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What is smart (sustainable) farming?

Remote sensing
Sensors in smart farming

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What is smart (sustainable) farming?

Introduction to smart farming techniques, circularity, and best practices

Remote sensing

Lecture on how farmers or ranchers observe their fields or pastures to assess their condition without physically touching them?

Sensors in smart farming

The role of real-time sensing data to assist farmers in monitoring and optimizing crops and adapting to environmental changes

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PrunusBOT

PDR 2020 PROGRAMA DE DESENVOLVIMENTO RURAL 2014-2020

PORTUGAL 2020

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A Europa Investe nas Zonas Rurais

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PrunusBOT

Multitask robotic rover for agricultural activities (R2A2)

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EIT Summer School
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Framework

- **Project:** PrunusBOT

- **Partners:**

Valério & Silva

Gonçalo Batista

- **Funding: EAFRD and EU under the Portugal 2020 program.**

Introduction

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- **Trends of evolution of agriculture towards mechanization due:**
  - Increase of world population –> Requires more food production,
  - Lack of human resources for labor in rural areas,
  - Cultures stressed by climate changes,
  - Environmental concerns related with sustainability and food waste

- **Step-by-step evolution:**
  - New agricultural management techniques,
  - Control systems (irrigation, dosing systems for fertilizer and pesticides),
  - Mechanization,
  - Precision agriculture (Agriculture 4.0)

Introduction

- **Rising of Agricultural robotics**
  - Harvesting robots
  - Monitoring robots
  - Load (transport) robots
  - Weed control robots
  - Robotic tractors

- **Tasks**
  - Automation of repetitive and difficult tasks,
  - Activities that endanger human life.

Introduction

- **Obstacles - High complexity due to variability of:**
  - Extrinsic conditions
    - Environmental conditions:
      - Different soil conditions
      - Different light conditions (sunny, cloudy, raining,…)
  - Intrinsic conditions:
    - Crop growth (tree, branches, leaves, fruits…),
    - Heterogeneity of color, shape, size…

Introduction

- **Agriculture 4.0 and Robotics are now intimally related:**
  - Hardware (locomotion platform, sensing, comms), software, and services.
- **This approach provides access to real-time data on:**
  - crop and soil conditions,
  - Environment conditions (weather forecasts),
  - Labor costs,
  - Equipment availability.
- **Predictive analytics software uses data to provide guidance:**
  - crop rotation,
  - optimal planting times and harvest times

State of the Art

- **Weed control**
  - Majority of devices use:
    - Computer vision to detect weed,
    - LiDAR for autonomous driving,
    - Robotic arms to position the spray nozzle,
    - Solar panel for extending the autonomy.

(a) Precision spraying robot ARA (Ecobotix 2019).

(b) Precision spraying robot Ladybird (Sukkarieh 2016).

(c) AgBot II for weed control (McCool 2018).

State of the Art

- **Strawberry**
  - Different robotic arm configurations for strawberries' harvesting,
  - Fruit detected using visible spectrum cameras.

(a) Rubion harvesting robot (De Preter 2018).

(b) Robotic structure - Agrobot strawberry harvesting robot (Agrobot 2019).

State of the Art

- **Tomato**
  - Most systems work in greenhouses.
  - Use 3D vision and algorithms to identify, locate and evaluate ripening state.

(a) Robot GRoW (2019).

(b) Virgo - tomatoes harvesting (Root AI 2019).

State of the Art

- **Pepper**
  - Approaches using collaborative robotic arm have been applied (> DoF)
  - Cameras used detect peppers.
  - Gripper with support used to harvest the fruit.

(a) Robot Sweeper (2019).

(b) Harvey (Lehnert et al. 2017).

State of the Art

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- **Apple**
  - Like in soft fruits, several complex technical problems must be solved:
    - Visually identifying fruits to be harvested,
    - Vacuum gripper used to harvest the fruit,
    - Safe navigation in the orchard.

a) Abundant robotics (Abundant robotics 2019).

(b) Harvest robot (FFRobotics 2019).

State of the Art

- **Kiwi**
  - Harvesting and detecting are challenging, as kiwi crops are ”tendons”.
  - Robots must move under the fruits to catch.
  - Detection is equally difficult due to leaf density (covering effect) with poor light conditions.

