team captain:	Steffen Hellermann		
Instructor(s):	Arno Ruckelshausen, Andreas Linz		
Institution:	University of Applied Sciences Osnabrück		
Department:	Engineering and Computer Science		
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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:	Commercially, based on Volksbot by Fraunhofer	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Skid drive, differential steering	Turning radius (cm):	0
Battery type / capacity (Ah):	Lead acid 2x 12V/7.2Ah	Total motor power (W):	2x 150W
Sensor(s) type(s) used:	Sick LMS100 Laserscanner, Xsens IMU/Compass, Odometry, Raspberry Pi Cams (RGB, IR)		

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 freespace approach using laserscanner data. The turning at the end of the rows uses the IMU sensor to perform a 90 degree turn, drives straight for the row width and heads back into the field by a 90 degree turn. Apart from that we use different tracking algorithms to identify and follow the pink golf balls (in order to spray them) and the red/blue line in the seeding task. Furthermore we implemented mechanical parts for spraying the weed and loading/spread out the seeds.

16. Zephyr

Team members:	Sven Höhn, Matthias Kölsch, Daniel Patoka, Oliver Tiebe, Sebastian Zeller		
Team captain:	Jan Kunze		
Instructor(s):	Jan Kunze, Simon Hardt, Prof. Dr.-Ing. Klaus-Dieter Kuhnert		
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Webpage:	http://www.eti.uni-siegen.de/ezls/		

THE MACHINE			
W x L x H (cm):	40 x 65 x 50 cm	Weight (kg):	20 kg
Commercial or prototype:	Prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	Four wheel drive	Turning radius (cm):	75 cm
Battery type / capacity (Ah):	4 cell LiFePo battery (20 Ah)	Total motor power (W):	2000 W
Sensor(s) type(s) used:	Accelerometer, Camera, Compass, Gyroscope, Kinect V2, Laser, Ultrasonic		

Controller system software description (sensor data analysis, machine control etc.)
Sensor data analysis and machine control are programed in C / C++ and Python using Robot Operating System (ROS), OpenCV and Point Cloud Library (PCL) running on Ubuntu Linux.

Controller system hardware description (motor controller, computer etc.)
Zephyr contains a self-developed energy board, a self-developed UDOO Connector Board (UCB), which connects all sensors with the UDOO Board and a mini-itx mainboard with an Intel I7-4785T because a lot of power is needed for image processing like OpenCV. For precise power and throttle setting Zephys motors are connected to two LPR Truck Puller motor controller.

Short strategy description for navigation and applications
The main idea for task 1 is the usage of the laser scanner to navigate to the middle of the actual row or the entrance of the following row. In Task 2 the laser range data is used to build a 2D grid from the field. The grid is then divided into several clusters and the algorithm tries to detect the clusters that are most likely the plant rows. The Kinect is used in task 3 to detect weed in front of the robot and mark its position. Detected weed will be sprayed behind the robot, using a rgb camera and a moveable arm.

17. ZukBot

Team members:	Błażej Błaszczuk, Mateusz Olszewski, Tomasz Węsierski
Team captain:	Mateusz Olszewski
Instructor(s):	Stanisław Raczyński
Institution:	Gdańsk University of Technology
Department:	Department of Automatic Control
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Webpage:	https://www.facebook.com/zukbot/

THE MACHINE			
W x L x H (cm):	51 x 65 x 38	Weight (kg):	15
Commercial or prototype:	prototype	Number of wheels:	4
Drivetrain concept / max. speed (m/s):	4 WD, 5 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	LiPo / 8 Ah	Total motor power (W):	201.6
Sensor(s) type(s) used:	LIDAR, USB Camera, 12bit encoders		

Controller system software description (sensor data analysis, machine control etc.)
ROS running SLAM using lidar and odometry data

Controller system hardware description (motor controller, computer etc.)
PC + Arduino + custom motor drivers

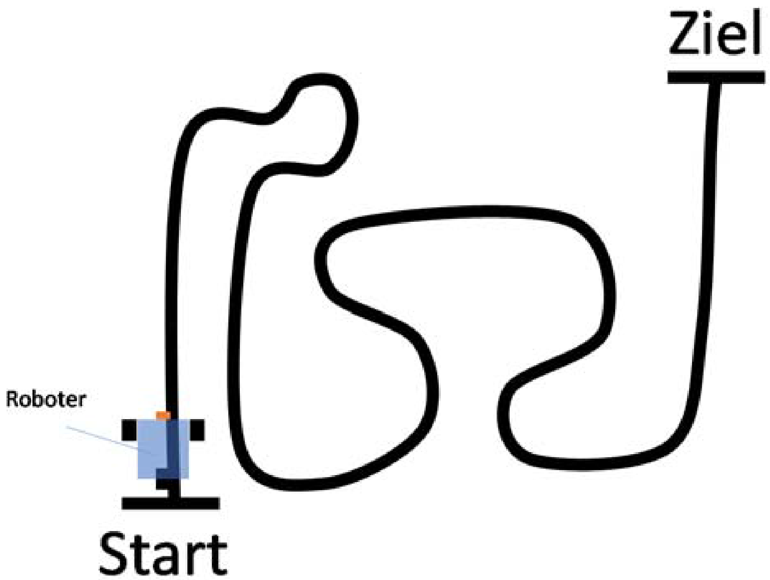
Short strategy description for navigation and applications
Robot moves based on location of closest corn and IMU data

