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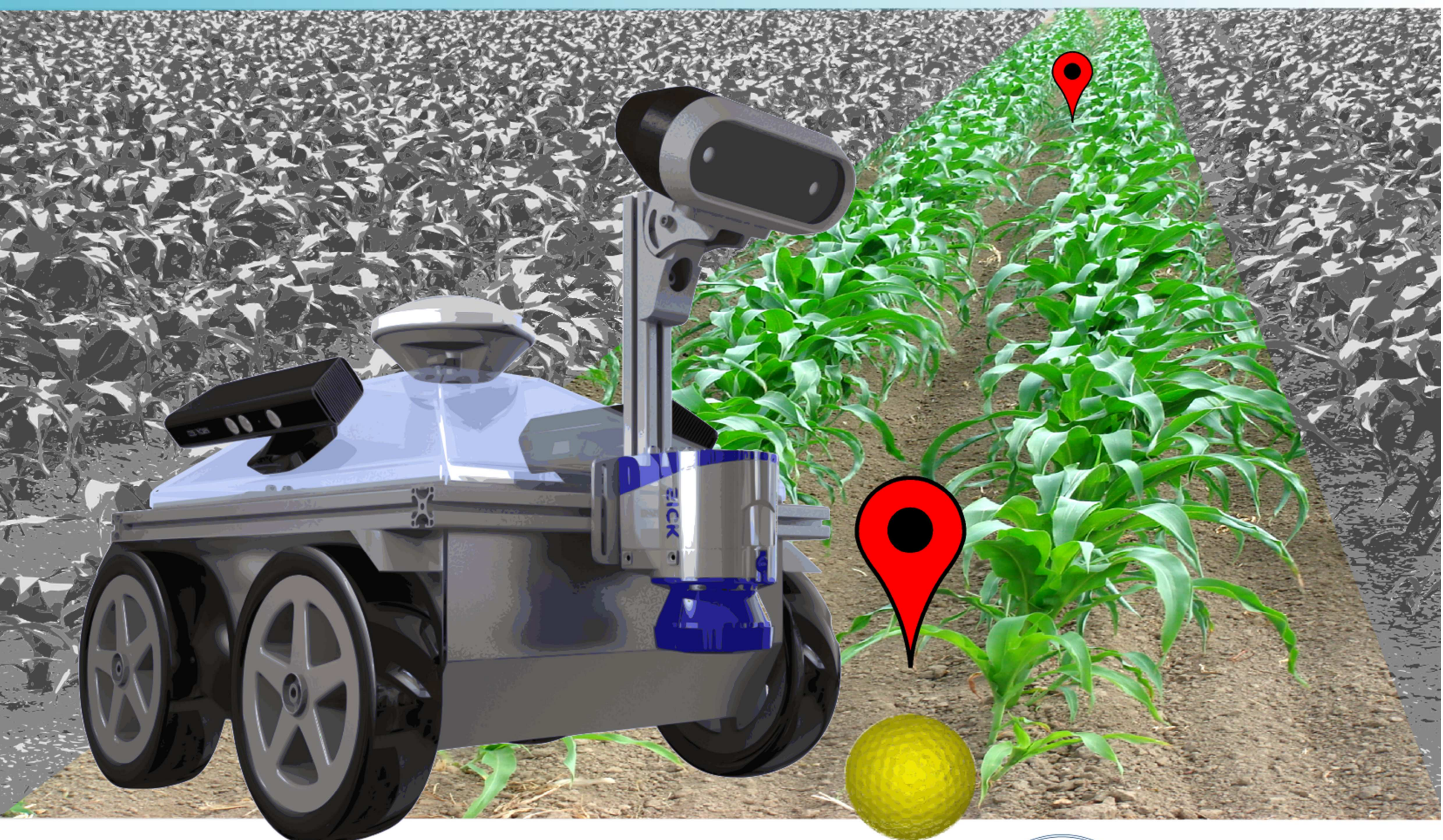
Field Robot Event

12th edition

17 - 19 June 2014

Program Booklet



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Index

Thanks to all who contributed to the organisation!

University of Hohenheim

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Deutsche Landwirtschafts-Gesellschaft e.V. (DLG)

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Hochschule Anhalt

Stephanie Eckstein, Susanne Thalmann

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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 three teams coming first time to the competition.

Welcome to the Field Robot Event 2014!

The 12th Field Robot Event will take place in Bernburg-Strenzfeld, Germany from Monday June 16th to Thursday June 19th 2014. The FRE 2014 is held in conjunction with the DLG Field Days (DLG-Feldtage), 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. We are looking forward to this year event and hope to enjoy interesting and creative solutions. 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 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. This year the contest will be different in duration and tasks. The well-known and famous 5 tasks will be spread over 3 days. This will offer more time for better preparation and adaptation to the local requirements. Furthermore, we also offer new degrees of freedom by providing GNSS technology to demonstrate weed mapping. Weed mapping requires weed detection and proper machine and sensor data analysis. Additionally we offer to use the GNSS systems for creative demonstrations during the collaboration task and the famous freestyle task. For navigation purposes the GNSS is not allowed in task 1, 2 and 3.

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: www.fre2014.uni-hohenheim.de

Field Robot Event 2014 - Task Description

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

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

0. Introduction

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

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

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

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

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

0.1. General rules

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

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

During the contests all robots have to wait in the parc fermé and no more machine modification to change the machine performance is - with regard to fairness - allowed. All PC connections (wired and wireless) have to be removed or switched off and an activation of a battery saving mode is recommended. This shall avoid having an advantage not being the first robot to conduct the task. The starting order will be random. When the 1st robot will move to the starting point the next robot will already be asked by the parc fermé officer to prepare for starting.

At the starting point the robot must start within one minute. If the robot doesn't start within this time, it will get a second chance after all other teams finished their runs, but it must - after a basic repair - as soon as possible brought back into the parc ferme. If the robot fails twice, the robot will be excluded for that task.

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

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

0.2. Awards

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

Rank	1	2	3	4	5	6	7	8	9	etc.
Points	10	8	6	5	4	3	2	1	1	etc.

Participating teams result in at least 1 point, not participating teams result in 0 points. If two or more teams have the same number of points for the overall ranking, the team with the better placements during all three tasks (1, 2 and 3) will be ranked higher.

1. Task "Basic navigation" (1)

1.1. General description

Within three minutes the robot has to navigate through long curved rows of maize plants (*picture 1* at the bottom of this text). The aim is to cover as much distance as possible. On the headland, the robot has to turn and return in the adjacent row. There will be no plants missing in the rows. This task is all about accuracy, smoothness and speed of the navigation operation between the rows.

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

1.2. Assessment

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

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

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

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

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

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

2. Task “Advanced navigation” (2)

2.1. Description

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

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

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

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

The code of the path pattern through the maize field is done as follows: S means START, L means LEFT hand turn, R means RIGHT hand turn and F means FINISH. The number before the L or R represents the row that has to be entered after the turn and the single number 0 means return in the same path. Therefore, 2L means: Enter the second row after a left-hand turn, 3R means: Enter the third row after a right hand turn. The code for a path pattern for example may be given as: S - 3L - 0 - 2L - 2R - 1R - 5L - F.

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

2.2. Assessment

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

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

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

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

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

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

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

3. Task “Professional Application” (3)

3.1. Description

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

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

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

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

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

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

3.2. Assessment

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

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

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

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

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

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

4. Task "Cooperation" (4)

4.1. Description

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

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

[4] The robot is welcome to also indicate GNSS mode status.

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

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

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

4.2. Assessment

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

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

5. Task “Freestyle” (5)

5.1. Description

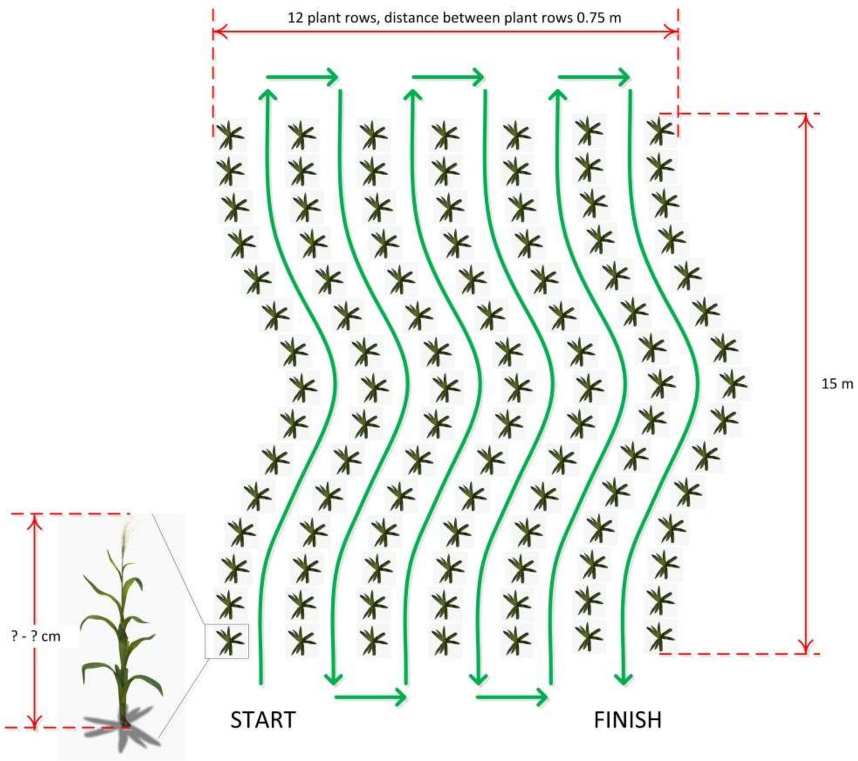
Teams are invited to let their robots perform a freestyle operation. Creativity and fun is required for this task as well as an application-oriented performance. One team member has to present the idea, the realization and perhaps to comment the robot’s performance to the jury and the audience. The freestyle task should be related to an agricultural application. Teams will have a time limit of five minutes for the presentation including the robot’s performance.

