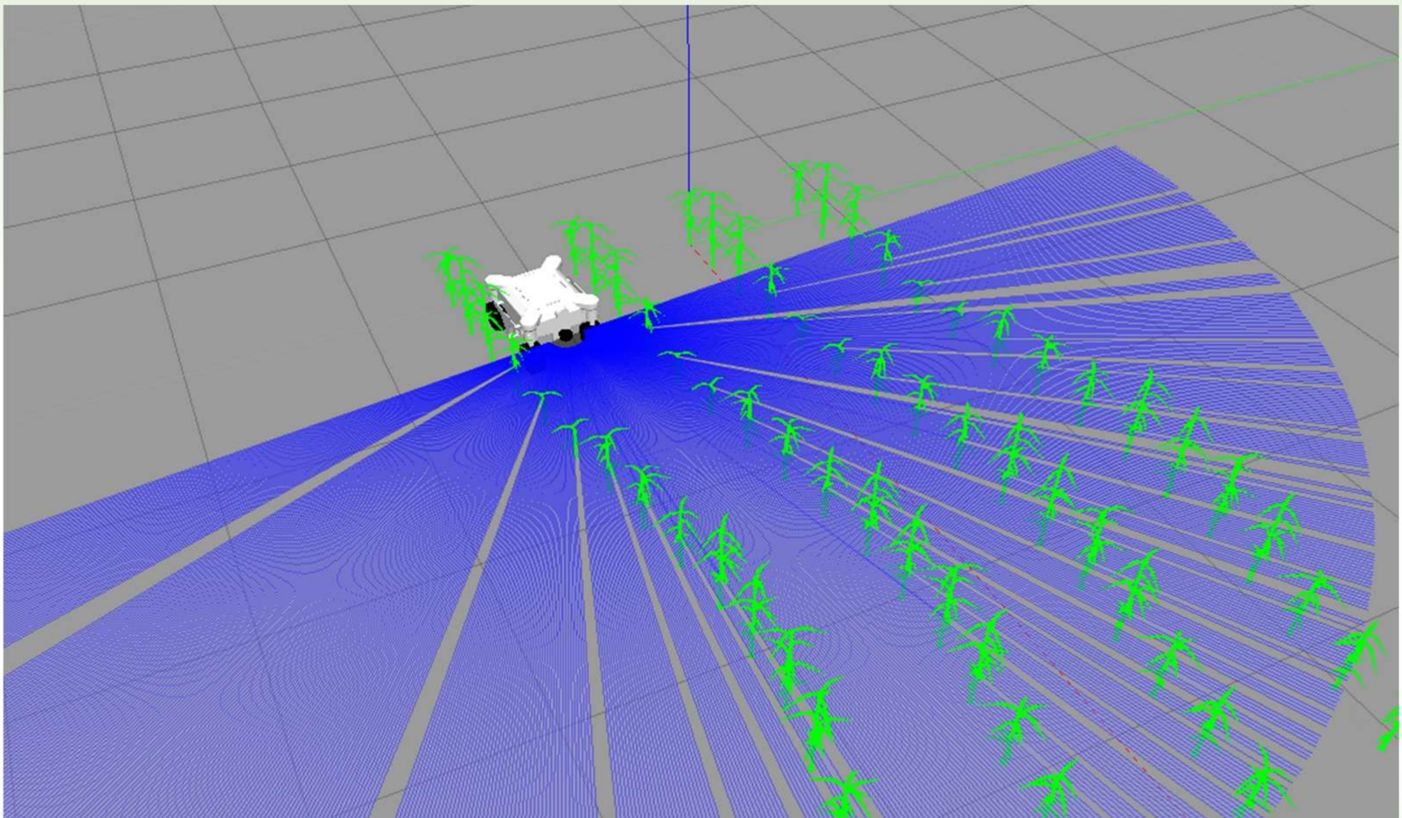
www.fieldrobot.com/event

Field Robot Event

International Contest on Virtual Fields **18th edition**

Booklet 2021 with program



DLG Feldtage
Meet the crop professionals

Index

Acknowledgement 3

Welcome 4

Program 5

Team and Robot Descriptions 6

We were supported by:

Acknowledgements

Thanks to all who contributed to the organisation!

Wageningen University, The Netherlands

Sam Blaauw, Thijs Ruigrok
and Gwen Dawes

University of Hohenheim, Germany

Helga Floto, Dimitris Paraforos,
David Reiser and Hans W. Griepentrog

Deutsche Landwirtschafts-Gesellschaft e.V. (DLG), Germany

Andreas Steul, Freya von Czettritz,
Rainer Winter, Malene Conlong

Sponsors

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

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

Welcome to the Field Robot Event 2021!

The field robots are back after a year's break - virtually.

The International Field Robot Event (FRE) is an annual competition where European universities and other participants compete with their field robots for the best results from various agricultural applications. Long before digitalization became a hot topic, the competition was initiated by Wageningen University (NL) back in 2003 to share knowledge and experience with autonomous field robots and to promote development in general, in a annual competition.

The FRE offers an exciting opportunity for participants to deal concretely with current challenges in agricultural technology: Automation and digitalization, optimized crop production and sustainable agriculture are the main topics. The agricultural tasks are always a challenge for the teams and their robots, as technical and agricultural process knowledge is essential. However, the fun of the competition should not be neglected.