Field Robot Junior

Beschreibung der Tasks

TASK 1: Eine Maschine, die einer schwarzen Linie folgt (Navigation)

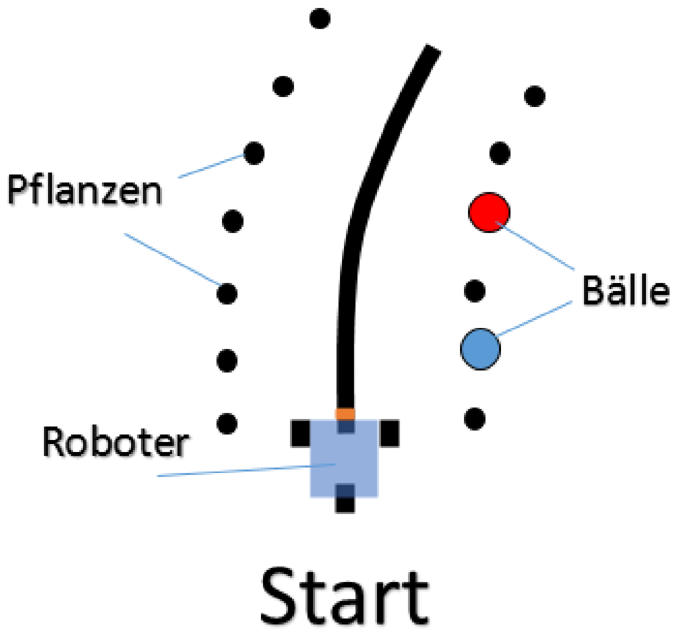
Um die Mobilität und Flexibilität der Roboter und der Regelung zu testen, müssen die Roboter einer vorgegebenen schwarzen Linie folgen. Diese folgt einer Strecke mit einer Gesamtlänge von ca. 10 m. Die Linienbreite beträgt 15 mm (+/- 5 mm). Der minimale Radius beträgt 150 mm. Start- und Stopp- Markierung werden durch einen schwarzen Querstreifen symbolisiert. Hält der Roboter selbständig an der Ziellinie an, werden Zusatzpunkte vergeben. Für die Navigation auf der schwarzen Linie darf nur ein einzelner Lichtsensor benutzt werden!



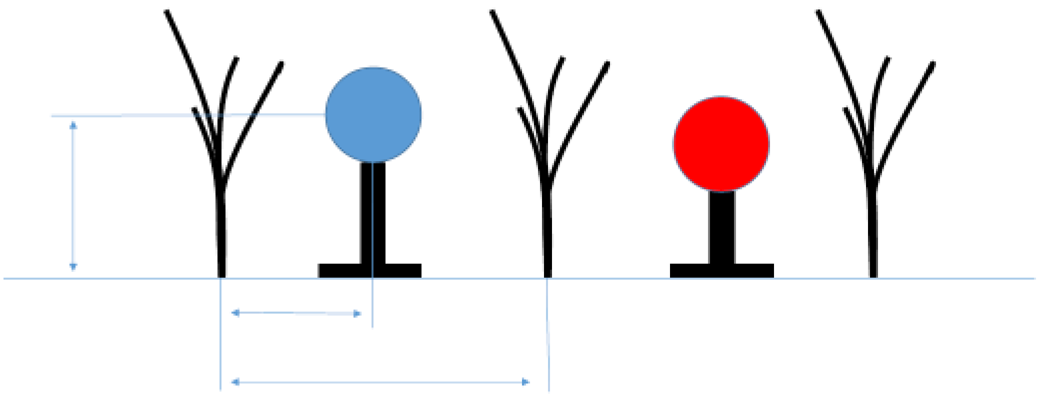
Wertung: Jedes Team hat zum Start 1000 Punkte. Es wird die Zeit vom Startpunkt bis zur Ziellinie in Sekunden gemessen. Für jede verstrichene Sekunde wird ein Punkt von dieser Punktzahl abgezogen. Sollte es nötig sein, den Roboter manuell wieder in die richtige Position zu bringen, werden dafür 10 Punkte abgezogen. Sollte der Roboter offensichtlich eine Abkürzung zur Ziellinie wählen, muss er zum letzten Punkt auf der Linie zurückgesetzt werden.