5.2. Assessment

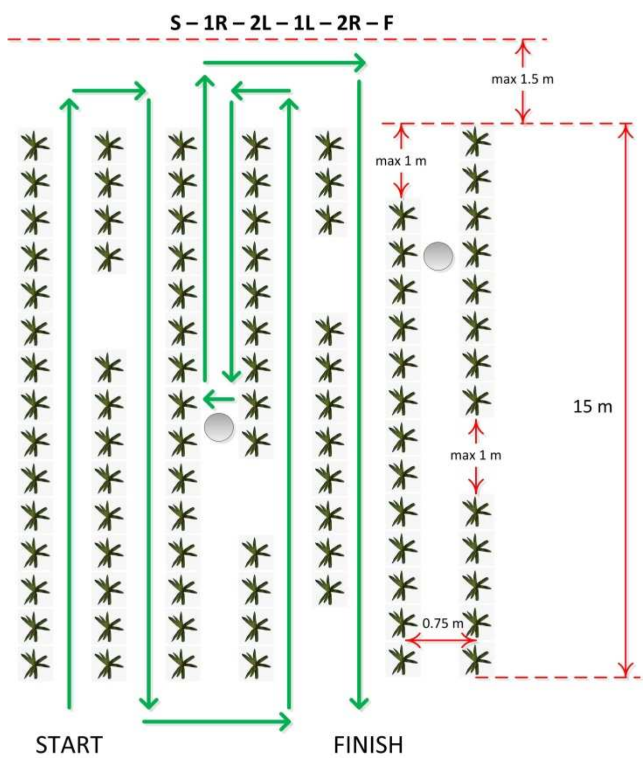
The jury will assess the (i) underlying idea, the (ii) technical challenge and the (iii) robot performance by giving points from 1 (fair) to 10 (excellent) for each. The three criteria will be weighted by factors 1, 1 and 2. The teams will be ranked by highest points.

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

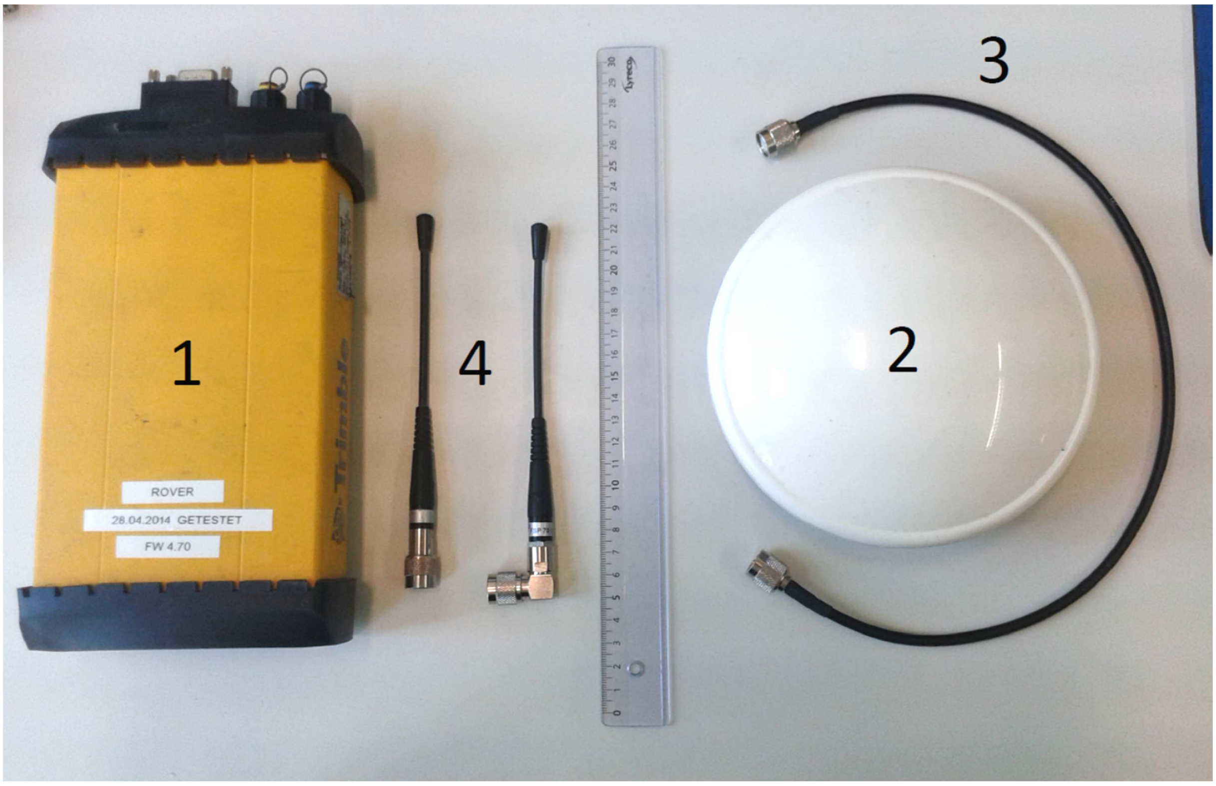
Appendix



Picture 1 – Dimensions and row pattern for task 1



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



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

Program

Monday, 16th June: Field Robot Preparation

When	What	Where
12.00-18.00	Team Registration	Contest Area / Strenzfeld
12.00-18.00	First testing in the test field	Contest Area / Strenzfeld
18.00-20.00	Dinner	Hochschule Anhalt

Tuesday, 17th June: Contest Day 1

When	What	Where
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-12.00	Team Registration Presenting the Teams & Robot Testing **Field Robot Demo**	Contest Area / Strenzfeld
10.00-11.00	Briefing of team captains	Contest Area / Strenzfeld
12.00-13.00	Lunch	
13.30-14.00	Welcome note	Contest Area / Strenzfeld
14.00-17.00	Contest Task 1 (Basic navigation) Contest Task 2 (Advanced navigation)	Contest Area / Strenzfeld
17.00-17.30	Awarding task 1 & 2	Contest Area / Strenzfeld
18.00-19.00	Dinner	Hochschule Anhalt

Wednesday, 18th June: Contest Day 2

When	What	Where
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-12.00	**Field Robot Talks** (selected topics) Presenting the Team & Robot Testing **Field Robot Demo**	Contest Area / Strenzfeld
12.00-13.00	Lunch	
14.00-17.00	Contest Task 3 (Application) Contest Task 4 (Cooperation)	Contest Area / Strenzfeld
17.00-17.30	Awarding task 4	Contest Area / Strenzfeld
18.00-22.00	Awarding task 3 & final awarding contest winner 2014 & BBQ & Music	Hochschule Anhalt

Thursday, 19th June: Contest Day 3

When	*What*	*Where*
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-10.00	Robot Testing	Contest Area / Strenzfeld
10:00-11:30	Contest Task 5 (Free style)	Contest Area / Strenzfeld
11.30-12.00	Awarding task 5	Contest Area / Strenzfeld
12.00-13.00	Lunch	
13.30-14.00	Welcome to the **Field Robot Junior**	Contest Area / Strenzfeld
14.00-17.00	Task 1, task 2 and Freestyle	Contest Area / Strenzfeld
17.00-17.30	Awarding Junior Winner	Contest Area / Strenzfeld

Field Robot Demo

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.
The machine was developed by Hochschule Osnabrück, Amazonen Werke and Bosch.

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 and in teaching to allow project work with autonomous vehicles.
The machine was developed by Universität Hohenheim and University of Southern Denmark (SDU).

Field Robot Talks

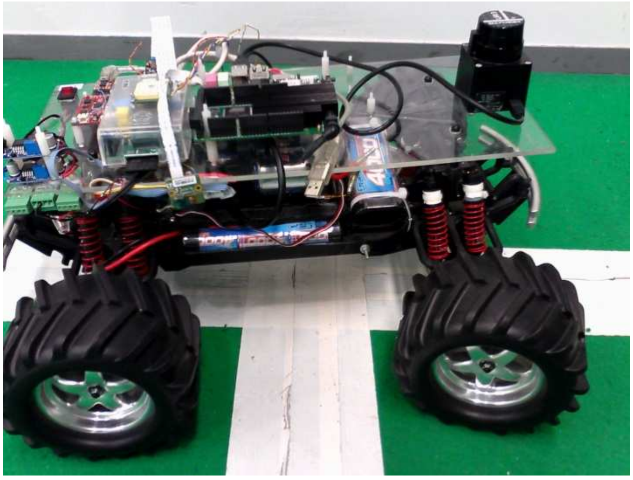
On 18th June Wednesday morning we will arrange a workshop with short presentations and discussions. The topic this year will be

Operating systems and controller frameworks – what is the state-of-the-art and what are the future directions?