This year, the 18th Field Robot Event (FRE) will be held virtually in a simulation of ROS Gazebo from June 8th to 10th due to the pandemic. Gazebo is an open-source 3D robotics simulator. It supports codes for sensor and actuator simulation and offers realistic design of environments including high-quality lighting, shadows and textures. For example, sensors can be modelled that "see" the simulated environment, such as with laser systems and cameras. Gazebo is known as a simulation environment for a number of technological competitions such as DARPA Robotics Challenge, NASA Space Robotics Challenge and Virtual RobotX Competition.

Fourteen international teams from Europe have registered for 2021, so fourteen virtual and some real robots will compete in agricultural tasks. We wish all teams to have good ideas for solving problems (challenges!), good success in implementation and fun & good luck!

The International Field Robot Event has been held every second year since 2014 together with the DLG Field Days. This cooperation will be continued. The FRE event will be live-streamed on DLG’s digital platform. You just need to register for free: Watch the three-day virtual event on www.dlg-connect.com.

The organising team 2021

Sam Blaauw, Thijs Ruigrok, David Reiser, Hans W. Griepentrog

You find the description of tasks and rules here:
https://www.fieldrobot.com/event/index.php/contest/tasks/

More general information on the internet: http://www.fieldrobot.com/event/

Program, June 8th to 10th, 2021

Monday, June 7th

(11:00 – 12:00 Briefing of team captains)*

Tuesday, June 8th

09:30 – 09:45 Welcome

09:45 – 10:00 Welcome Note - President of the EurAgEng

10:00 – 12:00 **Contest Task 1 (simulation)**
Basic navigation in a maize field with curved rows
(max travelled distance per time will win)

14:00 – 16:00 **Contest Task 2 (simulation)**
Advanced navigation in a maize field with straight rows with gaps following a given track pattern
(max travelled distance per time will win)

16:30 - 17:00 **Awarding Task 1 + 2**

17:00 – 17:30 **FAQ and support**

Wednesday, June 9th

10:00 – 12:00 **Contest Task 3 (simulation)**
Weed and object detection and georeferencing in a maize field
(the most correct map wins)

14:00 – 16:00 **Contest Task 4 (simulation)**
Removing weeds and objects out of a maize field to the headlands
(the most correct removed will win)

16:30 – 17:00 **Awarding Task 3 + 4 and Overall**
17:00 – 17:30 **FAQ and support**

Thursday, June 10th

10:00 – 11:30 **Contest Task 5 (live video)**
Freestyle: Free choice for the teams about what to present
(Complexity, performance and
agricultural usefulness will win)
12:00 – 12:30 **Awarding Task 5**
Farewell

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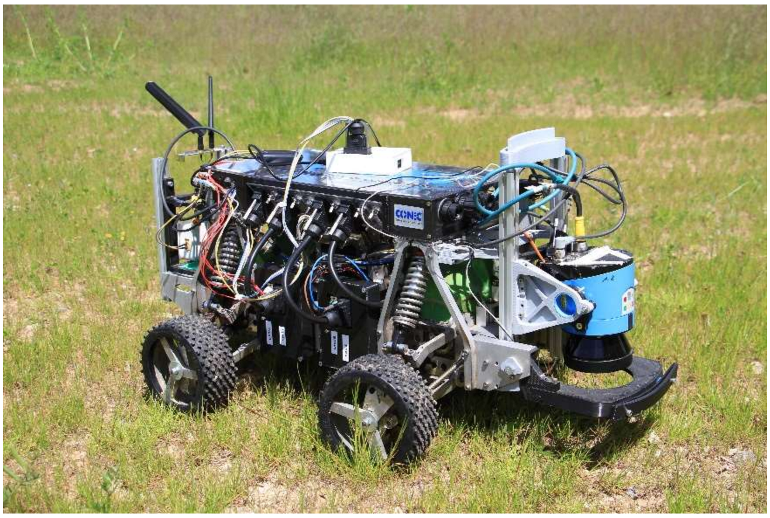
* internal, not public

Team and Robot Descriptions

#	*Robot Name*	*Country*	*Page*
1	Beteigeuze	Kamaro Engineering e.V. at Karlsruhe Institute of Technology KIT, Germany	7
2	Bullseye	Wageningen University, The Netherlands	9
3	Carbonite	Schülerforschungszentrum Südwürttemberg, Germany	11
4	Ceres II	Münster University of Applied Sciences, Germany	13
5	CollectHOHr	Hohenheim University, Germany	15
6	DTUbot	Technical University of Denmark DTU, Denmark	17
7	Farmbeast	University of Maribor, Slovenia	19
8	Field Balancer	Camper Robotics, Germany	21
9	Helios Evo	Technical University Braunschweig, Germany	23
10	Maize Runner	Technical University of Denmark DTU, Denmark	25
11	Spark	Banat University, Romania	27
12	Tafr	Mladinski tehnološki center 404, Slovenia	29
13	WeedInspector	Heilbronn University of Applied Sciences, Germany	31
14	WURking	Wageningen University, The Netherlands	33