TASK 2 - Eine Maschine, die erntet (Harvester)

Vielleicht werden in Zukunft Feldfrüchte nicht mehr von Hand, sondern von mobilen Maschinen geerntet?! Leider befinden sich Feldfrüchte nie an einer definierten Stelle, was es nicht leicht macht, sie zu finden. Ebenso die Unterscheidung zwischen „faulen“ und „guten“ Früchten, ist nicht so einfach, wie es schein.



Im Rahmen der MPT-Challenge werden die guten Feldfrüchte durch rote Bälle und die faulen, verdorbenen Feldfrüchte mit blauen Bällen symbolisch dargestellt. Diese befinden sich in einer Reihenstruktur, zwischen einer Höhe von 0 bis 30 cm. Jede „Feldfrucht“ ist auf einer Halterung angebracht, welche in der Reihe positioniert wird. Der Minimalabstand zwischen Feldfrucht und Pflanze beträgt 10 cm. Die Feldfrüchte werden nur auf der rechten Seite des Roboters positioniert. Es werden niemals zwei Feldfrüchte (Bälle) nebeneinander ohne Pflanze dazwischen positioniert. Die „reifen“ Feldfrüchte müssen „eingesammelt“ und die „verdorbenen“ Früchte entfernt werden. Eine Feldfrucht gilt als „eingesammelt“, wenn der Roboter die Frucht erfolgreich zur Ziellinie transportiert hat. Eine Feldfrucht gilt erfolgreich als entfernt, wenn der Roboter den Ball von seinem Ständer „geschupst“ hat.



Wertung: Für jeden richtig entfernten Ball gibt es 100 Punkte, für jede „zerstörte“ Pflanze gibt es 50 Minuspunkte, für jeden korrekt eingesammelten Ball gibt es 100 Punkte, sowie weitere 100 Punkte wenn der Ball korrekt zur Ziellinie transportiert wurde. Sollte ein Eingreifen der Teams erforderlich sein, werden dafür 10 Minuspunkte vergeben. Für das Erreichen der Ziellinie hat jedes Team 3 Minuten Zeit. Sollte nach der Zeit das Ziel nicht erreicht sein, wird die Distanz zur Ziellinie gemessen. Pro 10 cm Weg werden 5 Punkte abgezogen.

TASK 3 - Eine Maschine, die etwas Spannendes kann (Freestyle)

Im Freestyle-Wettbewerb könnt Ihr die besonderen Fähigkeiten Eures Roboters demonstrieren – ganz egal ob es um Landtechnik oder um andere Bereiche geht. Hauptsache, die Demonstration ist originell und kreativ. Ihr habt außerdem die Möglichkeit, den Zuschauern vor bzw. während der Vorführung kurz ein paar Erläuterungen zu geben. Die Vorführung kann auf der Wettbewerbsstrecke, oder aber auch – je nach Platzbedarf – auf dem Tisch oder Fußboden erfolgen.

Bewertung: Drei Maschinen, die gewinnen

Die Bewertung wird von einer Jury vorgenommen. Es werden bei jeder einzelnen Aufgabe die besten drei Teams platziert. Der Gesamtsieger des Field Robot Event Junior wird aus den Platzierungen von Aufgabe 1 und Aufgabe 2 errechnet, zusätzlich wird ein Preis für das beste Roboter-Design durch die Jury vergeben.

Program (short version)

Monday, June 13

12:00 – 18:00	Arrival and team registration (all day) First testing in test fields
18:30	Dinner at Accommodation Site

Tuesday, June 14

09:00 – 12:00	**Field Robot Demo** Team Registration Presenting 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	Dinner at Accommodation Site

Wednesday, June 15

09:00 – 12:00	**Robot Talks** Presenting Teams & Robot Testing
14:00 – 17:00	**Contest Task 3 (Weeding)** **Contest Task 4 (Seeding)** & Awarding
18:00 – 22:00	Final Contest Awarding Robot Design Award BBQ party

Thursday, June 16

9:00 – 10:00	Robot Testing
10:00 – 11:30	**Contest Task 5 (Free style)**
11:30 – 12:00	Awarding Task 5 Farewell to the student teams
13:30 – 14:00	Welcome to **Field Robot Junior**
14.00 – 17:00	Task 1, task 2 and freestyle
17:00 – 17:30	Awarding Field Robot Junior

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