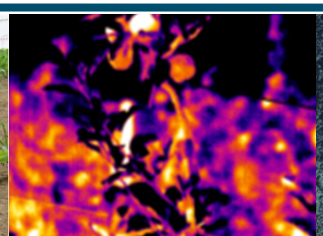
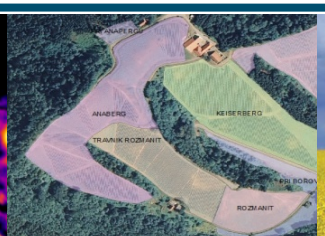
University of Maribor

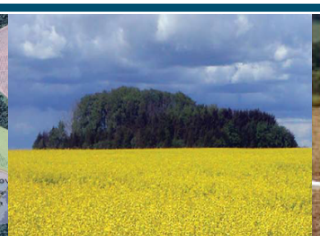
Faculty of Agriculture and Life Sciences

VIRAL

Robotics in agriculture

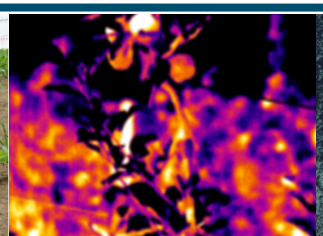
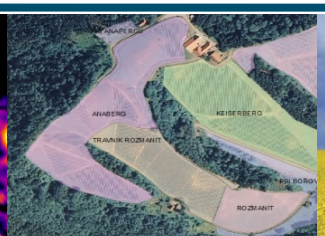
Jurij Rakun

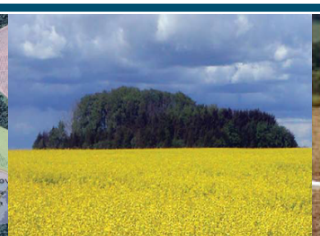






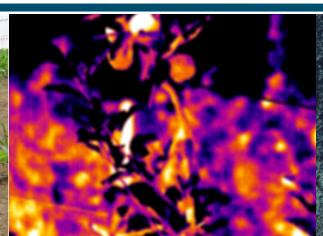
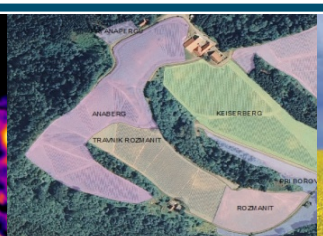
Contents

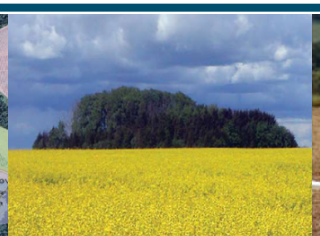
- Advantages of using robots in agriculture
- The state of precision farming in Slovenia (and wider)
- The development / readiness of Field robots
- Education / qualification of future research / support personal
- Rovitis – a prototype example



Why should we use robots in agriculture?



Advantages

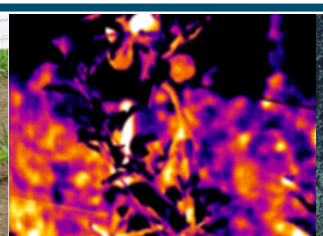
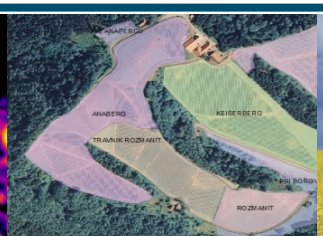
- Replace human labour
- The work is done faster
- With a higher degree of accuracy
- Safer use (in case of hazardous chemicals)
- Possible use in less favourable conditions
- Autonomous operation
- Economic advantage

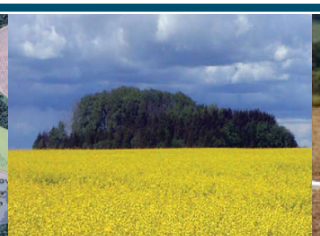

ORACLE robot

LEVY


Harvest CROO


Lettuce Bot



Economic advantage - calculation

Problem - Costs

Case study for 1 hectare (= 10'000 m^2)

In 1 hectare, considering a row length of 250m and row width of 2.6m, exists usually 15 rows ($\frac{10000}{250*2.9} \approx 13$), in a **fully mechanized vineyard**.