We will use the beamer & screen and the audio in the awarding tent.

Participating Teams

1. AGROB V14



Team members:	Filipe dos Santos, Filipe Ferreira
Team capitain:	Filipe dos Santos
Instructor(s):	
E-mail:	fbsantos@inesctec.pt

CHASSIS				SENSORS	
WxLxH (cm):	**50x44x34**	Weight (kg):	**5**	☒ Camera	☒ Laser
Model/Make:	**EMAXX/Traxxas**	Number of wheels:	**4**	☒ Compass	☐ Odometry
Drivetrain concept:	**Four-wheel drive**	~Turning radius (cm):	**79**	☒ Sonar	☒ Gyroscope
Battery time:	**1 hour**	Rain resistance:	**No**	☒ IR	☐ Mechanical sensor

Robot software description
This robot has two processing units running Linux with the robotic operating system (ROS) on top. There are five main nodes, running on ROS: Task executer, Maneuverer, Collision avoidance, Sensor information fusion, Visual plants detection.

Robot hardware description
This robot is built on top of RC model, the E-Maxx of Traxxas, with 2 main processing units (one raspberrypi, one udoo), where is attached one Laser Range Finder, one Inertial Measurement Unit, GNSS receiver (which will be disconnected), two cameras (IR,RGB), and an array of 7 distance sensors.

Task strategy description
This robot will be prepared to execute only the task 1 and task 2. **Task 1:** On this task the robot the robot will use the LRF measurements to guide the robot through the maze plants. The near observed plants will be used to steer the wheels. **Task 2:** The same procedure used on **task 1** will be used on **task 2**, however if an obstacle appears on the path the robot will execute the reversing maneuverer and follow the instructions given by the human supervisor.

Institution:	INESCTEC		
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Street/Number:	Feup Campus	ZIP Code:	4200-465
Homepage	www.inesctec.pt (www.hyselam.com/agrob.html)		

2. Agro-Bot

Team members:	To Doan Ngoc Hai, Tran Phu Long and Andrei Sandru
Team capitain:	Samrat Gautam
Instructor(s):	Markku Kippola
E-mail:	aksamrat.gautam@gmail.com

CHASSIS				SENSORS	
WxLxH (cm):	**36x52x106**	Weight (kg):	**12**	☒ Camera	☐ Laser
Model/Make:	**-**	Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**4WDD**	~Turning radius (cm):	**75**	☒ Sonar	☒ Gyroscope
Battery time:	**30minutes**	Rain resistance:	**No**	☐ IR	☐ Mechanical sensor

Robot software description
Lab View was used as main programming software. It was because the Labview is a graphical programming language. This makes it simple to use and debug. Two piece of Arduino Mega was used as an interface board between laptop, sensors and actuators. Serial communication was established between labview running on laptop and arduino mega.

Robot hardware description

Agro-Bot was the name given to the robot. The robot chassis was designed in Autodesk inventor 2012 and fabricated using aluminium AW 6063 T5 rectangular bar of size (100x20x2, 40x20x1.5 and 20x15x1.5) mm. Each wheel was separately powered by an electric motor and featured with a suspension system to ensure that all the wheels touched the ground. The robot chassis held everything attached to it and had a provision to hook follower.

As shown in figure, it had four sonar sensors whose positions were defined as -90, -45, 0, 45, 90. It had a laptop on the top which controls outputs through Arduino. 12V 15Ah battery was placed just below laptop. Motor H-bridge, power adapter and Arduino were placed inside a junction box which is underneath a laptop. Power adaptor was used to step down 12 Volt into 5 volt for powering arduino and other sensors. There were two cameras; one in the middle and the other on right hand side. Rare wheels were equipped with a wheel encoder. A camera placed on the centre was used to capture images for detecting a yellow coloured ball. The camera placed on the right hand side was used to synchronize the robot path.

For task5 a follower was used to irrigate the field. Follower consists of water tank and pipe rolled in a drum. Follower was hooked to main robot in task five only.

Task strategy description

Different control module was created to simplify the programming task such as: follow row, change direction and locate goals.

Follow Row: First and foremost control module developed was follow row. This module was used to navigate the robot in between two maize plant rows. For this task data from camera and sonar sensor was used. Camera was placed just above the crops field so that the robot can follow crops row to reach the goal. Sonar sensor attached on the side was used to keep the robot equidistance from the rows This module was used in all the task of FRE with other modules. Wheel encoder signal was used to store the total distance travelled before the change of controller.

Change Direction: In this module, turning mode was defined. This mode was used to take clock or counter clockwise turn as soon as the robot reaches end of row in conjunction with distance value from wheel encoder. This mode was used in all tasks when the maize plant was not detected within the field of view of camera.

Locate Goal: The main aim of this control module was to locate the absolute position of weed plants randomly placed in maize field. This was achieved by using RTK GNSS system to know the absolute position of the robot on the crops field and relative positions of weed plant were determined by processing images captured from camera. Whenever a weed plants were detected within the effective field of view then its centre was calculated using NI vision tool and a buzzer was activated as a successful identification. The coordinate transformation algorithm was used in LabView. It was assumed that the height of the camera and the weed plant were known and were kept constant throughout the test. Thus it was possible to project the pixel describing the centre of mass of the object down to a plane that was parallel to the ground. It was also possible to obtain desire height by using pinhole optics as an approximation.

These control modules were tested and switched to achive smooth navigation between crops rows to complete task 1, task3 and task5.

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Homepage	http://www.hamk.fi/Sivut/default.aspx		

3. BANAT

Team members:	Almasan Catalin, Negirla Paul, Simandan Caius, Toth Eniko
Team capitain:	Fitz Cristian-Leonard
Instructor(s):	Bungescu Sorin-Tiberiu, Nanu Sorin, Tucu Dumitru
E-mail:	fitzcristian@gmail.com

CHASSIS				SENSORS	
WxLxH (cm):	**40x40x20**	Weight (kg):	**10**	☒ Camera	☐ Laser
Model/Make:		Number of wheels:	**4**	☐ Compass	☐ Odometry
Drivetrain concept:	**All wheel drive in pairs**	~Turning radius (cm):	**0 cm**	☒ Sonar	☒ Gyroscope
Battery time:	**30 min.**	Rain resistance:	**Medium**	☐ IR	☐ Mechanical sensor

Robot software description
The software of BANAT robot makes no exception from our concept of having a very flexible and adaptable agricultural solution. We combined low level embedded C, used for data acquisition from the sensors and high level software for image processing, in order to create an advanced software system.

Robot hardware description
The robot is using an Stellaris® LM4F120 based on an ARM® Cortex™-M4F-microcontroller as the main board, followed by a Raspberry Pi for image processing tasks and an Arduino Mega 2560 microcontroller board based on the ATmega2560. The processing units will be connected to 7 * HC-SR04 ultrasonic ranging modules, a Raspberry Pi Camera a gyroscope, a wireless module, a bluetooth module, a soil hygrometer, and a Lynx robotic arm.

Task strategy description
For the navigation tasks, the algorithms will focus on mapping the rows. With the help of the hc-sr04 ultrasonic distance sensors, the robot will be adjusted in order to keep it centered on the row. On the headland, the robot will turn and return in the adjacent row, or for task 2, the required row. A headland can be easily detected when both side sensors detect an empty space. For task 3, the Raspberry Pi is going to provide information to the main board about the weeds found on the row. When the yellow ball will be detected, it will trigger a "weed found" state, so the correct algorithm will be called in the following sequences.

Institution:	USAMVBT & UPT - Timisoara		
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Homepage			

4. BullsEye

Team members:	Jasper van Meer, Hermen de Jong, Gijsbert Thomassen, Bastiaan Vergouw, Daan van der Stelt
Team capitain:	Jasper van Meer
Instructor(s):	Dr. ir. J.W. (Jan-Willem) Hofstee
E-mail:	hermen.dejong@wur.nl

CHASSIS				SENSORS	
WxLxH (cm):	**50x110x60**	Weight (kg):	**35**	☒ Camera	☒ Laser
Model/Make:	**LT-3.0i**	Number of wheels:	**4**	☒ Compass	☒ Odometry
Drivetrain concept:	**Direct drive**	Turning radius (cm):	**15**	☐ Sonar	☒ Gyroscope
Battery time:	**1h45m**	Rain resistance:	**Splash proof**	☐ IR	☐ Mechanical sensor

Robot software description
The software is build up in LabVIEW

Robot hardware description
Computer: Gigabyte GA-B75N, Intel Core i7 3770T Compass: Xsens Motion Tracker MTi Laser: Sick Laserscanner LMS111-10100 Batteries: ZIPPY Flightmax 8000 mAh 6S1P 30C Cameras: Guppy F033C

Task strategy description
Task 1: The laser scanner scans the rows and with that information we make a preferred route with an intersect and a slope. **Task 2:** Using laser scanner, which recognizes objects. **Task 3:** Using vision (cameras) and comparing colours/shapes. LED lights and a patlite are used for signalization with lights and a speaker for a sound signal. We will save the location of the golf balls in a map by using a GPS module. **Task 4 (Cooperation):** We are not going to prepare this before the event starts, if we find a partner during the event to do this task we will enter this part of the FRE **Task 5 (freestyle):** To spray the golf balls, between the rows and also in the path**.**

Institution:	Wageningen University		
Department:	Farm Technology Group		
Country:	The Netherlands	City:	Wageningen
Street/Number:	Bornsesteeg 48	ZIP Code:	6708 PE
Homepage	www.robatic.nl		

5. Ceres

Team members:	Jelle Adema, Daan van den Brandt, Tobias Davids, Jannick Eichert, Bram Geurts, Stefan Heijnen, Niek Lamers, Simon Norra, Nick Staaks, Patrick Surrey
Team captain:	Bram Geurts
Instructor(s):	Frank van Gennip
E-mail:	bram.geurts@student.fontys.nl f.vangennip@fontys.nl

CHASSIS				SENSORS	
WxLxH (cm):	**40x65x90**	Weight (kg):	**~15**	☒ Camera	☐ Laser
Model/Make:	**Fontys**	Number of wheels:	**4**	☒ Compass	☐ Odometry
Drivetrain concept:	**Servo**	~Turning radius (cm):	**35**	☐ Sonar	☐ Gyroscope
Battery time:	**1 h**	Rain resistance:	**Yes**	☐ IR	☐ Mechanical sensor

Robot software description
The field robot uses two cameras which are on top of the main housing and at the front to navigate through the field. The first camera is placed in a vertical position in the direction of a mirror. The second one looks to the front. The input of the cameras are processed by a labview program. This program gives signals to our motors that will determine how the robot will drive.