1. Beteigeuze



Team Name	KaMaRo Engineering e.V.
Names of team members:	Johannes Barthel, Johannes Bier, Kai Braungardt, Edvardas Bulovas, Fabian Duttlinger, Thomas Friedel, Stephan Göhner, Henri Hornburg, Hongchen Ji, Nicolas Kessler, Konstantin Lutz, Leon Tuschla, Erik Wustmann, Philipp Ziser
Name team captain:	Johannes Bier
Instructor(s):	Electronics: Stephan Göhner Mechanics: Erik Wustmann Software: Johannes Bier Organization: Nicolas Kessler
Institution:	Kamaro Engineering e.V. at Karlsruhe Institute of Technology
Department:	MOBIMA/ FAST
Country:	Germany
Street / Number:	Rintheimer Queralle 2, c/o Lehrstuhl für mobile Arbeitsmaschinen
ZIP Code / City	76131 Karlsruhe
Email:	mail@kamaro-engineering.de
Webpage:	https://kamaro-engineering.de/

THE MACHINE			
W x L x H (cm):	50 x 100 x 65	Weight (kg):	Approx. 40 kg
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4/4
Drivetrain concept / max. speed (m/s):	4-Wheeldrive/ 2m/s	Turning radius (cm):	50
Battery type / capacity (Ah):	6 cell LiPo/ 10 Ah	Total motor power (W):	main drive: 220W
No. of sensors internal / external: Sensor type:	LIDAR SICK LMS100, LIDAR SICK TIM551, 2x absolute encoder Pepperl&Fuchs CSS36M		

Controller system software description (sensor data analysis, machine control etc.)
The robot software is implemented on top of the Robot Operating System (ROS) Software Stack. This means that the software is separated into so called nodes which solve small parts of the overall problem. There is a crawl row node keeping the robot in the middle between two rows of corn and a turn node that manages the switching between the rows. The localisation and mapping is done with cartographer a SLAM algorithm developed by Google in 2016A detection node is using the camara data to detect litter and weeds on the field and add them to the created map. A state machine orchestrates the nodes to achieve the correct interplay for the given tasks.
Controller system hardware description (motor controller, computer etc.)
Mechanical: To full fill the requirements of a robot driving in a field the drive chain was designed as a 4-Wheeldrive with a single, central electric motor that can provide torque up to 9Nm per wheel. The power transmission flows on two self-designed differentials in the front and the back of the robot. Each axle mounting has its own suspension ensuring a smooth ride in rough terrain. The front and back axis can be steered independently therefore also diagonal movements are possible. Electrical: The central computing unit is an Nvidia Jetson Nano executing ROS. For all electric peripherals, we use the middleware RODOS developed by the University of Wuerzburg. Most Systems have an STM32-Controller executing RODOS. The communication between the Jetson Nano and the peripherals is BUS-based with a RODOS-ROS-Bridge on the PC-Side. The BUS-topology allows also for direct communication between peripherals.
Short strategy description for navigation and applications
We will use the LIDAR installed at the front to navigate between the rows of corn plants. For the weeding task, we use a camera for detecting the litter and weeds on the field. As our Freestyle task we are planning to present the advantages of our newly implemented BUS-Systems, which allows for a quick and easy installation of new modules.
These are the commercial team sponsors & partners (if there are)
Companies: SICK, Dunkermotoren, Schaeffler, Nozag, Igus, CONEC, Pepperl+Fuchs, Ganter Griff, Eurocircuits Institutes at the KIT: MOBIMA/FAST, WBK

2. Bullseye

Team Name	Robatic
Names of team members:	Herjan Riemens; Frans Kemp; Sophie Wildeboer; Aline Hazelaar; Dorien Goudsblom; Martijn Veldhuizen; Johan Blom; Thomas Frankes
Name team captain:	Thomas Frankes
Instructor(s):	Sam Blaauw; Thijs Ruigrok; Rick van Essen
Institution:	Wageningen University & Research
Department:	Farm Technology Group
Country:	Netherlands
Street / Number:	Droevendaalsesteeg 1
ZIP Code / City	6708 PB Wageningen
Email:	Robatic.bullseye@gmail.com
Webpage:	http://www.robatic.nl/

THE MACHINE			
W x L x H (cm):	250 x 100 x 85	Weight (kg):	17 kg
Commercial or prototype:	Commercial	Total no. of wheels / no. driven wheels:	4 wheels that are all driven.
Drivetrain concept / max. speed (m/s):	Two drivetrains but in the simulation every wheel has its own drivetrain/ 2.0 m/s	Turning radius (cm):	In the simulation it can turn on the spot so it is 0 cm.
Battery type / capacity (Ah):	Lthium ion battery/ 270 Watt hours or 11.25 Ah (depends on used voltage)	Total motor power (W):	500 W

No. of sensors internal / external: Sensor type:	1. IMU 2. Odometry 3. Camera 4. Lidar

Controller system software description (sensor data analysis, machine control etc.)
For software, the Clearpath Jackal comes packaged with ROS kinetic for its drivers and APIs. Furthermore, it has Ubuntu and Windows as supported operating systems.
Controller system hardware description (motor controller, computer etc.)
A standard Jackal uses an i3-4330TE, dual core 2.4GHz with 4GB RAM. On top of that is has 120 GB Hard drive and a Wi-Fi adapter. The Jackal has a wireless game controller, GPS, IMU, On-board computer and accessory mounting plates as integrated accessories.
Short strategy description for navigation and applications
For executions of the task a state machine is used. Within this statemachine all the different steps taken in the task have been identified and classified in different states. A state is called upon when a set of prerequisites have been fulfilled. At that moment the state will be executed.
These are the commercial team sponsors & partners (if there are)
1. Kaverneland 2. Steketee