Taking in consideration a FENDT 207V VARIO with average speed of 5 km/h and fuel consumption 0.214 kg/KWh. The used fuel per hectare is:

$$\frac{119\ km}{5\ km/h} \approx 23{,}8h$$

$$23{,}8h\ * 12{,}81\frac{L}{H} = 304{,}88\ L$$

Fuel cost: $304{,}88L\ *\ 0.803\ €/L\ = 244{,}82\ €$

Human Labour: $44.5\frac{H}{hectare} * 1\ hectare\ * 25\ \frac{€}{H} = 667{,}5€$

TOTAL: $912{,}32\ €/hectare$

REVENUE: $+9699{,}6\ €$

TOTAL: $+8067{,}28\ €/hectare$

Solution - Costs

Case study for 1 hectare (= 10'000 m^2)

In 1 hectare, considering a row length of 250m and row width of 2.8m, exists usually 14 rows ($\frac{10000}{250*2.8} \approx 14$), in a **partially mechanized vineyard**.

Taking in consideration a small diesel machine with average speed of 4 km/h and fuel consumption 4 L/H. The used fuel per hectare is:

$$\frac{101\ km}{4\ km/h} \approx 25{,}25h$$

$$25{,}25h\ * 4\frac{L}{H} = 101\ L$$

Fuel cost: $101L\ *\ 0.803\ €/L\ = 81{,}103\ €$

Human Labour: $4\frac{H}{hectare} * 1\ hectare\ * 25\ \frac{€}{H} = 100€$

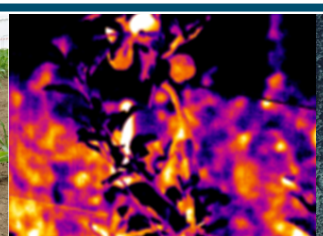
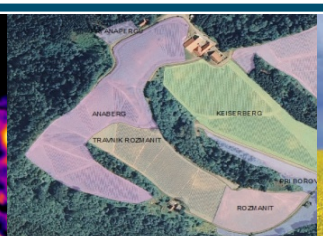
TOTAL: $181{,}10\ €/hectare$

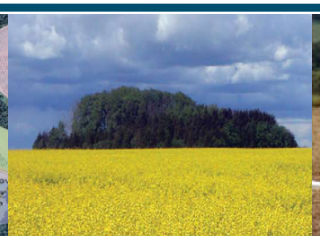
REVENUE: $+10722{,}6\ €$

TOTAL: $+9341{,}5\ €/hectare$

DIFFERENTIAL PROFIT: $+1274{,}22\ €/hectare$

(Source: Matteo Pantano, AGRA2018)



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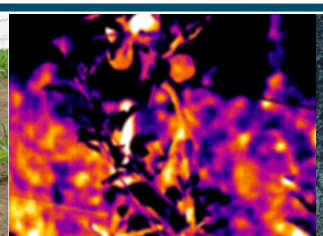
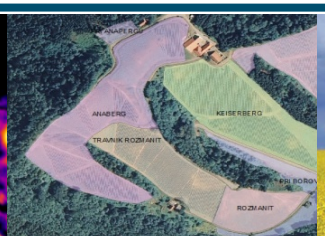
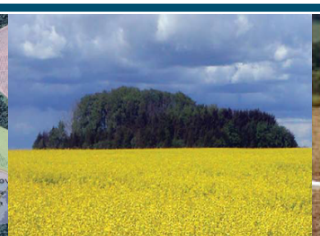
The state of precision farming in Slovenia (and wider)?