Robot hardware description
DC-motors and stepper motors make the field robot able to drive and steer. The DC motors are connected to a gearbox underneath the main housing. In the front of the robot and the back of the robot we have a module for the gearbox and one for the stepper holder. The wheels are connected with the gearbox through torque transmissions.

Task strategy description
A tablet is placed on top of the main housing. This tablet can also be used to control the robot and shows feedback for various data. The second camera will make it easier to detect the golf balls for one of the tasks. It's a lot closer to the ground than the first camera, so that it is easier to differentiate golf balls from the rest of the surface.

Institution:	Fontys FHTenl Venlo		
Department:	Mechatronics		
Country:	Netherlands	City:	Venlo
Street/Number:	Tegelseweg 255	ZIP Code:	5912
Homepage	www.fontysvenlo.nl		

6. CORNSTAR

Team members:	Uroš Jagodič, Jože Kraner, Miran Purgaj, Zvonko Šlamberger
Team capitain:	Miran Lakota
Instructor(s):	Peter Berk, Jurij Rakun
E-mail:	jurij.rakun@um.si

CHASSIS				SENSORS	
WxLxH (cm):	**40x60x40**	Weight (kg):	**15**	☐ Camera	☒ Laser
Model/Make:	**Custom build**	Number of wheels:	**4**	☒ Compass	☐ Odometry
Drivetrain concept:	**Car**	~Turning radius (cm):	**120**	☐ Sonar	☐ Gyroscope
Battery time:	**1.5h**	Rain resistance:	**Moderate**	☐ IR	☐ Mechanical sensor

Robot software description
Linux (Linaro) + ROS

Robot hardware description
Embedded computer - Nitrogen6x and a Peripheral expansion board - AVR atmega 128 mcu Camera - The imaging source's DBK31BU03 LIDAR - SICK TIM 310 3 phase motor – X-power eco A4130-06BL 3 LiPo Battery packs

Task strategy description
We will keep our fingers crossed and hope for the best ;)

Institution:	University of Maribor, Faculty of Agriculture and Life Sciences		
Department:	Biosystems engineering		
Country:	Slovenia	City:	Hoce
Street/Number:	Pivola 10	ZIP Code:	2311
Homepage	http://fk.uni-mb.si:85		

7. DTU Maize Monster

Team members:	Christian Myrhøj, Jan Lorenz, Mikkel Mortensen
Team capitain:	Morten Nylin
Instructor(s):	Ole Ravn, Nils A. Andersen
E-mail:	or@elektro.dtu.dk

CHASSIS				SENSORS	
WxLxH (cm):	**36x63x60**	Weight (kg):	**20**	☒ Camera	☒ Laser
Model/Make:		Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**Differential drive**	~Turning radius (cm):	**Min. 72**	☐ Sonar	☒ Gyroscope
Battery time:	**2 hours**	Rain resistance:	**Some**	☒ IR	☐ Mechanical sensor

Robot software description
DTU Mobotware software framework with modules for task specific behaviours

Robot hardware description
The robot has four wheels which is rear wheel differential drive with Ackermann steering. Inside there is a Mini ITX Computer running Ubuntu 32-bit version 12.04 for processing. The robot has the following exterior sensors: two Hoyuko laser scanners, two Allied Guppy cameras, and a Xbox Kinect.

Task strategy description
The overall strategy for the completion of the tasks is to finish as fast as possible, but also as robust as possible. This means sacrificing some time on correctness of the robot performance.

Institution:	Technical University of Denmark		
Department:	Department of Electrical Engineering		
Country:	Denmark	City:	Kgs. Lyngby
Street/Number:	Elektrovej Building 326	ZIP Code:	2800
Homepage	www.aut.elektro.dtu.dk		

8. Eduro Maxi HD

Team members:	Martin Dlouhy, Stanislav Petrasek, Josef Pavlicek, Petr Hanzlik
Team capitain:	Milan Kroulik
Instructor(s):	
E-mail:	kroulik@tf.czu.cz

CHASSIS				SENSORS	
WxLxH (cm):	**38x65x64**	Weight (kg):	**22**	☒ Camera	☒ Laser
Model/Make:	**Eduro Maxi HD**	Number of wheels:	**3**	☒ Compass	☒ Odometry
Drivetrain concept:	**Differential**	~Turning radius (cm):	**At place, i.e. 0**	☐ Sonar	☐ Gyroscope
Battery time:	**Approx 4h**	Rain resistance:	**Partial**	☐ IR	☐ Mechanical sensor

Robot software description
The main control program is written in Python. It communicates via CAN bus to dedicated modules for motors, sensors, arm and basic user interface.

Robot hardware description
Three-wheeled chassis, two wheels drive, third wheel towed

Task strategy description
Task 1 Depending on the height of plants camera or laser will be used to recognize the left/right plants. They will define obstacles and in given radius (say 1 meter) is selected the biggest gap where to navigate. Task 2 Laser is used for obstacle detection. If the gap is smaller than robot width it will turn in place and return in the same row. Task 3 The camera will be used for the golf balls detection and data will be connected with GPS position. Task 4 freestyle Unconventional design of robots will be presented for field tasks (Drone, Hexapod robot).

Institution:	CULS Prague		
Department:	Agricultural Machines		
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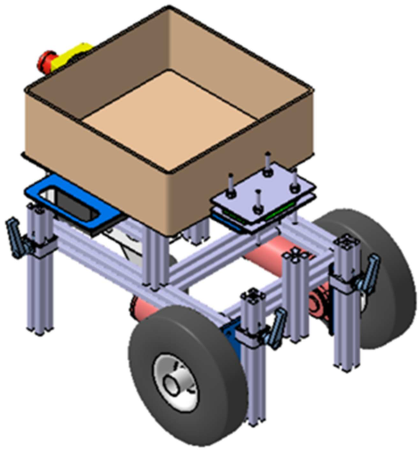
homepage	www.czu.cz; http://robotika.cz		

9. FloriBot



Team members:	Benedict Bauer, Björn Eistel, Felix Binder, Jens Seifried, Lisa Schäfer, Manuel Rixen, Michael Gysin, Torsten Heverhagen, Vera Bauer
Team captain:	Benedict Bauer
Instructor(s):	Prof. Dr.-Ing. Torsten Heverhagen
E-mail:	torsten.heverhagen@hs-heilbronn.de

CHASSIS				SENSORS	
WxLxH (cm):	**41,3x48,4x49,8**	Weight (kg):	**25**	☒ Camera	☒ Laser
Model/Make:	**Modified Explorer / CoreWare**	Number of wheels:	**3**	☐ Compass	☐ Odometry
Drivetrain concept:	**Differential wheeled robot**	~Turning radius (cm):	**30**	☐ Sonar	☐ Gyroscope
Battery time:	**2 h**	Rain resistance:	**No**	☐ IR	☐ Mechanical sensor

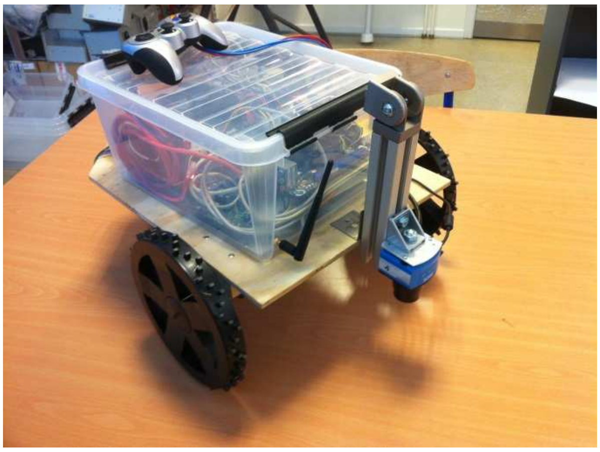
Robot software description
Code generated from Simulink model in conjunction with ROS drivers.

Robot hardware description
Differential wheeled robot made of aluminium profiles.