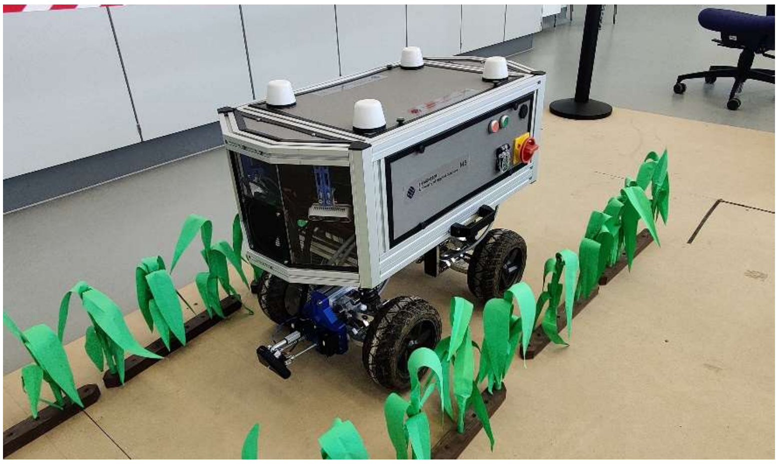
3. Carbonite

Team Name	Carbonite
Names of team members:	Junus Hirner; Jonas Mayer; Janis Schönegg; Jacob Schupp
Name team captain:	Klara Fauser
Instructor(s):	Lukas Locher
Institution:	Schülerforschungszentrum Südwürttemberg (SFZ) e.V.
Department:	Standort Überlingen
Country:	Germany
Street / Number:	Obertorstraße 16
ZIP Code / City	88662 Überlingen
Email:	sfz.carbonite@gmail.com
Webpage:	https://sfz-bw.de/ueberlingen/

THE MACHINE			
W x L x H (cm):	50 x 45 x 17	Weight (kg):	20
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4 / 4
Drivetrain concept / max. speed (m/s):	- / 2	Turning radius (cm):	ca. 66
Battery type / capacity (Ah):	- / -	Total motor power (W):	-
No. of sensors internal / external: Sensor type:	1 x gyrosensor, 1 x camera, 1 x laserscanner		

Controller system software description (sensor data analysis, machine control etc.)
ROS (Kinetic)
Controller system hardware description (motor controller, computer etc.)
-
Short strategy description for navigation and applications
Only navigating with lasersacanner and IMU
These are the commercial team sponsors & partners (if there are)
Schülerforschungszentrum Südwürttemberg, Micro Macro Mint, Wilhelm Stemmer Stiftung, Sick AG, Volksbank Überlingen

4. Ceres II



Team Name	CERES Team
Names of team members:	Andy Dehn; Marc Funcke; Maximilian Grote; Christine Hoffmann; Jochen Korn; Matthias Nießing; Natalie Peracha; Jannis Wagner
Name team captain:	Marc Funcke
Instructor(s):	Jochen Korn; Matthias Nießing
Institution:	Münster University of Applied Sciences
Department:	Department of Mechanical Engineering
Country:	Germany
Street / Number:	Stegerwaldstr. 39
ZIP Code / City	48565 Steinfurt
Email:	marc.funcke@fh-muenster.de; jochen.korn@fh-muenster.de
Webpage:	www.fh-muenster.de/maschinenbau/index.php www.fh-muenster.de/maschinenbau/labore/agrarroboter/agrarroboter.php

THE MACHINE			
W x L x H (cm):	42 x 82 x 60	Weight (kg):	60
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4 / 4
Drivetrain concept / max. speed (m/s):	Differential drive / 4 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	LiIon 7S 24,15Ah	Total motor power (W):	4 x 250 = 1000
No. of sensors internal / external: Sensor type:	4 x Intel RealSense D435 Depth Camera, 1 x IMU ICM-20948, 4 x motor encoder, 1 x battery voltage sensor, 1 x battery current sensor, 1 x temperature + humidity sensor		

Controller system software description (sensor data analysis, machine control etc.)
The software of the robot runs on ROS Melodic, which is used as the basic framework. The functionality of the robot is set up on the use of several already existing ROS nodes as well as additionally added nodes. The additional nodes are implemented in C++ and Python. All robot operations are organized via a state machine, which coordinates between the different tasks (e.g. row drive, row turn).
Controller system hardware description (motor controller, computer etc.)
The chassis of the robot is based on aluminium extrusion profiles with four hoverboard wheels. The wheels are each mounted with individual suspension. Furthermore, the robot is equipped with a hitch to connect the trailer to the robot. The central computing unit is an Intel NUC. The wheels are controlled by two O-Drive motor controllers. To communicate with different sensors and actuators (e.g. for the hitch), numerous Arduino microcontrollers are installed in the robot.
Short strategy description for navigation and applications
For detection of the plants, the robot uses four depth cameras. Their data is evaluated by numerous algorithms to determine the position of the plants. Other ROS nodes use this information to tell the robot to navigate through the plant rows as well as to do a turn at the end of a row.
These are the commercial team sponsors & partners (if there are)
Münster University of Applied Sciences, Department of Mechanical Engineering