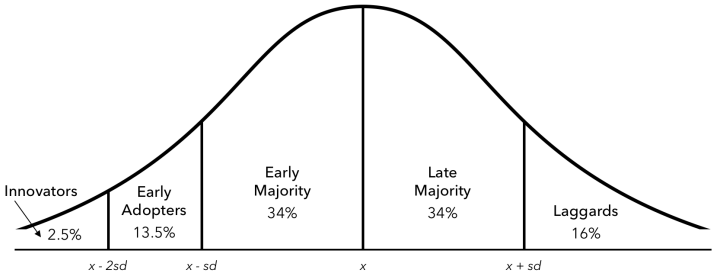






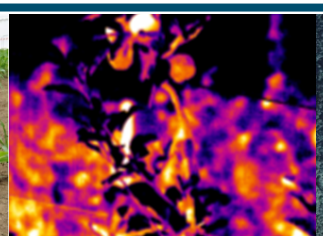
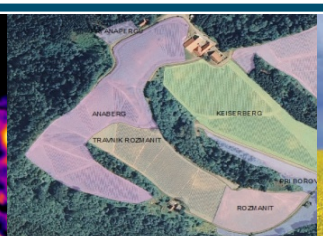
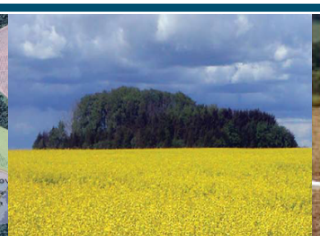
The state of PF

(vir: Transfarm 4.0, Interreg Central Europe, CE-1550)

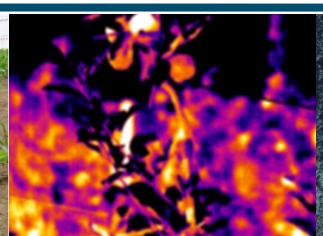
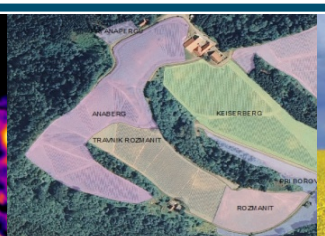
- State: 57.5 % of the respondent did not yet implement PFT, 20 % are starting to, 12.5 % are using on regular basis, 5 % are not interested in PFT
- Main obstacles: initial investment (87.5 %), technical support (62.5 %), compatibility (60 %), maintenance (75 %).
- Benefits: less labour (76 %), higher quality (74 %), usefulness-reliability-traceability (62 %).
- Changes: policy (80 %), education(70 %), compatibility (35 %).

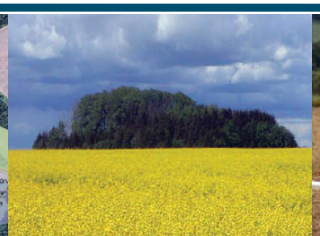


Reference: Rogers, 1983

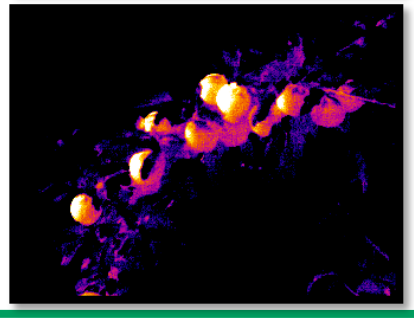





The development / readiness of Field robots ?

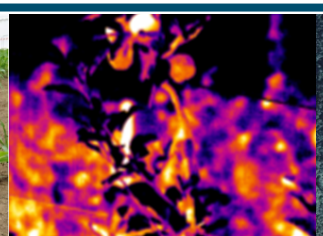


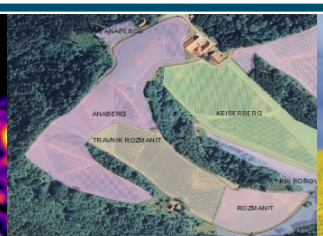
Challenges

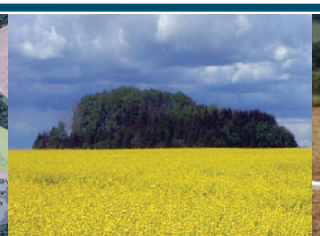


- Safety
- Reliability and robustness
- Intuitive and easy tu use

- Uninterrupted operation (time, weather,…)
- Ability to work in changing environment
- Operation in uncontrolled environment

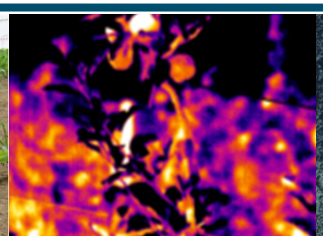
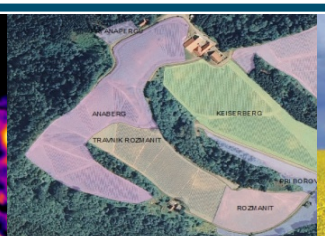