Task strategy description
Essential strategy: potential field method

Institution:	Heilbronn University		
Department:	Mechanics and Electrics Electronics		
Country:	Germany	City:	Heilbronn
Street/Number:	Max-Planck-Str. 39	ZIP Code:	74081
Homepage	www.hs-heilbronn.de		

10. FROBYTE



Team members:	Anders Kanokpon Garlov Wehland Michael René Andersen Anders Nygård Lauridsen
Team capitain:	Mathias Mikkel Neerup
Instructor(s):	Leon Bonde Larsen
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CHASSIS				SENSORS	
WxLxH (cm):	**50x50x50**	Weight (kg):	**15**	☐ Camera	☒ Laser
Model/Make:	**Frobyte**	Number of wheels:	**2**	☐ Compass	☒ Odometry
Drivetrain concept:	**Diff.**	~Turning radius (cm):	**25**	☐ Sonar	☒ Gyroscope
Battery time:	**1 hour**	Rain resistance:	**7/10**	☐ IR	☐ Mechanical sensor

Robot software description
The hardware is based on a wooden plate with two 3D printed wheels mounted directly on the gear axel of the motors. The motors are of the EMG-49 type with planetary gearbox and encoder feedback. The motors are driven by SimpleH H-bridges connected through control logic to an ATmega168 on a RoboCard. The RoboCard is controlled from the on-board PC via a serial connection. The platform is equipped with a SICK TiM310 Laser Range Scanner (LRS) and a Sparkfun Razor Inertial Measurement Unit (IMU), both connected directly to the on-board PC. All electronics are mounted in a stain-proof plastic box.

Robot hardware description
The software is based on Robot Operating System (ROS) and the architecture of FroboMind (Figure 2) thus separating into action, perception and decision making. All software on the Frobyte is running in nodes on ROS. FroboMind is a way to use ROS to avoid one node doing everything or many nodes doing almost nothing. Using nodes, it is possible to make complex functions and still maintain low coupling. When using nodes it is easy to debug and port to other projects.

Task strategy description

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Department:	Maersk McKinney Moller Institute		
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Street/Number:	Campusvej 55	ZIP Code:	5250
Homepage	www.sdu.dk		

11. GARDENERROB

Team members:	Mihaela Tilneac
Team capitain:	Mihaela Tilneac
Instructor(s):	-
E-mail:	mihaelatilneac@gmail.com

CHASSIS				SENSORS	
WxLxH (cm):	**340x550x230**	Weight (kg):	**8**	☒ Camera	☐ Laser
Model/Make :		Number of wheels:	**4**	☐ Compass	☐ Odometry
Drivetrain concept:	**Electrical motor type 540; Four wheel drive via cardan shaft; Ball-bearing drive; Differential in front and rear axles.**	~Turning radius (cm):	**30**	☐ Sonar	☐ Gyroscope
Battery time:	**Depends. Each group of sensors has its own power supply.**	Rain resistance:	**Depends on the rain intensity.**	☒ IR	☐ Mechanical sensor

Robot software description
Robot software is developed with Arduino 1.0.5. http://arduino.cc/en/Main/Software

Robot hardware description
Energy: 1.2 V rechargeable battery (~35 pieces) in different combinations of current and voltage. **Microcontroller board:** Arduino Uno (3 pieces) **Motor:** DC motor 20 V, 2A (1 piece) **Motor driver:** Dual VNH5019 Shield Arduino (1 piece) L298 v2 Shield (1 piece) **Servomotor:** RC-Car Servo 4519 (1 piece) Power HD Standard Servo 6001HB (2 pieces) Servomotor 9G (1 piece) Servo medium (4 pieces) **Camera:** CMUCam v4 (1 piece) **Distance sensors:** Sharp GP2Y0D810Z0F 10cm (2 pieces) Sharp GP2Y0A21YK (10cm - 80cm) (1 piece) Sharp GP2Y0A02YK0F (15cm - 150cm) (2 pieces) **Other components:** Robotic claw (1 piece) Pan-Tilt (2 pieces) Acoustic alarm for weed detection (1 piece) Light lamp for weed detection (1 piece)

Task strategy description
Task 1 Navigation through maize rows based on IR distance sensors. **Task 2** The robot follows an established route through maize rows. **Task 3** A single camera will be used to detect weeds (golf balls) on both sides. The camera will be mounted on a pan-tilt that rotates left and right.

Cooperation Still not decided. **Freestyle:** Removing weeds with robotic claw.

Institution:	Private		
Department:			
Country:	Romania	City:	**Arad**
Street/Number:	General Traian Doda / 21	ZIP Code:	**310507**
Homepage	http://mihaelatilneac.wix.com/agriculture-research		

12. HARPER CROP-BOT

Team members:	Yuyao Song, Xian Liu
Team captain:	Yuyao Song
Instructor(s):	Samuel Wane
E-mail:	13270200@live.harper.ac.uk

CHASSIS				SENSORS	
WxLxH (cm):	**29.7x42.9 x13.5**	Weight (kg):	**2.7**	☐ Camera	☒ Laser
Model /Make:	**Dagu**	Number of wheels:	**6**	☐ Compass	☐ Odometry
Drivetrain concept:	**6 DC motors and outfitted with 75:1 steel gearboxes**	~Turning radius (cm):	**Skid steer (0cm radius)**	☐ Sonar	☐ Gyroscope
Battery time:	**1.5h**	Rain resistance:	**No**	☐ IR	☐ Mechanical sensor

Robot software description
Microsoft Robotics Development Studio

Robot hardware description
Controller: RoboteQ MDC2260C Dual Channel 60A Brushed DC Motor Controller; Computer: fit-PC2i Computer; Sensor: PEPPERL+FUCHS R2000 2D laser scanner (360°); Battery: Conrad Energy LiPo Battery 50-4855.

Task strategy description
Task 1 (basic navigation), Task 2 (advanced navigation), Task 3 (Professional Application)

Institution:	Harper Adams University		
Department:	Engineering		
Country:	United kingdom	City:	Shropshire
Street/Number:	Newport	ZIP Code:	TF108NB
Homepage	http://www.harper-adams.ac.uk/		

13. Helios

Team members:	Danny Behnecke Matthias Kemmerling Hans-Walter Brandt
Team capitain:	Michaela Pußack
Instructor(s):	Till-Fabian Minßen
E-mail:	info@fredt.de

CHASSIS				SENSORS	
WxLxH (cm):	**35x66x42**	Weight (kg):	**ca. 25**	☒ Camera	☒ Laser
Model/Make:	**designed by FREDT**	Number of wheels:	**4**	☐ Compass	☐ Odometry
Drivetrain concept:	**central motor, 4WD**	~Turning radius (cm):	**75**	☐ Sonar	☐ Gyroscope
Battery time:	**ca. 1 h**	Rain resistance:	**medium**	☐ IR	☐ Mechanical sensor

Robot software description
The software is written in C++ using the framework ROS Simulation for testing the robot is based on Gazebo

Robot hardware description
Both rigid axles driven and steered using Ackermann steering concept Shock absorbers included in chassis Chassis and carriage mostly built from aluminium parts

Task strategy description
Use RANSAC based algorithm for finding rows, estimate structure of field Find weeds using camera data

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Department:	Institute of Mobile Machines and Commercial Vehicles		
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Homepage	www.fredt.de		

14. Idefix

Team members:	Christoffer Raun, Frederic Forster, Ulrich Schmied, David Lippner, Johannes Hruza
Team capitain:	David Lippner, Johannes Hruza
Instructor(s):	Lukas Locher
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CHASSIS				SENSORS	
WxLxH (cm):	**40x60x50**	Weight (kg):	**40**	☒ Camera	☒ Laser
Model/Make:	**-**	Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**electric**	~Turning radius (cm):	**100**	☐ Sonar	☒ Gyroscope
Battery time:	**15 min**	Rain resistance:	**yes**	☐ IR	☐ Mechanical sensor

Robot software description
This is the fith Field-Robot-Event for Idefix and the age of Idefix is the reason why the Code of Idefix is based on the perhaps outdated Player-Framework. To manage the tasks, we are using and developing C++ based drivers and clients for this Player Framework. Software development is done with gcc, open source libraries, eclipse and linux. Our favorite tool is icecc to speed up the compilation time. With this tool we can compile our software parallel on many machines.

Robot hardware description
Our robot Idefix is homemade. Most of the parts are self-milled. The axes are from model cars. The motors are two 120W electric brushless motors from Maxon. The heart of our robot is a Linux PC (Dual Core 1.4 GHz, 2GB RAM). The whole robot is powered by to lead batteries. The drives communicate over CAN-Bus. Sensors are connected to the PC with a USB2Serial-Adapter (Gyro), USB-Bus (Sick Tim 3xx LiDAR), a USB2CAN-Adapter and Ethernet (Sick LMS 100, Camera)

Task strategy description
The Sick- LiDAR-sensors detect the plants and a local 2D map of plant positions is created. We use a grid for preselection of valid plant positions. Then we feed a proportional controller with a kind of average of the preselected plant positions. This mean-value is used to drive our robot through the rows. That means, if there is a curve our mean is changing and that's why our robot will than change its direction. The tricky issue is to find good settings for speed and the proportional constant Kp. With a LiDAR on the front and rear side, we can drive in both directions. For moving the robot straight ahead in the headlands (task2) we experiment with a (temperature compensated) gyrosensor and odometric data from the drives.