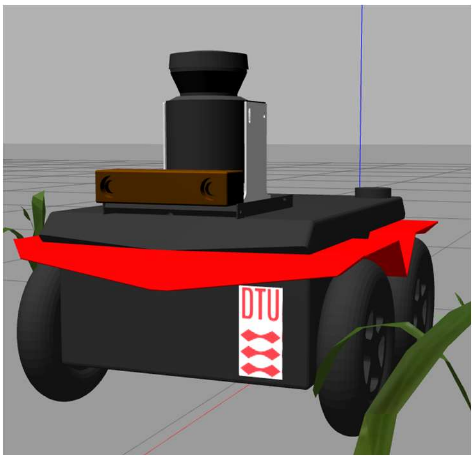
5. CollectHOHr

Team Name	AgcHOH Robotics
Names of team members:	Daniel Mayer; Johannes Bringsken; Christoph Brüning; Philipp Tegethoff; Sebastian Biederwolf; Lars Krämer
Name team captain:	Lars Krämer
Instructor(s):	David Reiser, Jonas Boysen
Institution:	University of Hohenheim
Department:	Technology in crop production
Country:	Germany
Street / Number:	Garbenstr. 9
ZIP Code / City	70599 Stuttgart
Email:	lars.kraemer@uni-hohenheim.de
Webpage:	www.uni-hohenheim.de

THE MACHINE			
W x L x H (cm):	46x74x40	Weight (kg):	ca. 22 kg
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4/4
Drivetrain concept / max. speed (m/s):	All wheel drive / 2 m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	Lithium Ion / 270 Wh	Total motor power (W):	2000 W
No. of sensors internal / external: Sensor type:	2/2 IMU, Encoder, Camera, Lidar		

Controller system software description (sensor data analysis, machine control etc.)
ROS Melodic, Open CV
Controller system hardware description (motor controller, computer etc.)
Short strategy description for navigation and applications
Navigation: Detecting the plant rows with the use of point cloud data that is provided by the laser scanner. The data gets edited into Ransac lines which simplifies the following steps. For the guidance we use the mean value between the left and right distance to the already mentioned Ransac lines. That creates a target which the robot is following. Object detection: Image Processing with colour filtering and finding contours with form attributes
These are the commercial team sponsors & partners (if there are)

6. DTUbot



Team Name	amaizDTU
Names of team members:	Ruijie Ren; Chuqian Zhou; Ruixin Chen; Zhicun Tan; Youyang Shen
Name team captain:	Ruijie Ren
Instructor(s):	Ole Ravn; Nils Axel Andersen
Institution:	Technical University of Denmark
Department:	Department of Electrical Engineering
Country:	Denmark
Street / Number:	Building 326
ZIP Code / City	2800 Kongens Lyngby
Email:	s210203@student.dtu.dk
Webpage:	elektro.dtu.dk

THE MACHINE			
W x L x H (cm):	43x50.8x25	Weight (kg):	17
Commercial or prototype:	Commercial	Total no. of wheels / no. driven wheels:	4
Drivetrain concept / max. speed (m/s):	2.0	Turning radius (cm):	0
Battery type / capacity (Ah):	Li-Ion 12 V / 22.5Ah	Total motor power (W):	500
No. of sensors internal / external: Sensor type:	1 * LiDAR sensor: SICK LMS100 1 * Stereo camera: Bumblebee		

Controller system software description (sensor data analysis, machine control etc.)
The software runs in Robot Operating System (ROS) Melodic on Ubuntu 18.04LTS and is programmed in Python and C++
Controller system hardware description (motor controller, computer etc.)
Simulation Only
Short strategy description for navigation and applications
Navigation (task 1 & 2): ➢ Laser scanner scans the maize and generate point cloud. This point cloud is divided into a right and left row. ➢ The target line between left and right rows are generated and the robot follow the line to the end of the row. ➢ Robot turns and detects next row. Object Detection (task 3): ➢ Recognize QR code to get reference frame. ➢ Detect and classify weeds and beer cans on the filed via Bumblebee camera. ➢ Calculate the detected objects' pose in robot frame. ➢ Transform object pose from robot frame to reference frame.
These are the commercial team sponsors & partners (if there are)