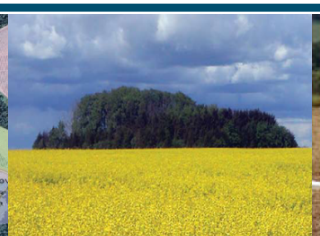




Supervised environment

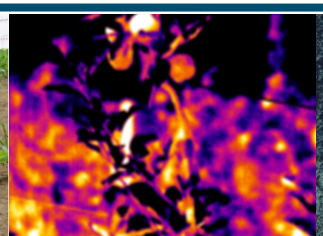
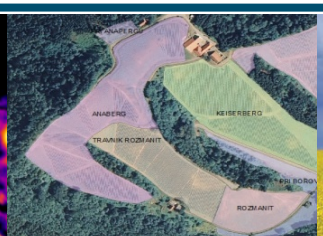
- A solution for insufficient work force and a way for production optimization.
- NL: in 2019 11 % of greenhouse owners use robots, 8 % in 2018.
- Used for:
  - Plant protection agents application (25 %)
  - Planting and harvesting (22 %)
  - Logistics (15 %)
- Commercially available solutions. We can influence where and how to capture data.

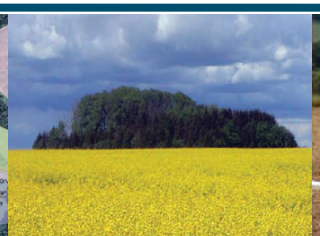






Field robots

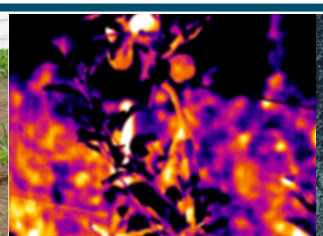
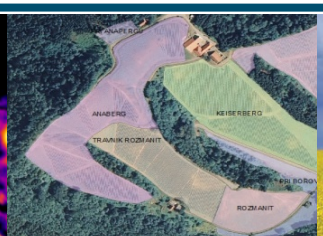
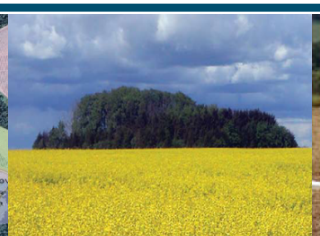
Company - Robot	Intended for	Format	Drive	GPS	LIDAR	Vision
SITIA - Trektor	Vineyards, Orchards, Fields	Big	Hybrid	YES, RTK	NO	NO
Ecorobotis - AVO	Fields	Big	Electric	YES	NO	YES
AGROINTELLI - Robotti	Fields	Big	ICE	YES, RTK	YES, multichannel	YES
Instar - Trooper	Horticulture, logistika	Small	Electric	YES	NO	YES
Bakus - ViTiBOT	Vineyards, Orchards, Fields	Big	Electric	YES	NO	YES
VineScout	Vineyards	Small	Electric	YES	YES	YES
Naio – TED, Dino, OZ	Vineyards, Orchards, Fields	Big, Big, Small	Electric	YES, RTK	YES	YES
Meropy - SentiV	Fields	Small	Electric	YES	NO	YES
Rhoban - E-Tract	Fields	Big	Electric	YES, RTK	YES	NO
Ag. Giorgio Pantano - ROVITIS	Vineyards	Big	ICE	YES, RTK	YES, multichannel	YES, visual odometry
Farmbeast	Fields	Small	Electric	NO	YES, multichannel	YES, weed detection



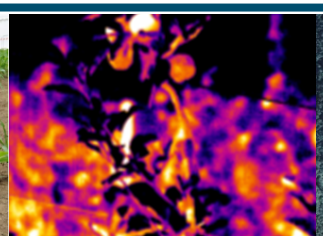
Instar - Trooper

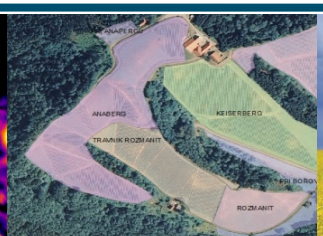
- Use: logistics in greenhouses – to distribute or to re-group plants in pots.
- Autonomous operation – the robot is thought what to do and then repeats the operation.
- Sensors: LIDAR
- Safety: uses AI methods to control the behaviour of the robot.