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15. KAMARO

Team members:	50
Team captain:	Simon Merz, Stefan Baur
Instructor(s):	
E-mail:	kamaro.engineering@googlemail.com

CHASSIS				SENSORS	
WxLxH (cm):	**50x70x30**	Weight (kg):	**30**	☒ Camera	☒ Laser
Model/Make:	**Kamaro**	Number of wheels:	**4**	☒ Compass	☐ Odometry
Drivetrain concept:	**4x4**	~Turning radius (cm):	**40**	☒ Sonar	☒ Gyroscope
Battery time:	**40 min**	Rain resistance:	**Light rain (IP 22)**	☐ IR	☒ Mechanical sensor

Robot software description
Low-Level Controllerboards programmed in C API for hardware abstraction written in C++ Main Computer Software written in Java

Robot hardware description
Main Computer: Mini ITX Mainboard, x86 Components Controllerboards: Diverse ARM Based Chips Mechanics: Custom Kamaro Design

Task strategy description
Run fast, run far!

Institution:	Karlsruhe Institute of Technology		
Department:	Lehrstuhl für Mobile Arbeitsmaschinen		
Country:	Germany	City:	Karlsruhe
Street/Number:	Rintheimer Querallee 2	ZIP Code:	76131
Homepage	www.kamaro.kit.edu		

16. PARS

Team members:	Onuralp SEZER, Muhammed Mahbub İBİŞ, Mustafa DURGUN
Team capitain:	Mustafa TAN
Instructor(s):	Sefa TARHAN, Mehmet Metin ÖZGÜVEN, Muzaffer Hakan YARDIM
E-mail:	mustan79@gmail.com

CHASSIS				SENSORS	
WxLxH (cm):	**38,5x51x15**	Weight (kg):	**5**	☐ Camera	☐ Laser
Model/Make:	**Custom**	Number of wheels:	**4**	☐ Compass	☐ Odometry
Drivetrain concept:	**Gear**	~Turning radius (cm):	**33**	☐ Sonar	☐ Gyroscope
Battery time:	**50 min**	Rain resistance:		☐ IR	☒ Ultrasonicl sensor

Robot software description
While writing the software, the algorithm we organized, and input and output pins of the microcontroller in our electronic circuit should be considered. C/C++ will be used as the programming language, and MATLAP will be used as the simulation. We are going to use the Arduino DUE circuit board. We can easily program the Arduino microcontroller with libraries. The code we wrote will be converted into machine language through ARDUİNO compiler, and will be transmitted into microcontroller through the programmer.

Robot hardware description

1. Mechanical Design

1.1. Chassis

Our robot will be designed at a mechanic order that will fulfill its purpose as the simplest. In this sense, "Tamiya TXT1" mechanic chassis accepted through its power and durableness will be used (Figure 1). The robot will be built upon this chassis.

As the engine, 2 "Servo motors" (Figure 2) with 15 kg/cm torque will be used.

Figure 3 Tamita TXT1 chassis CAD drawing   Figure 2 Servo motors

1.2. Cover

The robot is designed to cover special (Figure 3, 4).

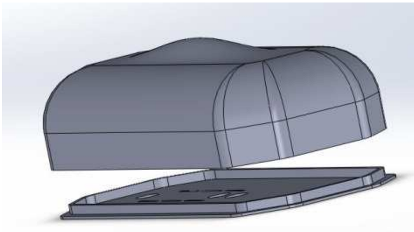

Figure 3 Cover CAD drawing   Figure 4 Cover manufacturing step

2. Electronic

2.1. Controls

"Arduino DUE (Figure 5)" embedded system will be used as the main circuit. And the other peripheral units will be connected to this.

Figurel 5 Arduino DUE

2.2. Battery

The main idea in battery selection was easy-changeable battery use at equal sizes. For that reason, we decided to use lithium polymer battery (LIPO) as 3300 mAh.

2.3. Sensors

The robot should have sensors providing it to have peripheral communication in order to make decisions in accordance with its purpose. The robot will include ultrasonic sensors as the leading.

Task strategy description
The robot will compete at Task1, Task2 and Freestyle. The main algorithms and methods of the robot will be Line perception, Line break perception and Return skills. The study plan will be as such. Firstly, a simple and easy-to-use method will be developed. Then, a more improved method will be developed providing the input and output interfaces of the algorithms to remain as the same. Doing such, it will be easier to learn what the robot should perform. So, we will analyze the aforementioned algorithms and methods, and choose the method providing the optimum result.

Institution:	Gaziosmanpaşa University		
Department:	Biosystem Engineering and Mechatronics Engineering		
Country:	Turkey	City:	Tokat
Street/Number:	-	ZIP Code:	60250
Homepage	www.gop.edu.tr, www.robotpars.com		

17. Robot
TU Kaiserslautern

Team members:	F. Altes, J. Barthel, V. Dänekas, S. Feick, T. Groche, Al. Klein, An. Klein, A. Jung, L. Nagel, K. Sabzewari, C. Simonis, P. Sivasothy, P. Batke, J. Hinkelmann, V. Leonhardt, D. Nshimyimana
Team captain:	M.Sc. Kiarash Sabzewari
Instructor(s):	Prof. Dr. –Ing. Jörg Seewig
E-mail:	sabzewari@mv.uni-kl.de

CHASSIS				SENSORS	
WxLxH (cm):	**45x112x45**	Weight (kg):	**~ 25**	☒ Camera	☒ Laser
Model/Make:	**Hurrax Yukon monster truck (strongly customized)**	Number of wheels:	**4**	☐ Compass	☐ Odometry
Drivetrain concept:	**4 Wheel Drive, Central Brushless DC Motor (2kW)**	~Turning radius (cm):	**60**	☐ Sonar	☒ Gyroscope
Battery time:	**15 min**	Rain resistance:	**no**	☐ IR	☐ Mechanical sensor

Robot software description
For signal processing and robot control, the vehicle uses the *dSPACE* rapid control prototyping hardware. This unit includes the *MicroAutoBox* II (MAB-II) with an embedded PC which is a compact system. While the actual control functions are being computed on the real-time prototyping unit of the *MAB-II*, additional applications like camera-based object detection and receiving laser scanner data are carried out by embedded PC. The algorithm for row detection, path tracking and headland turns as well as the sequence control of the entire vehicle are essential parts of the software running on *MAB-II*. By using the software MATLAB/SIMULINK and its toolboxes, the algorithms are developed in *MATLAB* owns language as embedded functions and converted

automatically to c-code.
The algorithm for row detection, path tracking and headland turns as well as the sequence control of the entire vehicle are essential parts of the software running on *MAB-II*. By using the software MATLAB/SIMULINK and its toolboxes, the algorithms are developed in *MATLAB* owns language as embedded functions and converted automatically to c-code.

Robot hardware description
Mechanics The hardware of the robot is based on *Hurrax Yuckon* monster truck drive-train and chassis. The body which is fully detachable from the robot is made of sheet metal. In order to reduce the vehicle mass two carbon fiber plates are used, which take the different components. The power of *Plattenberg* central brushless DC drive with 2 kW is transmitted to the wheels by a permanent four-wheel drive shaft. Furthermore a *miControl* 100A inverter is used to control the motor in 4-quadrant mode. The steering system was redesigned by using the CAD software Siemens NX and were manufactured as different other new parts by the workshop of the MEC chair to increase the performance which is necessary to drive the heavy robot on any ground conditions. For this propose two *HITEC* servos *HS-M7990TH* operating synchronously on each axle are mounted and a gear wheel and steering rack are used to transmit the force to the wheels. There are also some additional features, such as a piezo siren and a rotating light as well as a 7-segment display, e.g. to signalize any predefined states: detecting obstacles or show the distances to the plants. Electronics The electric supply of the robot is carried out by using a lithium ion battery with the total capacity of 8 Ah and a nominal voltage of 33.4 V. Two DC-DC-converters from *TRACO POWER (approx. output power of* *100W)* are used to supply the different 5V and 12V consumers of electric energy. **Sensors** According to obstacle detection two one dimensional laser scanners (*Hokuyo UBG-04LX-F01, 240° field of view with a max. range of 5600mm)* is implemented on the front and rear of the vehicle. Located on the top of the vehicle, four *DevantechSRF05* Ultrasonic Range Finders can deliver additional information about the lateral distances to the environment for another propose beyond the competition. For some of the maneuvers such as the turning an inertial measurement unit of *Continental* is installed which is able to measure yaw rate, lateral, longitudinal and vertical acceleration. In order to detect certain objects for the professional task, two standard webcams orientated to the right- and left side are located on the frame construction. For autonomous navigation, the vehicle carries a WLAN interface and an R/C receiver for development and testing purposes.
Task strategy description

Generally the field robot is controlled by a logic for supervisory control and task scheduling implemented in *Stateflow®* as a state machine. The integrated state machine consists of various kinds of states which includes e.g. path tracking, turning maneuver as well as additional function, which can be activated according to the current task. Moreover, there are algorithms for path tracking, for the detection and counting of rows and the turning maneuver at the headlands.

Path tracking (TASK I) – strategy: speed and robustness
The distance to the obstacles is measured by the corresponding laser scanner. The preprocessing scripts are run and the relevant information are filtered and prepared. Based on this information a desired position with a predefined distance to the robot is calculated. A fuzzy control system is utilized to set the steering angle and the robot speed.

Blockade and gap detection (TASK II) – strategy: speed and reliability
Also the blockades and the plant rows are detected by the information of the laser scanners. The plant rows are counted by detecting the gaps between the plants if the software runs in relevant state.

