EUROPEAN ROBOTICS FORUM
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PAL ROBOTICS

Workshop
Robotics and agriculture: from the labs to the fields

Alessandro Di Fava | Barcelona, 2021

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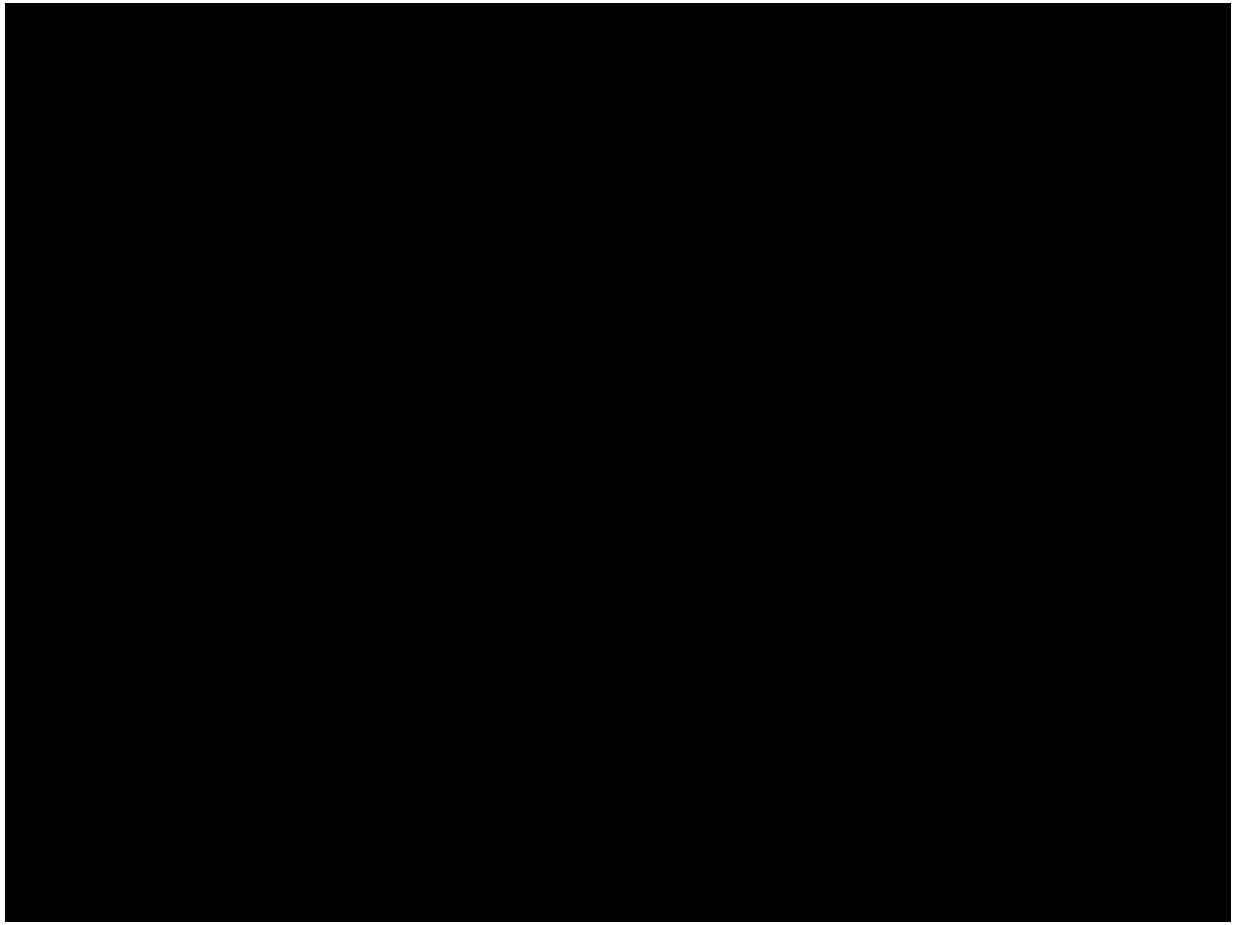
- Our company
- Products for Research
- Collaborative projects
- Challenge: from indoors to outdoors
- HRI in agriculture
- Conclusion