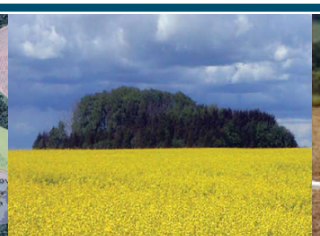





Naio technologies

- Naio is one of the first companies to commercially offer field robots and cooperates with farmers to solve problems.
- Products:
  - OZ – weeding robot
  - TED – vineyard robot
  - DINO – vegetable robot
- All three platforms use electric driven platforms.
- Sensory systems: RTK GPS, LIDAR, cameras

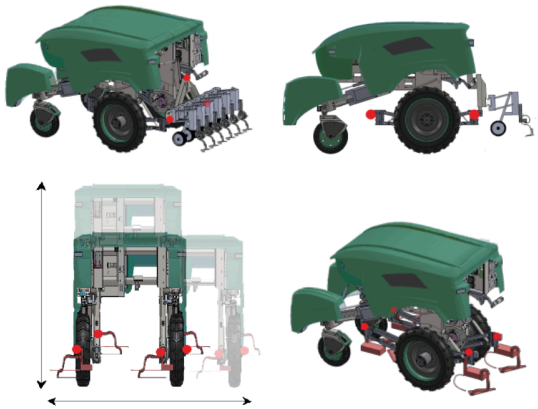


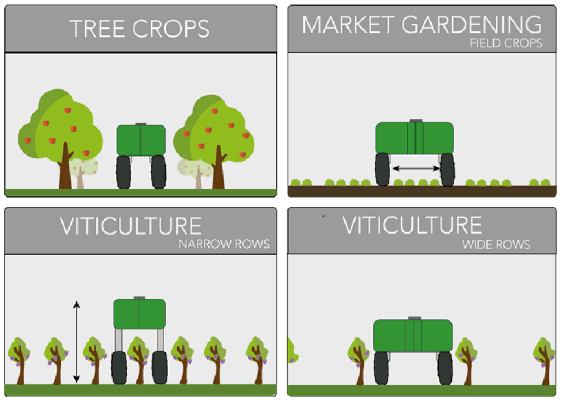


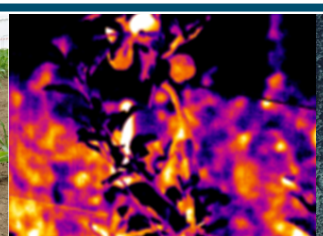


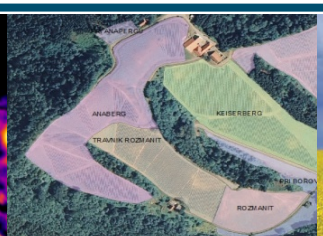
SITIA - Trektor

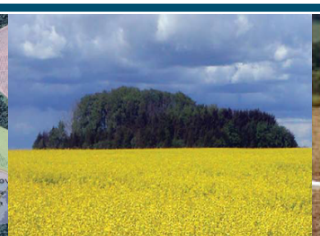
- Hybridni drive (diesel + electric for 24/7 operation)
- Adjustable dimensions (Vineyards, Fields,…)
- Standard three-point hitch (cat. 2)
- Sensors: RTK GPS
- Safety: bumpers + sensors