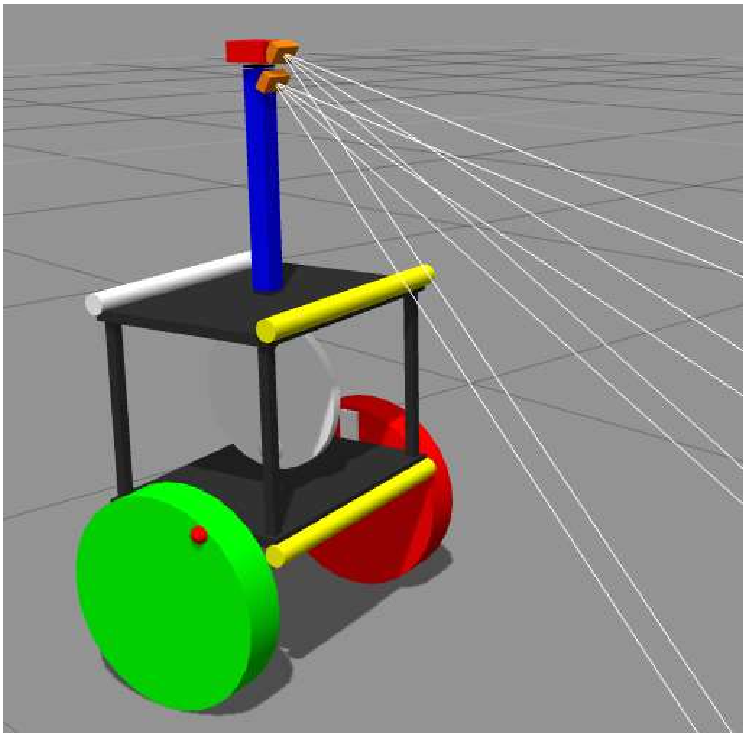
7. Farmbeast

Team Name	FarmBeast
Names of team members:	Urban Kenda, Erik Rihter, Erik Voh, Gregor Popič, Aljaž Zajc, Rok Friš Domen Toš, Miha Kajbič, Valentin Podkrižnik, Kristijan Polovič, Peter Bernad Jernej Mlinarič
Name team captain:	Kristijan Polovič
Instructor(s):	Miran Lakota, Jurij Rakun
Institution:	University of Maribor, Faculty of Agriculture and Life Sciences
Department:	Biosystems Engineering
Country:	Slovenia
Street / Number:	Pivola 10
ZIP Code / City	Hoče
Email:	farmbeast@um.si
Webpage:	farmbeast@um.si

THE MACHINE			
W x L x H (cm):	52,7 x 65 x 50	Weight (kg):	35
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4
Drivetrain concept / max. speed (m/s):	0,5	Turning radius (cm):	75
Battery type / capacity (Ah):	6	Total motor power (W):	800
No. of sensors internal / external: Sensor type:	Velodyne VLP-16 multichannel LIDAR ||SICK TIM310 LIDAR sensor,2 x camera, IMU		

Controller system software description (sensor data analysis, machine control etc.)
Linux Ubuntu, Robot Operating System
Controller system hardware description (motor controller, computer etc.)
Raspberry Pi 3 Model B (low level computer) + Intel NUC 7i7BNH (high level computer)
Short strategy description for navigation and applications
Custom infield navigation algorithm based on Velodyne and IMU readings.
These are the commercial team sponsors & partners (if there are)
SMTd.o.o, CLAAS d.o.o, EMSISO d.o.o, Tuli d.o.o, IHS d.o.o, AzureFIlm d.o.o, Šeško d.o.o

8. Field Balancer



Team Name	Camper Robotics
Names of team members:	Fabian Paul, Erwin Kose
Name team captain:	Simon Sure
Instructor(s):	
Institution:	
Department:	
Country:	Germany
Street / Number:	
ZIP Code / City	
Email:	info@simonsure.com (Simon Sure), lods@microenergie.com (Erwin Kose)
Webpage:	

THE MACHINE			
W x L x H (cm):	35 x 20 x 60	Weight (kg):	10
Commercial or prototype:	prototype	Total no. of wheels / no. driven wheels:	2 differential drive 1 reaction wheel
Drivetrain concept / max. speed (m/s):	self balancing differential drive max speed 10m/s	Turning radius (cm):	35
Battery type / capacity (Ah):	10 Li-Ion 18650 cells, 36V/4.4Ah	Total motor power (W):	700

No. of sensors internal / external: Sensor type:	imu, webcam, wheel encoders

Controller system software description (sensor data analysis, machine control etc.)
FOC motor control written by Niklas Fauth and Emanuel Feru ROS1, ROS2, everything else home made
Controller system hardware description (motor controller, computer etc.)
modified hoverboard Raspi and Arduino Mega 2560
Short strategy description for navigation and applications
Looking for unobstructed paths by means of an ordinary webcam
These are the commercial team sponsors & partners (if there are)

9. Helios Evo

Team Name	Field Robot Event Design Team (FREDT)
Names of team members:	David Bernzen, Steffen Lohmann, Alexander Brümmer, Tobias Lamping, Enrico Schleef, Julius Steinmatz, Christopher Prange, Marc Schernus
Name team captain:	David Bernzen
Instructor(s):	Jan Schattenberg
Institution:	Technische Universität Braunschweig
Department:	Institut für mobile Maschinen und Nutzfahrzeuge
Country:	Germany
Street / Number:	Langer Kamp 19a
ZIP Code / City	38106
Email:	info@fredt.de
Webpage:	www.fredt.de

THE MACHINE			
W x L x H (cm):	35 x 69 x 40	Weight (kg):	25 kg
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4/4
Drivetrain concept / max. speed (m/s):	4WD / 3,5m/s	Turning radius (cm):	75 cm
Battery type / capacity (Ah):	2x 4500 mAh	Total motor power (W):	250 W

No. of sensors internal / external: Sensor type:	2x LIDAR: SICK TIM 571 Odometry Unit Camera: Intel RealSense
HELIOS evo is the next generation robot of the FRED-Team. Based on a proven chassis with four wheel drive and all wheel ackermann steering we added a completely new vehicle body. The main components are an agricultural rear lift system with 20 kg load capacity with integrated electrical- and fluid-lines as well as a new central electrical distribution and battery-management-unit. The vehicle body also includes the main computer as well as the cooling and light system.	