(RoboticsPlus 2019)

State of the Art

- **Other applications could be described:**
  - Orange
  - Transport
  - Multitask
  - …

(a) Energid –orange- harvest robot (Energid 2019).

b) Modular robotic system for different agricultural tasks (Grimstad and From 2017).

R2A2

- **Based on the State of the Art, a multitask ROBOTIC ROVER for AGRICULTURAL ACTIVITIES (R2A2) was designed for peach orchard (project PrunusBot).**
  - Autonomous robotic to perform particular and controlled spraying reducing the amount of herbicide.
  - Predict fruit production.
  - Pick up fallen peaches in the orchard at the end of season (reduce plagues and labor costs of manual removal).

R2A2

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Technical specifications

- Ability to move autonomously in the orchard;
- Able to move around under the canopy (robot height < 60cm).
- Perform tasks near the tree trunk without passing between two trees, only being able to move in the corridor between the tree lines.
- Overcome slopes up to 20º.

Robot specifications	Value
Weight	Approx. 90 kg
Payload	15 kg
Max. speed	5 km/h
Acceleration	1 m/s2
Length	120 cm
Width	105 cm
Height	50 cm

R2A2

- **Structure:**
  - T-slotted aluminum profile (resistant and light structure.
- **Locomotion:**
  - 4-wheel drive (25 Nm stepper motors)
- **Batteries:**
  - 12 V gel batteries (1.3 kWh): 4h autonomy.
- **Positioning system:**
  - Spray nozzle and gripper in cart. robotic arm (5 axes), w/ 120cm extension
- **Sensors:**
  - Two cameras, (1) weeds and peaches detection, (2) aid navigation combined with a GPS antenna and a LIDAR.

R2A2

- **Technical characteristics**

(R2A2): 1) Herbicide reservoir. 2) Computer vision system. 3) Cartesian robotic manipulator with spray nozzle. 4) Control system.

Test fields

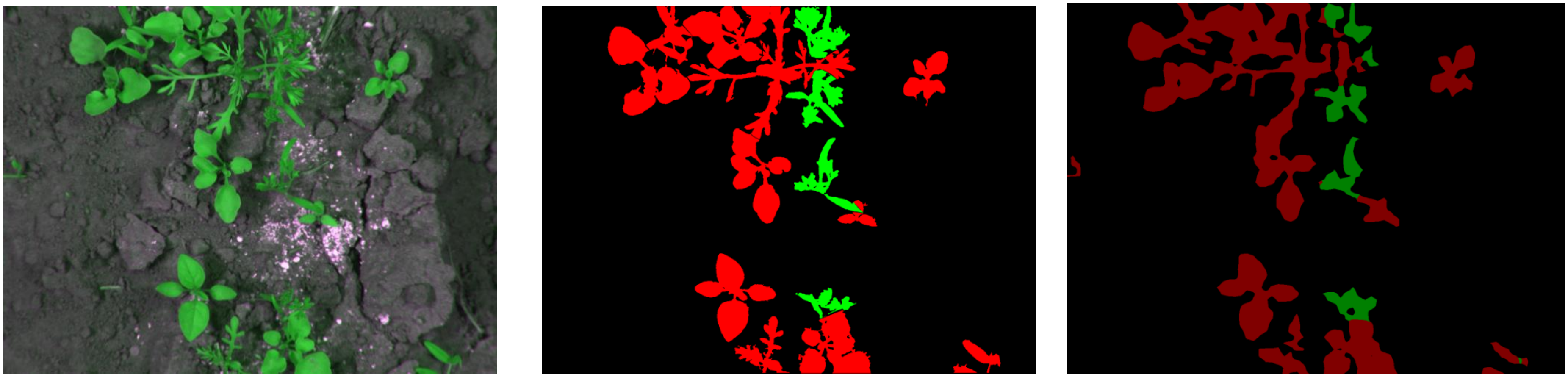
- Autonomous locomotion (CNN for trunk detection)