Image Processing (TASK III) - strategy: speed and reliability
Two conventional web cams are used to identify the random located golf balls. Recognizing the golf balls is performed sequentially by:

- identification of image areas containing a high proportion of the yellow color
- measuring the distance between the vehicle and the obstacle by using the depth information of the stereo image and the size of discovered shapes
- locating of the ball and indicating on the map

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18. Phaethon

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Team capitain:	Klaus Müller
Instructor(s):	Dipl.-Inform. Klaus Müller, Prof. Dr. Ing. Klaus-Dieter Kuhnert
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CHASSIS				SENSORS	
WxLxH (cm):	**37x62x41**	Weight:	**14,5 Kg**	☒ Camera	☒ Laser
Model/Make:		Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**four wheel drive**	~Turning radius (cm):	**86 cm**	☒ Sonar	☒ Gyroscope
Battery time:	**~ 3 h**	Rain resistance:		☐ IR	☐ Mechanical sensor

Robot software description
The Phaethon takes advantage of the Robot Operating System (ROS) framework, which provides an easy, modular way of implementing software and a fault tolerable communication between the different software modules. Also the inter – module communication isn't bounded to one machine, but can also be done over a network. So we are able to split the modules and let the complex algorithms run on a performant mainboard, while other modules (e.g. the sensor modules) run on an embedded PC. Based on that there are more "low level modules" which communicate with the sensors and actuators, either in use of libraries for the given interface, or directly using

the IO pins of the Embedded PC. Upon that there are more abstract "high level modules" which uses the information gathered by the sensor modules to manage the movement of the robot.
Robot hardware description
Computer Hardware: The main components of the computer hardware include an embedded PC, which provides different interfaces like gpio pins to connect peripherals and standard bus types (I^2C, SPI, UART or USB) to establish connections to the sensors and actuators. Beside that the robot is equipped with a x86-computer with a 2Ghz quad-core Intel processor. These components are connected through ethernet, which is established by a switch. Other Hardware: The Phaeton is moved by two brushless motors in connection with two motor control units. It has several sensors like a *Hokuyo* laser scanner, a gyroscope, an odometry-sensor, webcam and four sonar sensors.

Task strategy description
Task 1: The main idea behind this task-solution is the usage of the laser scanner to find the middle of the actual row. At the end of the row the laser scanner is also used to find the entrance of the next row where it wants to turn. **Task 2:** For task 2 we extended the concept of task 1 and used the odometry, too. This is important to guarantee a reliable navigation, even if the row is interrupted by missing plants. To drive backward the Phaethon uses the sonar sensor to estimate the way through the row. **Task 3:** Based on the the images made by a web cam Phaethon uses computer vision algorithms to detect the golf balls.

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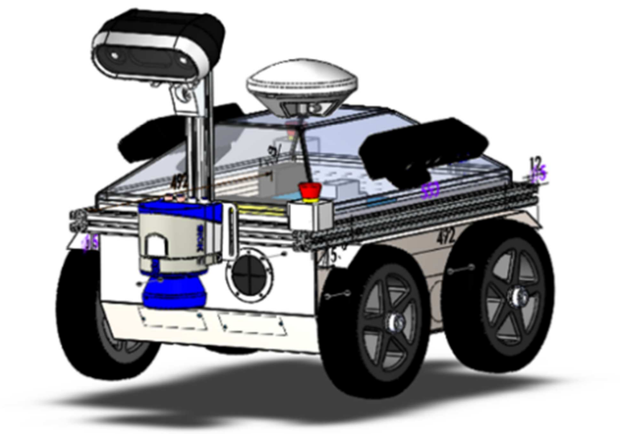
19. TALOS



Team Members:	Christian Jenth, Florian Ballbach, Jan Berlemann, Jannick Coenen, Michael Glaser, Thomas Wilmsmann, Tomas Islas, David Reiser
Team captain:	Tomas Islas
Instructor:	David Reiser
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CHASSIS				SENSORS	
WxLxH (cm):	**55x75x40**	Weight (kg):	**33**	☒ Camera	☒ Laser
Model/Make:	**-**	Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**4 WD**	~Turning radius (cm):	**0**	☐ Sonar	☐ Gyroscope
Battery time:	**2 h**	Rain resistance:	**mid**	☐ IR	☐ Mechanical sensor

Robot software description
The TALOS uses the MobotWare which is a standard mobile robot control framework. It includes three core modules. The Robot Hardware Demon (RHD) supports a flexible hardware abstraction layer for real-time critical sensors. The second core module is the Mobile Robot Controller (MRC) which is a real-time closed-loop controller of robot motion and mission execution. The third core module is the Automation Robot Servers (AURS) which is a framework for processing of sensors and non-real-time mission planning and management. SMR-CL is the controlling language that provides the bridge between the hard real-time demands of the control layer and the soft real-time demands of the planning.

Robot hardware description
The TALOS is a four wheel drive robot with full rubber wheels with a diameter of 220 mm where all components are carried and protected by a rectangular 0.8 mm sheet material container chassis. Different sensors can be mounted to profiled rails which are attached around the container body and on top of the upper plexiglas cover. The gear motors are of the type 1.61.050.411 and combined with encoders from PWB. TALOS uses the non-contact laser sensor LMS111 from SICK. It is especially designed for outdoor anti-collision environments with a scanning angle amounts 270° and has a wide variety of interfaces. The output data can easily be used for RANSAC-algorithm and further programming. For data handling the TALOS uses an Intel Core i3-2120 processor with a 3M Cache and a clock speed of 3.3 GHz. It uses 2 Cores with an Intel Smart Cache of 3 MB and an instruction set of 64-bit with a maximum TPD of 65W. The graphic processor is an Intel HD Graphics 2000 with a base frequency of 850 MHz and a maximum dynamic frequency of 1.1 GHz. For the power supply there are four sealed lead batteries with 12 V and 12 Ah. They are connected in a parallel circuit and can be refreshed with a usually recharger. The safety system of the TALOS is the SNO 4063K from Wieland Electrical Connections. It includes applications like an emergency stop, safety door, and light grill.
Task strategy description
For the first three tasks we are using three different programs while the program for the third task includes the main aspects of the first. In the beginning we elaborated all possibilities and tried to define them in smaller behaviors. With those smaller behaviors we were able to create a flow chart which was the abstract for the programming part. With this strategy it was possible to use module elements which we used for different parts of the script. For all three tasks we wanted to keep it as simple as possible to avoid failures and a failing of a task. To provide a mostly independent reaction of the robot we tried to find all different and imaginable pathways. Finally we created our own navigation algorithm.

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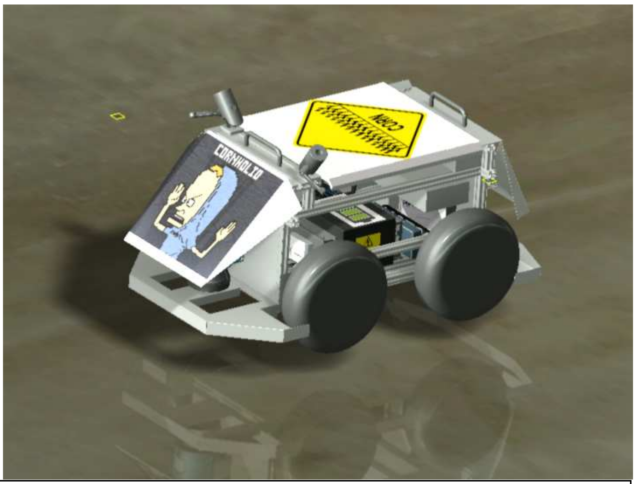
20. The Great Cornholio



Team members:	Kevin Bilges, Fabian Ellermann, Carlo Feldmann, Fabian Lankenau, Alejandro Lorca-Mouliaa, Michael Marino, Adrian Merrath, Andreas Trabhardt
Team captain:	Heiko Wilms
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CHASSIS				SENSORS	
WxLxH (cm):	**44x69x54**	Weight (kg):	**24,2**	☒ Camera	☒ LIDAR
Model/ Make:	**Based on Fraunhofer Volksbot RT4**	Number of wheels:	**4**	☒ Compass	☒ Odometry
Drivetrain concept:	**differential steering**	~Turning radius (cm):	**0**	☐ Sonar	☒ Gyroscope
Battery time:	**~1h**	Rain resistance:	**None (umbrella)**	☐ IR	☐ Mech. sensor

Robot software description
The core of the software is based on the Robot Operating System (ROS) and makes use of the built-in state-machine functionality to perform the main control procedures. For the Image processing tasks we use OpenCV.

Robot hardware description
''The Great Cornholio'', whose CAD draft can be seen in the picture above, has an overall size of 44x69x54 cm. As is typical for robots based on ''Volksbot'' – the robot-platform of the Frauenhofer Institute – Cornholio's case relies on item profiles, making it easy to mount sensors, motors, etc. The profiles and the cover panels are made of aluminium. As a light metal the usage of aluminium saves weight so the robot will be able to move faster. When the top plate is removed, two claps provide fast access to the fuse-boards and cables. To control the robot there is a touch panel installed with a GUI. The main sensors for navigating the robot are two laserscanners. Dependent on which direction the robot drives, the rear or front laserscanner is used for navigation.

Task strategy description
The main strategy in our design was to keep the software and hardware as simple as possible while still being robust enough to complete the tasks effectively and efficiently. The basic functionality is designed to approach each task in a slow and detail-oriented way in order to optimize the chance of task completion and maintaining the safety of the robot.