Controller system software description (sensor data analysis, machine control etc.)
Two LIDAR at different heights are used to approximate the distances between the rows of maize plants. In addition, it is easier to recognise obstacles such as leaves from different angles. By processing it is possible to determine the centre of the robot to the plant rows to predict how the robot can drive through the rows as fast as possible.
Controller system hardware description (motor controller, computer etc.)
The navigation runs on a Gigabyte Barebone with i7-4770R ,16GB RAM, 256 GB SSD. It contains steering the motor for driving and steering servos for turning as well as data analysis by several sensors, which are localized in front of the robot. In addition, there is another micro-controller (ESP-WROOM-32) which is used for battery management and all other functions concerning task-implements (e.g. servos, rear power lift, sprayer, ...). It is connected with the main Computer via WIFI.
Short strategy description for navigation and applications
The goal in the tasks is to come to the end as quickly as possible by prediction of the plant rows and then turn around.
These are the commercial team sponsors & partners (if there are)
Technische Universität Braunschweig · INSTITUT FÜR mobile Maschinen und Nutzfahrzeuge

10. Maize Runner

Team Name	DTU Maize Runner 1.0
Names of team members:	Stefan Larsen, Isabella Schøning, Victor Haavik, Frederik Zilstorff
Name team captain:	Stefan Larsen
Instructor(s):	Ole Ravn, Nils Axel Andersen
Institution:	Technical University of Denmark (DTU)
Department:	Electrical Engineering
Country:	Denmark
Street / Number:	Ørsteds Plads 348
ZIP Code / City	2800, Kongens Lyngby
Email:	or@elektro.dtu.dk
Webpage:	www.aut.elektro.dtu.dk

THE MACHINE			
W x L x H (cm):	33 x 55 x 44	Weight (kg):	~30kg
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4 / 2
Drivetrain concept / max. speed (m/s):	Real-wheel drive, Ackermann steering, ~2m/s	Turning radius (cm):	~50cm
Battery type / capacity (Ah):	Lead acid / 14Ah	Total motor power (W):	200W
No. of sensors internal / external: Sensor type:	6 / 2 Gyroscope, wheel encoders, camera and lidar.		

Controller system software description (sensor data analysis, machine control etc.)
ROS
Controller system hardware description (motor controller, computer etc.)
Maxon Motor Controller, Intel NUC
Short strategy description for navigation and applications
Scan with lidar, detect nearest point, extrapolate the row that point belongs to, displace robot path 0.375m from detected row, navigate robot along path. Repeat until end of row, then turn and repeat.
These are the commercial team sponsors & partners (if there are)
None

11. Spark

Team Name	Banat Robot
Names of team members:	Tucudean Adrian-Ionut, Aniel Alexa, George Borsa, Almasan Catalin, Merticariu Samuel
Name team captain:	Tucudean Adrian-Ionut
Instructor(s):	Bungescu Sorin Tiberiu, Sorin Nanu
Institution	Univesitatea Politehnica din Timisoara &Universitatea&Universitatea de Stiinte Agricole si Medicina Veterinara a Banatului "Regele Mihai I al Romaniei" din Timisoara
Department:	AC&MA
Country:	Romania
Street / Number:	Calea Aradului
ZIP Code / City	300645
Email:	ireallcu3@gmail.com
Webpage:	https://www.usab-tm.ro/ro/undefined/informatii-generale-11380 & https://ac.upt.ro/

THE MACHINE			
W x L x H (cm):	30x40x50	Weight (kg):	5 kg
Commercial or prototype:		Total no. of wheels / no. driven wheels:	4x4
Drivetrain concept / max. speed (m/s):	2m/s	Turning radius (cm):	40
Battery type / capacity (Ah):	5A	Total motor power (W):	36
No. of sensors internal / external: Sensor type:	Camera RGB 30fps, 640x480 FOV 45 degrees BGR		

Controller system software description (sensor data analysis, machine control etc.)
Fuzzy movement system
Controller system hardware description (motor controller, computer etc.)
Raspberry pi 4 , 4 GB RAM
Short strategy description for navigation and applications
Freespace Detection&Classification, EndOfRows Detection, Object Detection
These are the commercial team sponsors & partners (if there are)

12. Tafr

Team Name	TAFR Robotics
Names of team members:	Urban Bobek, Janez Cimerman, Luka Hrastovec, Matej Germek
Name team captain:	Urban Bobek
Instructor(s):	/
Institution:	TAFR Robotics (Zavod 404)
Department:	TAFR Robotics
Country:	Slovenia
Street / Number:	Mencingerjeva 7
ZIP Code / City	1000 Ljubljana
Email:	info@tafr.si
Webpage:	http://tafr.si/

THE MACHINE (physical robot)			
W x L x H (cm):	45x79x40	Weight (kg):	45
Commercial or prototype:	Prototype	Total no. of wheels / no. driven wheels:	4/4
Drivetrain concept / max. speed (m/s):	DC motors / 2m/s	Turning radius (cm):	0
Battery type / capacity (Ah):	LiPo 5Ah	Total motor power (W):	4x125W
No. of sensors internal / external: Sensor type:	IMU, 2D LIDAR, 4 encoders, camera		

