Workshop
Robotics and agriculture: from the labs to the fields

Alessandro Di Fava | Barcelona, 2021
● Our company
● Products for Research
● Collaborative projects
● Challenge: from indoors to outdoors
● HRI in agriculture
● Conclusion
Our company
PAL Robotics

- Founded in 2004
- Based in Barcelona
- 19 nationalities
- ~60 employees
- 80% engineers | 10% Ph.D.
- Robots sales +30 countries
PAL Robotics in a nutshell

2004

2021
Our expertise

Navigation
- SLAM
- Navigation
- Localization

Software
- DevOps
- Continuous integration
- Perception

Embedded
- Motor & Sensor
- Control boards
- Connectivity

HMI
- AI
- Speech
- Face recognition

Control
- Real Time
- Manipulation
- Walking

Electronics
- Firmware
- Sensor boards
- Integration

Mechanics
- Bio-inspired
- and actuation designs
- Integration

Sales
- Flexibility
- Adaptation
- Customised solutions

Post-sales
- Training sessions
- Technical assistance
- On-demand programs

Community
- Collaboration
- Open Source
- R+D

We help you integrate cutting-edge robotics

- R&D
- RETAIL
- INDUSTRY
- LOGISTICS
- ASSISTED LIVING
- HOSPITALITY
- AUTOMOTIVE
- AEROSPACE
Business Units

**Social Robotics**
Platforms and services for social interaction

**Products for Research**
Out of the box products for research

**Collaborative Projects**
H2020, Eurostars Public funding

**Intra-Logistics**
Platforms for automating transportation of objects

**Retail**
Inventory robots Assets tracking

*Bank, Shops, Malls, Events*  
*Companies, Universities*  
*International Consortiums*  
*Healthcare, Industry*  
*Retailers*
Products for research
Take It And Go

**Characteristics**

- Height: 110 cm - 145 cm
- Expandable
- Mobile manipulation
- Free tutorials and simulations available online
- Research, Industry and Ambient Assisted Living
- 100% integrated
TIAGo Features

- Perception
- Human-Robot Interaction
- Manipulation
- Navigation

TIAGo Accessories

- Head Mounting Ports
- Customizable Color
- Customizable Torso
- NVIDIA Jetson
- TIAGo Base
- Laptop Tray
- Expansion Panel
- Plug and Play End-effectors
- 6 Axis Force Sensor
- Gripper Camera
Customizable
Modular Manipulation

TIAGo BASE
TIAGo IRON
TIAGo STEEL
TIAGo TITANIUM
TIAGo ++
TIAGo ++

Specifications

- Base footprint: Ø 54 cm | Weight: ~ 90 kg
- Torso lift stroke: 350 mm
- 7 DoFs each arm
- Optional 6-axis F/T sensors in the wrist
- Arm payload (without end-effector): 3 kg
- Arm reach: 87 cm
- Laser: 5.6 m, 10 m and 25 m range
- Pan-tilt head with a RGB-D camera
- Optional Nvidia Jetson
Collaborative projects
Collaborative projects

We cooperate with other European partners in order to boost innovation in several fields through more than 15 EU-funded projects.

<table>
<thead>
<tr>
<th>HEALTHCARE</th>
<th>AGRI-FOOD</th>
<th>INDUSTRY</th>
<th>R&amp;D</th>
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</thead>
<tbody>
<tr>
<td></td>
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**ON GOING**

- SPRING
- SHAPES
- memmo
- neu touch
- deep 5G

**PAST PROJECTS**

- RobMoSys
- SOCRATES
- 24 ROBOTS
- COVER
- INBOTS
- SACRe
Canopies project

- Canopies is a Collaborative Paradigm for Human Workers and Multi-Robot Teams in Precision Agriculture Systems.
- Addressing the challenges of **Human Robot Interaction and Human-Robot Collaboration** in the unstructured highly dynamic outdoor environment of permanent crop farming (Agri-Food Area).
- Real-world validation of two economically relevant agronomic operations within a table-grape vineyard: **harvesting and pruning**.
Where
Cooperativa Agrícola Corsira, Italy

- Vineyards → traditional trellis system “Tendone”
- Wide distance between each plant, 3m x 3m
- Field validation from 2nd year according to:
  - DEC/JAN → Pruning
  - JUL/SEP → Harvesting

TIAGo++ Tasks
- Perform harvesting and pruning in table-grape vineyards together with farmworkers
PAL Robotics’ role

1. Agronomic dual arms system design

Starting point

→ TIAGo++ upper body

Customizations

→ Torque sensors for each arm’s joint
→ 2 DoFs in the torso base
→ Investigate the increase in IP rating for dust and water protection
→ Migration CAN to EtherCAT to have higher control bandwidth
PAL Robotics’ role

2. Agronomic end-effectors design for harvesting and pruning
   → PAL Robotics would investigate if a single robust new
   end-effector can do above functions by adding tools

3. Expose a hardware abstraction layer with open interfaces for the mid-level control

4. Participation in Requirements, Validation, Dissemination and Exploitation activities

Timeline: First Release of Robot Prototypes at M14 | Final Release of Robot Prototypes at M40
Challenge: from indoor to outdoors
NAVIGATION IN AN OUTDOOR ENVIRONMENT

How does it affect the stability?

- Flat terrain with some stones and tractor lines
- Typical environment (dust and water)
  - IP rating for dust and water protection → Probability to operate in such scenarios
- Sunlight can affect the working of some sensors, especially visual based sensors
WORKSHOP ROBOTICS AND AGRICULTURE: FROM THE LABS TO THE FIELDS

NAVIGATION IN AN OUTDOOR ENVIRONMENT

How does it affect the stability?

- Images taken by cameras of the same environment can look vastly different under varying seasonal, weather, or lighting conditions.
- During night time outdoors, or in dark areas, visual self-localization becomes more difficult and can affect the navigation localization as well the obstacle avoidance.

Potential solutions?

- Relying on GPS for outdoor localization and navigation that can facilitate these processes.
- Turn on the body of the robot for lighting the dark spot or when the sun light it’s not good enough.
Human-Robot Interaction in agriculture
There are two operational mode for robots in agriculture:

In both mode, the robot has to be able to interact with people and ensure a safety interaction.

During precision agriculture people collaborate with the robot, supervisioning and correcting the robot, so the HRI is even more important.

HRI in outdoors

HRI is based on the sensors of the robot: microphone, speakers, cameras, even probable touch sensors where possible. Therefore, all the issues reviewed in the previous slides about the sensors, the light, the occlusions and the noisy environments are reflected in the HRI as well.

Extensive agriculture
Plowing fields, vegetable harvest that does not require precision, etc.

Precision agriculture
Harvesting of grapes, harvesting of apples, etc.
Conclusion
World population is growing so more needs of technologies and service robotics is needed to tackle with the increasing in the demand of food thus to help in the agricultural industry to improve the food production and processing.

Some of the work done in agriculture is very 

**tiring and repetitive** so the use of robots to help in it is more than welcome.

Our aim is to create the best service robots to enhance people’s quality of life.
Thank you

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