Test fields

- **Fruit counting (CCN model)**

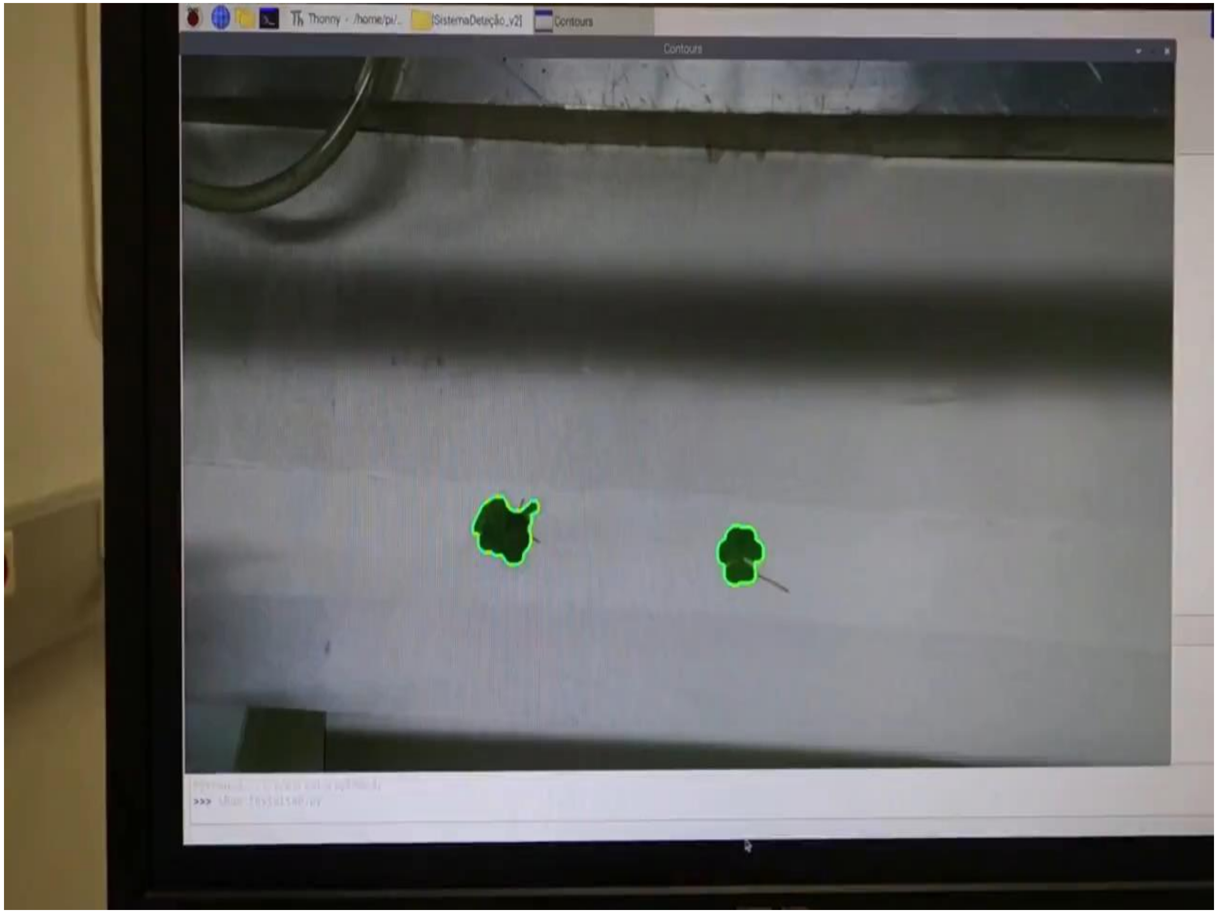
Test fields

- **Weed classification**
  - CNN model
  - Result: 0.96 (F1-score)