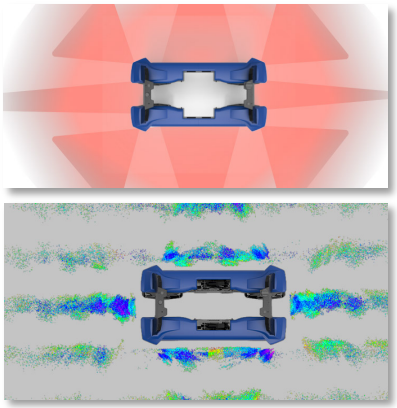


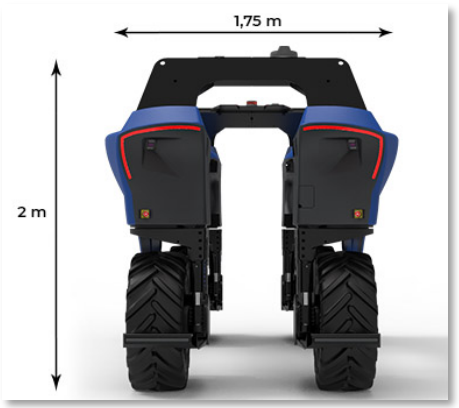


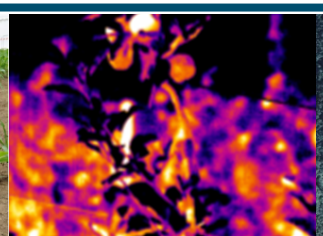


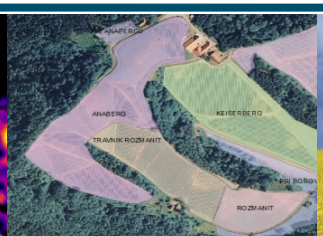
BACUS - ViTiBOT

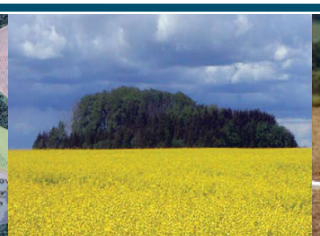
- 100 % Electric (80 kWh ≈ 10 h)
- Use: Vineyards, with inclination up to 45°
- Sensors: 8 x IR 3D camera, 2 x RTK GPS and 2 x IMUs
- Safety: 8 x bumpers, 4 x sensors in 6 x emergency OFF switches



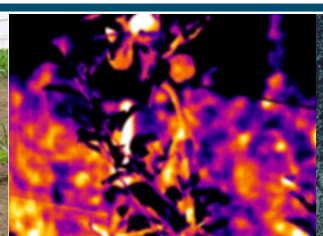
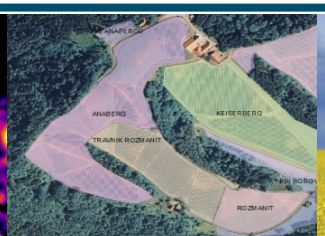


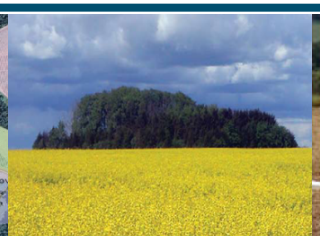






Education / qualification for future personnel?



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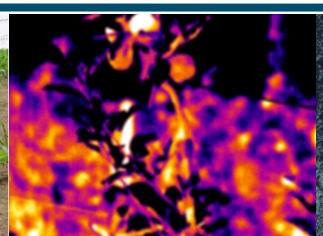
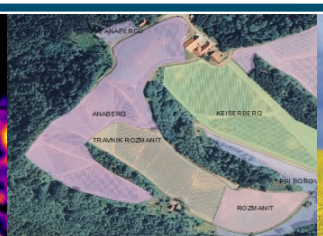
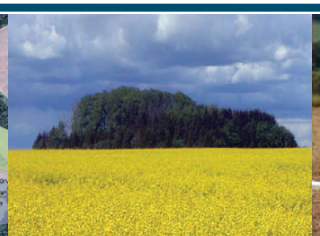
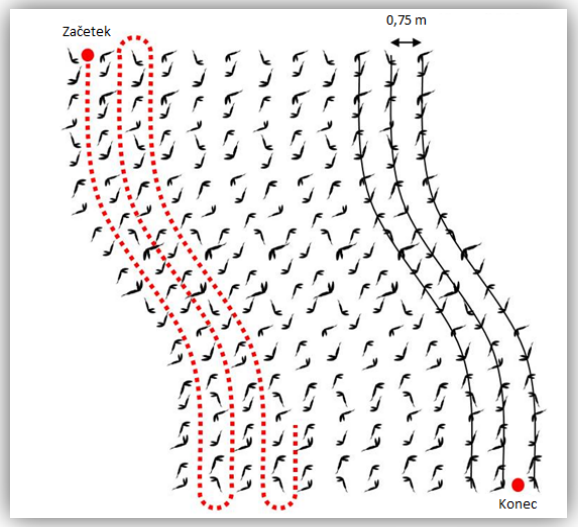
Field Robot Event