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

BANKS, SHOPS, MALLS, EVENTS

Products for Research

Out of the box products for research

COMPANIES, UNIVERSITIES

Collaborative Projects

H2020, Eurostars
Public funding

INTERNATIONAL CONSORTIUMS

Intra-Logistics

Platforms for automating transportation of objects

HEALTHCARE, INDUSTRY

Retail

Inventory robots
Assets tracking

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
- ROS 100% integrated

TIAGo Features

- Perception
- Human-Robot Interaction
- Manipulation
- Navigation

TIAGo Accessories

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

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Collaborative projects

H2020
Eurostars
Public funds

INTERNATIONAL CONSORTIUMS

Collaborative projects

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

	HEALTHCARE	AGRI-FOOD	INDUSTRY	R&D
ON GOING	SPRING, SHAPES	CANOPIES, agROBOfood	memmo, CYBER FACTORY NO.1 CF#1, SeCoIIA	Deep Robotics, 3D HERO, eurobench, PERSEO, neu touch, evolved 5G
PAST PROJECTS	RobMoSys, SOCRATES, 3D HERO, growmeup, ENRICH me, SACRO		4Robots, SIMBIOTS, Factory in a Day	COVER, INBOTS, SIC, ROSin

Horizon 2020 ICT-2018-20

January 2021 — **December 2024**

2021 2022 2023 2024

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).

Farming robot + Logistics robot + farmworkers

- Real-world validation of two economically relevant agronomic operations within a table-grape vineyard: **harvesting and pruning.**

Partners

Horizon 2020 ICT-2018-20

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

Horizon 2020 ICT-2018-20

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

Horizon 2020 ICT-2018-20

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?

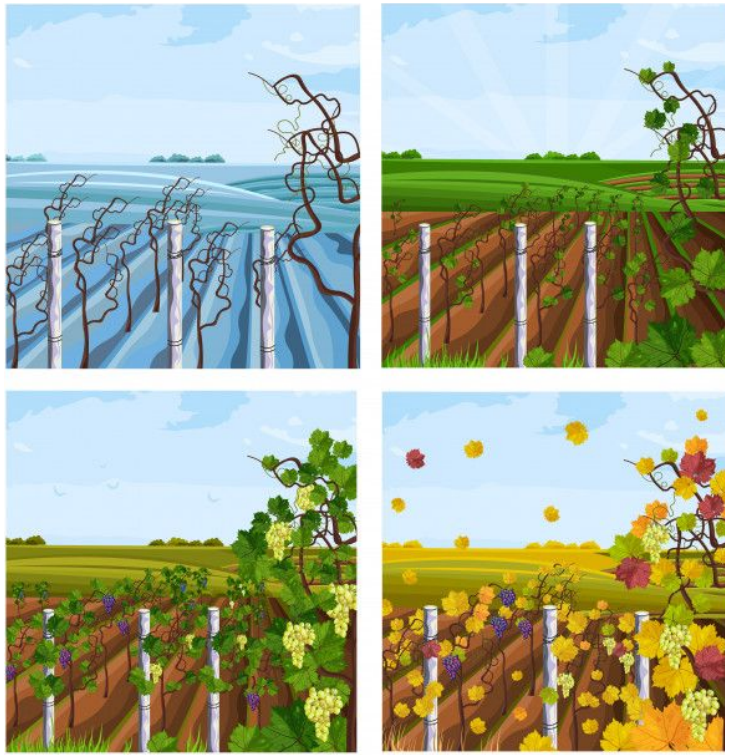
- Flat terrain with some stones and tractor lines
- Typical environment (dust and water)

  + 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

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

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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.**

Teamwork makes the dreamwork

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Thank you

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