PANTHEON
Precision Farming of Hazelnut Orchards
Project ID: 774571
Modern Hazelnut Farming (MHF)

- **Well-structured orchards** with a regular planting pattern
- **Regular layout** allows the **mechanization** of many field operations
- Typical Operations in MHF:
  - Irrigation
  - Pruning
  - Pest and Disease Control
  - Production Estimation

Hazelnut Harvesting Process
(Source: FERRERO)

May 13°, 2018
MHF – Observations

• In current best practice decisions are made by
  1. Dividing the large-scale orchards in sectors
  2. Observing few representative plants per sector
  3. Performing homogeneous treatments per sector

• This may result in
  1. Product waste (economic loss)
  2. Avoidable pollution (environmental damage)
PANTHEON Ambition

• To Introduce a **new paradigm** for the management of **large-scale** hazelnut orchards

• To achieve the **resolution of a single plant** in terms of
  1. collecting information
  2. performing (some) farming operations

Large Hazelnut Orchard with a 5 x 3 planting pattern
(Source: FERRERO)
Continuous monitoring will enable a prompt detection of per-plant limiting factors and trigger focused (automatic) interventions.

1. **Increase of Production** by improving the general phytosanitary state of the orchard

2. **Environmental-Friendly Management** by
   1. Reducing waste of water
   2. Decreasing the need of chemical inputs

3. **Reduction of Human Burden** by the automatization on large scale of tedious and repetitive operations
Approach: An Agricultural SCADA

- Unmanned aerial and ground robots move within an orchard to
  - collect data
  - perform farming operations
- An IoT-based agro-meteorological network for environmental monitoring
- A central operative unit integrates the collected data to
  - perform automatic feedback actions (e.g. regulate the irrigation system)
  - support the decisions of the agronomists

Agricultural SCADA Concept
(Source: ULB)

May 13°, 2018
Workshop on Small UAVs for Precision Agriculture, Monte Roberto, Italy – Andrea Gasparri
PANTHEON – A pragmatic approach

- Objectives identified **in collaboration** with agronomists of FERRERO

- We focus (only) on:
  1. Phytosanitary status estimation
  2. Automatic irrigation regulation
  3. Automatic suckers’ treatment
  4. Improvement of pruning practices
  5. Automatic estimation of the production

Hazelnuts at different ripe stage
(Source: UNITUS)

May 13th, 2018
Workshop on Small UAVs for Precision Agriculture, Monte Roberto, Italy – Andrea Gasparri
UAV Main Activities

- **Data Collection** for Agronomical Indicators:
  1. Water Stress
  2. Pest and Disease Detection
  3. Fruit Detection
- Typical approaches are based on **Orthomosaic Techniques**
Orthomosaic Techniques

**Measuring process:**
- Cover the area of interest using a lawnmower pattern
- Ensure overlap between pictures and in between bands

**Validation process:**
1. Pictures correction
2. Band creation through matching
3. Bands alignment and orthomosaic
Orthomosaic Techniques

**Orthomosaic characteristics:**

- Overlap > 80%
- Higher altitude  worst resolution
- Does not exploit localization accuracy
- The coverage time highly depends on the amount of turns (bands)
UAV Aircraft Model

DJI Matrice 600 Pro

• **Design**: Six-rotor flying platform

• **Applications**: Professional aerial photography and industrial applications

• **Main Features**:
  • RTK Localization Accuracy (~cm)
  • Triple IMU Accuracy for Flight Control
UAV: Architecture

Ground computer
(Trajectory Planning, Ros Enabled)

Radio Communication

On-board computer
(Trajectory Execution, Sensor Triggering, Data Collection)

Multispectral camera

Thermal camera

RGB camera

On-board computer
(Trajectory Execution, Sensor Triggering, Data Collection)
Multispectral camera

- **Model:** Tetracam MCAW 6
- **Features:** Multi-spectral information on a pixel-by-pixel basis
- **Application:** Compute *vegetation spectral features* to measure the photosynthesis activity of leaves such as *production capability*
Thermal camera

• **Model**: Teax ThermalCapture 2.0 640
• **Features**: Fully radiometric per pixel temperature data
• **Application**: Measurement of the *leaf temperature* to detect possible *water stress*.
RGB camera

- **Model**: Sony α5100
- **Features**: 24.3 megapixel APS-C CMOS sensor
- **Application**: Detect the main features of areas of interest such as *tree precise location* and macro-management.
Bulding an Orthomosaic In Our Setting

Setting Constraints:
• High resolution required (~2.5cm/pixel)
• Different FOVs (Field of view)
• Low resolution thermal camera

Outcome:
• 3 different orthomosaics
Building an Orthomosaic In Our Setting

A **classical approach** implies altitude of less than 50 m to reach the demanded constraints:

To map 10 hectares:

- >2500 pictures = **High amount of data**
- **Unnecessary resolution** and pictures for RGB camera
- **Excessive time** (>1.5 hours)
- Several flights required ( >6 flights)

**Necessity of new techniques**
A change of Perspective

Observations:
• UAV High Localization Accuracy
• Regular disposition of the trees
• Presence of non-interesting areas

Objective:
• Reduce Coverage Time
• Reduce Amount Data

Hazelnut plantation (Source: UNITUS)
Research Challenges

UAV High Localization Accuracy

Idea: *Reduce the picture overlap.*

Advantages:

- *Reduced coverage time* by minimizing the number of bands;
- *Reduced amount of data* by avoid oversampling (up to 16 times with 80% overlap, 4 bands)
Research Challenges

Idea: Adaptive measurement strategies focused only on points of interests (trees).

• Varying accuracy w.r.t. areas of interest;
• No necessity of matching bands.

Advantages:

• Reduced coverage time by avoiding non-essential bands;
• Reduced amount of data by only covering the necessary areas.
Research Challenges

Idea: Information-based Adaptive UAV trajectory planning using different altitude flights.

• First high altitude flight for anomalies detection only.
• Second less altitude flight at reduced speed to inspect specific areas of interest.

Advantages:

• Reduced coverage time by increasing altitude (=less bands);
• Reduced amount of data by changing spatial resolution of the acquisition.
Thanks for your attention! ;-)

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