Controller system software description (sensor data analysis, machine control etc.)
Lidar and IMU data for navigation, camera for detection (task 3 and 4).
Controller system hardware description (motor controller, computer etc.)
/
Short strategy description for navigation and applications
Using SLAM algorithm to generate a map of the maize field. We analyze it using custom computer smart vision algorithms and generate commands for robot.
These are the commercial team sponsors & partners (if there are)
Epilog (https://www.epilog.net/) Zavod 404 (https://404.si/) Mestna občina Ljubljana (Municipality of Ljubljana, https://www.ljubljana.si/sl/mestna-obcina/)

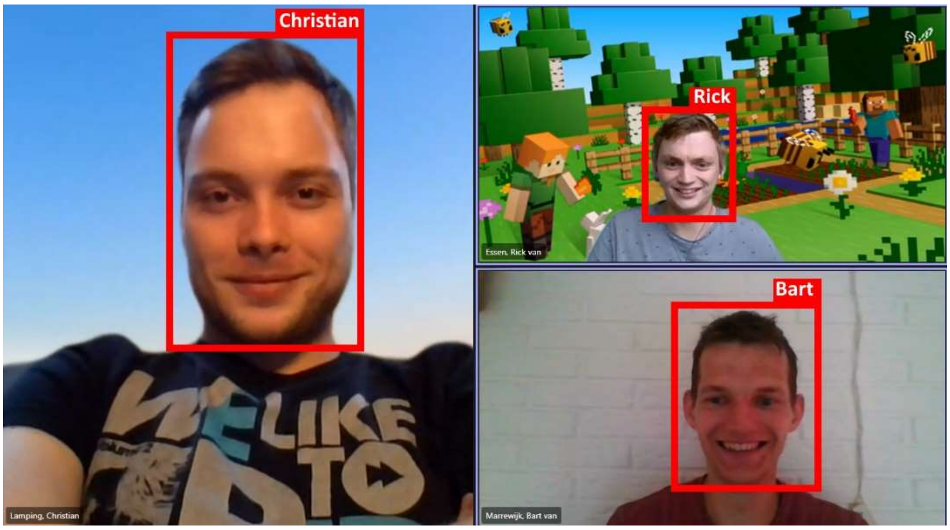
13. WeedInspector

Team Name	Team FloriBot
Names of team members:	Ibrahim Can, Moritz Böker, Josef Stöger, Benedict Bauer
Name team captain:	Benedict Bauer
Instructor(s):	Torsten Heverhagen
Institution:	Heilbronn University of Applied Sciences
Department:	Faculty of Mechanics and Electronics
Country:	Germany
Street / Number:	Max-Planck-Str. 39
ZIP Code / City	74081 Heilbronn
Email:	benedict.bauer@hs-heilbronn.de
Webpage:	hs-heilbronn.de/floribot

THE MACHINE			
W x L x H (cm):	50,8 x 43,0 x 25,0	Weight (kg):	17 kg
Commercial or prototype:	commercial	Total no. of wheels / no. driven wheels:	4 / 4
Drivetrain concept / max. speed (m/s):	4×4 differential drive / 2.0 m/s	Turning radius (cm):	50,8
Battery type / capacity (Wh):	lithium battery pack / 270	Total motor power (W):	500
No. of sensors internal / external: Sensor type:	4 Odometry Lidar, 3D Camera, RGB Camera		

Controller system software description (sensor data analysis, machine control etc.)
Gazebo Simulation
Controller system hardware description (motor controller, computer etc.)
Gazebo Simulation
Short strategy description for navigation and applications
The navigation in rows is based on a simple algorithm which uses the position of the robot relative to the middle of the rows and it’s angle to the rows to determinate it’s speed and steering angle. Outside of the rows in the headlands the robot uses a implementation of a standard path planner and follower to reach the right rows. In Task 3 the image processing is performed by a neural network which gives the position and the type of the given obstacles while driving by.
These are the commercial team sponsors & partners (if there are)

14. Wurking



Team Name	WURking
Names of team members:	Bart van Marrewijk, Christian Lamping, Rick van Essen
Name team captain:	Rick van Essen
Instructor(s):	We are a self-made team without instructor.
Institution:	Wageningen University and Research
Department:	Farm Technology
Country:	The Netherlands
Street / Number:	Droevendaalsesteeg 1
ZIP Code / City	6708 PB Wageningen
Email:	rick.vanessen@wur.nl
Webpage:	-

THE MACHINE			
	Standard Jackal		

Controller system software description (sensor data analysis, machine control etc.)
The robot tries to follow a straight line through waypoints provided by the inrow and headland path planners using a PID controller. As feedback for the controller, the filtered odometry using both IMU and wheel encoders is used. All tasks in the robot are executed using a statemachine implemented in FlexBE.
Controller system hardware description (motor controller, computer etc.)
We are only using the ROS and Gazebo simulation environment without real hardware.
Short strategy description for navigation and applications
Inrow navigation uses a particle filter that assigns lidar points to either the left side of the row, the right side of the row or noises. This assignment is done based on position of lidar points with respect to the row. Based on the points belonging to the left and right row of plants, the pose of the robot is calculated. The end of the row is detected when number of lidar points is below threshold. Headland navigation uses a line detection algorithm based on lidar point clouds. Lines/rows are detected and counted to find the next target row.
These are the commercial team sponsors & partners (if there are)