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21. TrackKing

Team members:	Dini Ras, Jan-Willem Kortlever, Andries van der Meer, Robin Cornellissen, Valentijn van Rooyen, Sebastiaan Dreessen
Team capitain:	Dini Ras
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CHASSIS				SENSORS	
WxLxH (cm):	**30x40x40**	Weight (kg):	**10**	☒ Camera	☒ Laser
Model/Make:	**AT-1.0i**	Number of wheels:	**6**	☒ Compass	☒ Odometry
Drivetrain concept:	**Direct drive**	Turning radius (cm):	**0 cm (turn around the axis**	☐ Sonar	☒ Gyroscope
Battery time:	**2h00m**	Rain resistance:	**Splash proof**	☐ IR	☐ Mechanical sensor

Robot software description
The software is build up in LabVIEW

Robot hardware description
Computer: MSI Z87I, Intel Core i7 4770T Compass: Xsens Motion Tracker MTi Laser: Sick Laser scanner LMS111-10100 Batteries: Hacker TopFuel LiPo 20C-ECO-X 5000 mAh Cameras: Microsoft LifeCam HD-5000

Task strategy description
Task 1: The laser scanner scans the rows and with that information we make a preferred route with an intersect and a slope. **Task 2:** Using laser scanner, which recognizes objects. **Task 3:** Using vision (cameras) and comparing colours/shapes. Lights and a patlite are used for signalization and a speaker for a sound signal. We will save the location of the golf balls in a map by using a GPS module. **Task 4 (Cooperation):** We are not going to prepare this before the event starts, if we find a partner during the event to do this task we will enter this part of the FRE **Task 5 (freestyle):** Only if there is time left after preparing the other tasks

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22. TRACTACUS

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CHASSIS				SENSORS	
WxLxH (cm):	**44x58x33**	Weight (kg):	**7**	☒ Camera	☐ Laser
Model/Make:	**Make**	Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**Differential**	~Turning radius (cm):	**30**	☒ Sonar	☒ Gyroscope
Battery time:	**35 min.**	Rain resistance:	**Yes**	☐ IR	☐ Mechanical sensor

Robot software description
Arduino software for interpreting sensor datas and navigation inside rows with headland turn(task1-task2-task5) and roborealm software for image processing at task3.

Robot hardware description
Robot consist 4 x wheel encoder for odometry, 4 x 12DC motor for each wheel, 2 x dual channel motor driver, 5 x ultrasonic sensor and 1 x gyroscope for navigation and Arduino mega. Also we will use pc and web cam for task 3.

Task strategy description
Task 1: smooth navigation between rows as fast as possible Task 2: smooth navigation between rows as fast as possible Task 3 : detecting golf balls inside rows. Task 4: we will not participate. Task 5: we will perform a freestyle operation.

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23. FINNFERNO

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CHASSIS				SENSORS	
WxLxH (cm):	**45x80x135**	Weight (kg):	**25**	☒ Camera	☒ Laser
Model/Make:		Number of wheels:	**4**	☐ Compass	☒ Odometry
Drivetrain concept:	**Individual steering and drivetrain**	~Turning radius (cm):	**100**	☒ Sonar	☒ Gyroscope
Battery time:	**>30 min**	Rain resistance:	**IP33**	☒ IR	☐ Mechanical sensor

Robot software description
The robot runs on a Windows platform, both CE and 7. Algorithms are generated to C-code from Matlab. Data handling and communication is done via C#. Machine Vision uses OpenCV libraries and self-implemented functionalities for twin cameras.

Robot hardware description
Wide variety of sensors for robust positioning and object detection capabilities. Two computers: 1 GHz, 512MB RAM Windows CE and 1.8 GHz i5, 4 GB RAM Windows 7 32-bit. ISOBUS-derived CAN bus and communication. Independent steering and drivetrain for each wheel.

Task strategy description
TASK 1 & 2: Navigate using positioning data from ultrasound, infrared and laser sensor. Turning sequences are input from remote user interface. Headland driving is done at constant distance from end of row. TASK 3: Navigation as above, twin cameras used to detect yellow golf balls in the rows. Golf balls assigned coordinates according to GNSS systems output. TASK 4: Cooperative task with other team TASK 5: Freestyle. Weed plant eradication using thermal deactivation. Separate trailer that detects weeds using cameras is attached to robot. Trailer communicates the need to stop at detected weed plants via CAN bus. A gas heater is used to kill weed plant.

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Field Robot Junior

TASK 1: Folgen einer Linie

Pic 1 - Folgen einer schwarzen Linie

Beschreibung

Im TASK 1 muss der Roboter dem Verlauf einer schwarzen Linie auf heller Holz-Oberfläche folgen. Diese Linie hat eine Breite von ca. 4 cm. Die kleinste zu durchfahrende Kurve innerhalb dieser Strecke hat einen minimalen Kurvenradius von nicht unter 60 cm. Der umgebende Boden ist besteht aus unlackiertem, hellem Holz. Die Strecke ist waagerecht und besteht aus geraden wie aus kurvigen Teilsegmenten. Die Gesamtlänge der Strecke beträgt ca. 7 m.

Bewertung

Die Punktevergabe erfolgt nach gefahrener Strecke, die innerhalb einer festgelegten Zeit (z.B. 2 min) zurückgelegt wurde. Wenn der Roboter während der Fahrt berührt oder umgesetzt wird, werden Strafpunkte von den bereits erreichten Streckenpunkten abgezogen. Jedes Team erhält die Möglichkeit, zwei Läufe in diesem Task zu absolvieren.

TASK 2 - Navigation in Pflanzenreihen

Pic 2 - Möglicher Streckenverlauf für Task 1 und 2

Beschreibung

Im TASK 2 muss der Roboter derselben Strecke folgen, dieses Mal soll die Navigation jedoch anhand der künstlichen Pflanzen rechts und links der Strecke erfolgen. Diese Pflanzen haben eine Höhe von ca. 20 cm und sind in einem Abstand von etwa 10 cm zueinander angeordnet. Die Reihenbreite beträgt 40 cm. Im hinteren Streckenabschnitt können vereinzelt Pflanzen auf der linken oder rechten Seite fehlen.
Die Gesamtlänge und Aufbau entspricht der Strecke aus TASK 1. Jedes Team erhält die Möglichkeit, zwei Läufe in dieser Task zu absolvieren.

Bewertung

Die Punktevergabe erfolgt nach gefahrener Strecke, die innerhalb einer festgelegten Zeit (z.B. 2 min) zurückgelegt wurde. Der Roboter darf während der Fahrt die Pflanzen berühren. Wenn der Roboter während der Fahrt berührt oder umgesetzt wird, werden Strafpunkte von den bereits erreichten Streckenpunkten abgezogen.

TASK 3 – 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

Die Bewertung wird von einer Jury vorgenommen, die den Lauf aller teilnehmenden Teams bewertet.

Gewinner - Platzierung

Es werden bei jeder einzelnen Task die besten drei Teams platziert. Der Gesamtsieger des Field Robot Event Junior wird aus den Platzierungen von Task1 und Task2 errechnet, zusätzlich wird ein Preis für das beste Roboter-Design durch die Jury vergeben.

Program

Monday, 16th June: Field Robot Preparation

When	What	Where
12.00-18.00	Team Registration	Contest Area / Strenzfeld
12.00-18.00	First testing in the test field	Contest Area / Strenzfeld
18.00-20.00	Dinner	Hochschule Anhalt

Tuesday, 17th June: Contest Day 1

When	What	Where
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-12.00	Team Registration Presenting the Teams & Robot Testing **Field Robot Demo**	Contest Area / Strenzfeld
10.00-11.00	Briefing of team captains	Contest Area / Strenzfeld
12.00-13.00	Lunch	
13.30-14.00	Welcome note	Contest Area / Strenzfeld
14.00-17.00	Contest Task 1 (Basic navigation) Contest Task 2 (Advanced navigation)	Contest Area / Strenzfeld
17.00-17.30	Awarding task 1 & 2	Contest Area / Strenzfeld
18.00-19.00	Dinner	Hochschule Anhalt

Wednesday, 18th June: Contest Day 2

When	What	Where
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-12.00	**Field Robot Talks** (selected topics) Presenting the Team & Robot Testing **Field Robot Demo**	Contest Area / Strenzfeld
12.00-13.00	Lunch	
14.00-17.00	Contest Task 3 (Application) Contest Task 4 (Cooperation)	Contest Area / Strenzfeld
17.00-17.30	Awarding task 4	Contest Area / Strenzfeld
18.00-22.00	Awarding task 3 & final awarding contest winner 2014 & BBQ & Music	Hochschule Anhalt

Thursday, 19th June: Contest Day 3

When	What	Where
08.00-09.00	Breakfast	Hochschule Anhalt
09.00-10.00	Robot Testing	Contest Area / Strenzfeld
10:00-11:30	Contest Task 5 (Free style)	Contest Area / Strenzfeld
11.30-12.00	Awarding task 5	Contest Area / Strenzfeld
12.00-13.00	Lunch	
13.30-14.00	Welcome to the **Field Robot Junior**	Contest Area / Strenzfeld
14.00-17.00	Task 1, task 2 and Freestyle	Contest Area / Strenzfeld
17.00-17.30	Awarding Junior Winner	Contest Area / Strenzfeld

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