- 4th place in weed detection– Field robot event 2010 (Braunschweig, Germany)
- **1st place in Freestyle– Field robot event 2012 (Venlo, Netherland)**
- **3rd place overall – Field robot event 2013 (Herning, Denmak)**
- **3rd place in basic navigation - Field robot event 2014 (Bernburg-Stranzdfeld, Germany)**
- 4th place in basic navigation- Field robot event 2018 (Bernburg-Stranzdfeld, Germany)
- 4th place in weed elimination - Field robot event 2018 (Bernburg-Stranzdfeld, Germany)
- 4th place overall - Field robot event 2018 (Bernburg, Germany)
- **1st place in Freestyle – Field robot event 2019 (Hohenheim, Germany)**

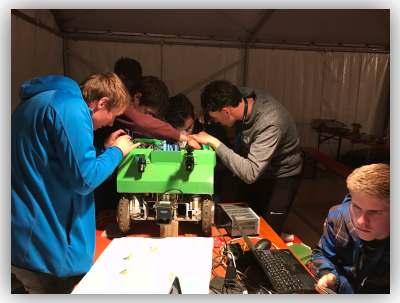




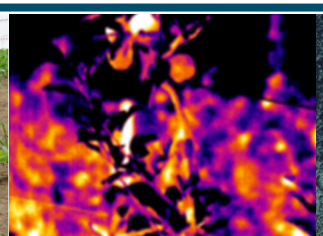
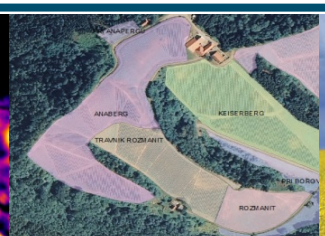


FRE – tasks and requirements



- Tasks:
  - 1st task – Basic navigation
  - 2nd task – Advance navigation
  - 3rd task – weed (object) detection
  - 4th task - weed (object) elimination (handling)
  - Freestyle
- Robot
  - Custom build hardware
  - Custom build software



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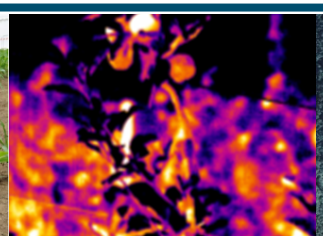
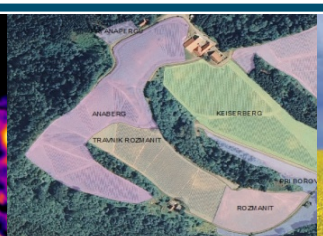
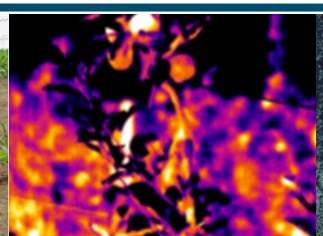
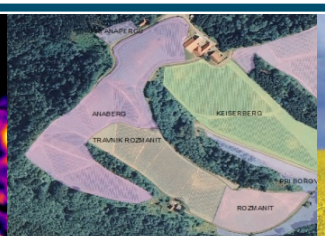
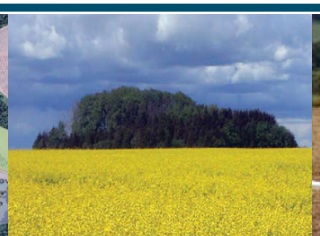
Študentski projekt – avtonomni robot





Rovitis –
a prototype example



ROVITIS 4.0 – vineyard robot

Starting point

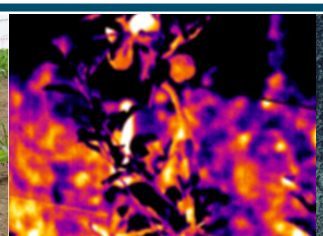
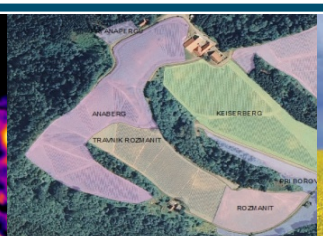
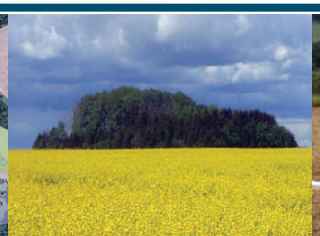
- Platform
  - DODICH loader
  - Wheels, SKID STEER drive
- Sensors
  - 2D LIDAR, MEMS IMU, odometry
- Software
  - Linux + Programs in C++

