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
Economic advantage - calculation

Problem - Costs

Case study for 1 hectare (= 10’000 m²)

In 1 hectare, considering a row length of 250m and row width of 2.6m, exists usually 15 rows (\( \frac{10000}{250 \times 2.6} \approx 13 \)), 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:

\[
\frac{119 \text{ km}}{5 \text{ km/h}} = 23.8 \text{ h}
\]

\[
23.8 \text{ h} \times \frac{12.81 L}{H} = 304.88 L
\]

**Fuel cost**: 304.88L \( \times \) 0.803 €/L \( = \) 244.82 €

**Human Labour**: 44.5 \( \frac{H}{\text{hectare}} \times 1 \text{ hectare} \times 25 \frac{€}{H} = 667.5 €

**TOTAL**: 912.32 €/hectare

Solution - Costs

Case study for 1 hectare (= 10’000 m²)

In 1 hectare, considering a row length of 250m and row width of 2.8m, exists usually 14 rows (\( \frac{10000}{250 \times 2.8} \approx 14 \)), 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:

\[
\frac{101 \text{ km}}{4 \text{ km/h}} = 25.25 \text{ h}
\]

\[
25.25 \text{ h} \times \frac{4 L}{H} = 101 L
\]

**Fuel cost**: 101L \( \times \) 0.803 €/L \( = \) 81,103 €

**Human Labour**: 44.5 \( \frac{H}{\text{hectare}} \times 1 \text{ hectare} \times 25 \frac{€}{H} = 100 €

**TOTAL**: 181,10 €/hectare

**REVENUE**: +9699.6 €

**DIFFERENTIAL PROFIT**: +1274.22 €/hectare

**TOTAL**: +8067.28 €/hectare

**REVENUE**: +10722.6 €

**TOTAL**: +9341.5 €/hectare

(Source: Matteo Pantano, AGRA2018)
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%).
The development / readiness of Field robots?
Challenges

• Safety
• Reliability and robustness
• Intuitive and easy to 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

<table>
<thead>
<tr>
<th>Company - Robot</th>
<th>Intended for</th>
<th>Format</th>
<th>Drive</th>
<th>GPS</th>
<th>LIDAR</th>
<th>Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITIA - Trektor</td>
<td>Vineyards, Orchards, Fields</td>
<td>Big</td>
<td>Hybrid</td>
<td>YES, RTK</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Ecorobotis - AVO</td>
<td>Fields</td>
<td>Big</td>
<td>Electric</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>AGROINTELLI - Robotti</td>
<td>Fields</td>
<td>Big</td>
<td>ICE</td>
<td>YES, RTK</td>
<td>YES, multichannel</td>
<td>YES</td>
</tr>
<tr>
<td>Instar - Trooper</td>
<td>Horticulture, logistika</td>
<td>Small</td>
<td>Electric</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Bakus - ViTiBOT</td>
<td>Vineyards, Orchards, Fields</td>
<td>Big</td>
<td>Electric</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>VineScout</td>
<td>Vineyards</td>
<td>Small</td>
<td>Electric</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Naio – TED, Dino, OZ</td>
<td>Vineyards, Orchards, Fields</td>
<td>Big, Small</td>
<td>Electric</td>
<td>YES, RTK</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Meropy - SentiV</td>
<td>Fields</td>
<td>Small</td>
<td>Electric</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Rhoan - E-Tract</td>
<td>Fields</td>
<td>Big</td>
<td>Electric</td>
<td>YES, RTK</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Ag. Giorgio Pantano - ROVITIS</td>
<td>Vineyards</td>
<td>Big</td>
<td>ICE</td>
<td>YES, RTK</td>
<td>YES, multichannel</td>
<td>YES, visual odometry</td>
</tr>
<tr>
<td>Farmbeast</td>
<td>Fields</td>
<td>Small</td>
<td>Electric</td>
<td>NO</td>
<td>YES, multichannel</td>
<td>YES, weed detection</td>
</tr>
</tbody>
</table>
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?
Field Robot Event

- 4\textsuperscript{th} place in weed detection – Field robot event 2010 (Braunschweig, Germany)
- 1\textsuperscript{st} place in Freestyle – Field robot event 2012 (Venlo, Netherlands)
- 3\textsuperscript{rd} place overall – Field robot event 2013 (Herning, Denmark)
- 3\textsuperscript{rd} place in basic navigation - Field robot event 2014 (Bernburg-Stranzfeld, Germany)
- 4\textsuperscript{th} place in basic navigation - Field robot event 2018 (Bernburg-Stranzfeld, Germany)
- 4\textsuperscript{th} place in weed elimination - Field robot event 2018 (Bernburg-Stranzfeld, Germany)
- 4\textsuperscript{th} place overall - Field robot event 2018 (Bernburg, Germany)
- 1\textsuperscript{st} 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
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)
ROVITIS 4.0 – vineyard robot
Questions?

Thank you!