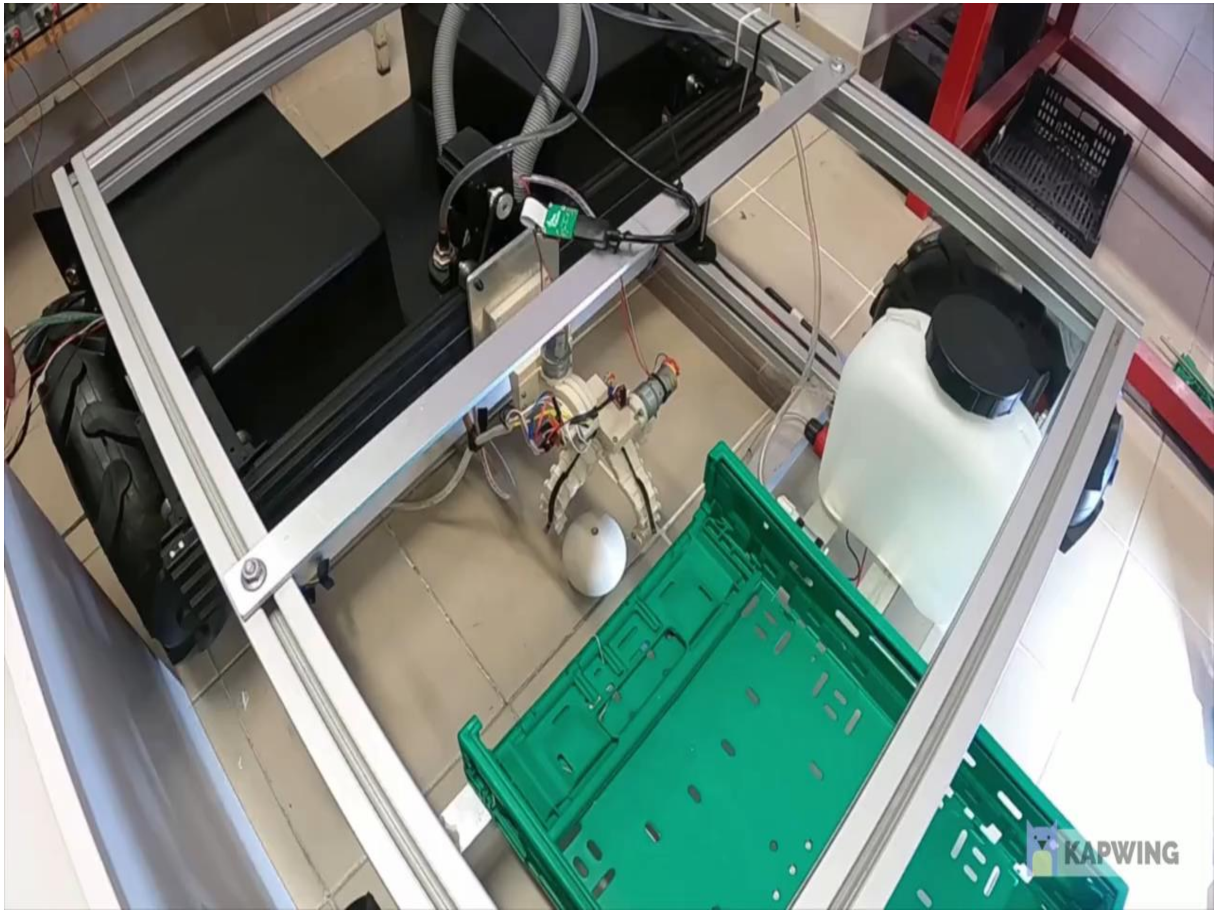
Test fields

- **Spraying tests (lab)**



Test fields

- **Picking fruits (lab simulation)**

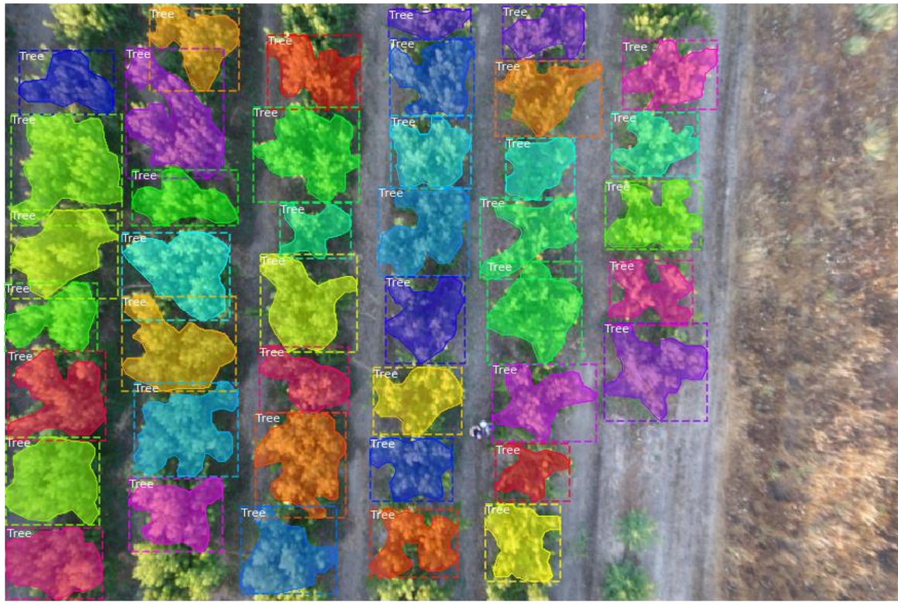


Test fields

- **Canopy area prediction to production prediction (CNN model)**

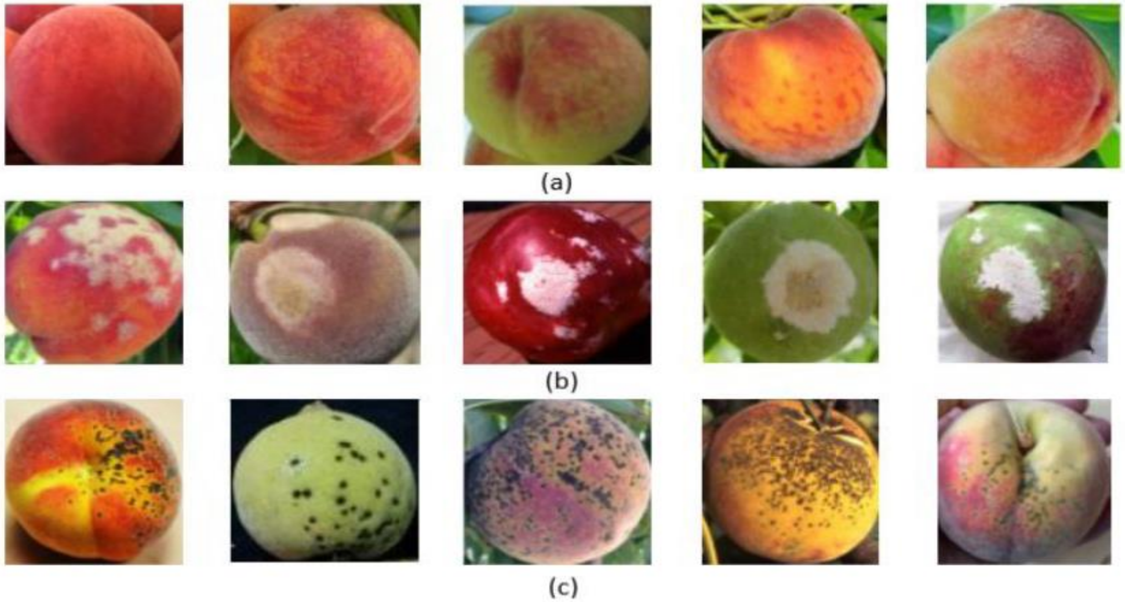
Input image

Tree segmentation



Test fields

- **Diseases prediction**
  - CNN model
  - Result: 0.96 (F1-score)
  - Mildew, Scab, and rot



Conclusions

- The development of agricultural robots can effectively help to perform some repetitive or life-threatening field tasks.

- Increasing speed and accuracy of robot detection for agricultural applications are the main difficulties.

- Modifying the cultivation and planting systems of the various crops so that robots can be introduced into these cultures.

Conclusions

- **Based on the State of the Art, a robotic platform to operate in peach orchards was proposed.**

- **The laboratory and field tests are very promising.**

- **The R2A2 will continue to be developed to:**
  - Increase detection accuracy (weed and peach)
  - Improve spraying actuation
  - Improve picking up capabilities
  - Optimize navigation

Acknowlegments

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Thanks for your attention,

Questions?