Mid phase

- Platform
  - DODICH loader
  - Wheels, SKID STEER drive
- Sensors
  - 2D LIDAR, MEMS IMU, odometry, **RTK GPS**
- Software
  - LINUX + **ROS + additional algorithms (row following)**

Currently

- Platform
  - **ENERGREEN platform**
  - **Tracks,** SKID STEER drive
- Sensors
  - **3D LIDAR**, MEMS IMU, odometry, RTK GPS
- Software
  - LINUX **+ ROS + additional algorithms (path planning, path following, localization, FieldSLAM)**

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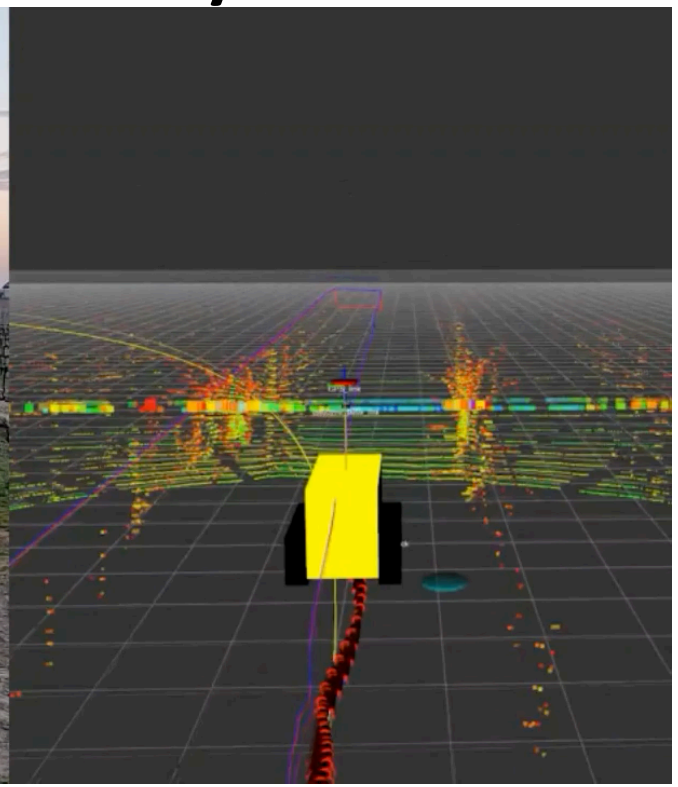
ROVITIS 4.0 – vineyard robot



FEASR

Regione del Veneto

PSR Veneto 2014-2020

FONDO EUROPEO AGRICOLO PER LO SVILUPPO RURALE: L'EUROPA INVESTE NELLE ZONE RURALI

PANTANO

Univerza v Mariboru

TERRE GROSSE

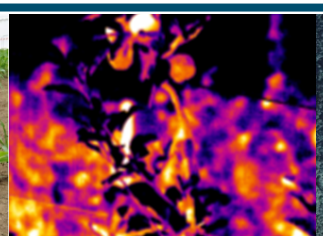
crea

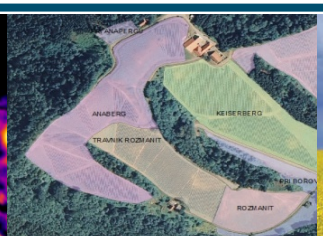
cet

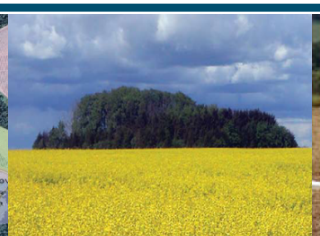
cirve

ENERGREEN

Confagricoltura Veneto







Questions?

Thank you!