FruitFlyNet II

FruitFlyNet-ii

Commercialisation of an Automated Monitoring and Control System against the Olive and Med Fruit Flies of the Mediterranean Region

Training Seminar

OliveFlyNet: Introduction to LAS e-services

by

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Athens, Greece, June 17th, 2022

1

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2

FruitFlyNet-ii: Project Overview

1. **Beneficiary:**
AUA: Agricultural University of Athens, Department of Agricultural Economy and Rural Development, Informatics Laboratory, 75 Iera Odos, Athens 11855, Hellenic Republic, Attika region, EU.
2. **Partnership:**
   - PP01/UCO: University of Cordoba (Spain, Andalusia, EUMC).
   - PP02/UNIMOL: University of Molise (Italy, Lazio, EUMC).
   - PP03/LARI: Lebanese Agricultural Research Institute (Lebanon, MPC).
   - PP04/IO: Institut de l'Olivier (Sfax, Tunisie, MPC)
   - PP05/RCCHAB: Centre Régional des Recherches en Horticulture et Agriculture Biologique (Sousse, Tunisie, MPC)

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Contents

1. Location Aware System (LAS): The concept

IPM principle: Monitoring
- Field observations.
- Scientifically sound warnings.
- Forecasting and early diagnosis systems.
- Advices from professionally qualified personnel (IoT/agricultural advisors).

IPM principle: Decision Making
- Decision as to where, when and how must apply plant protection measures.
- Robust and scientifically sound threshold values are essential components for decision-making.

How the idea of LAS came from?

Intuition-1: Develop e-trap devices for semi-automated or automated monitoring system of insect pests.

Cloud – Edge
Data analysis
Pest detection
Pest count
Spatial interpolation tools for e-services

Intuition-2: Develop geospatial tools for orthological spraying applications.

According to IPM, a decision algorithm should be developed to provide information on the:
- **Time (when),**
- **Space - Location (where)**
- **Best practices (how)**

for bait spraying application

IPM Principles: Intervention
Decision module for spraying operations

Develop smart (IoT) farm devices to significantly reduce the use of pesticides

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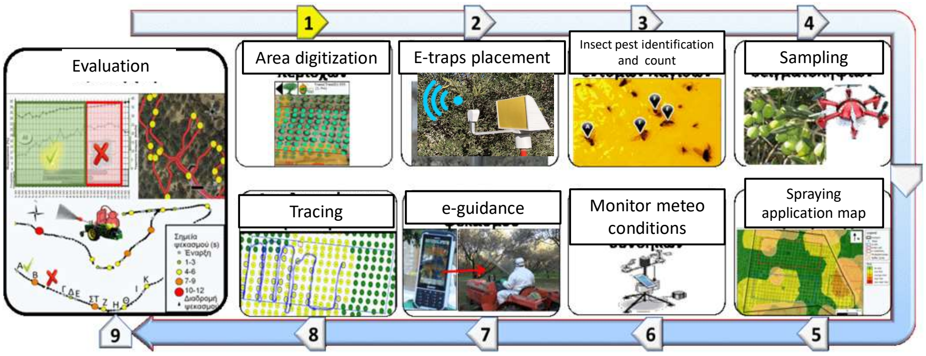
5

1. LAS: The Concept

Towards a solution



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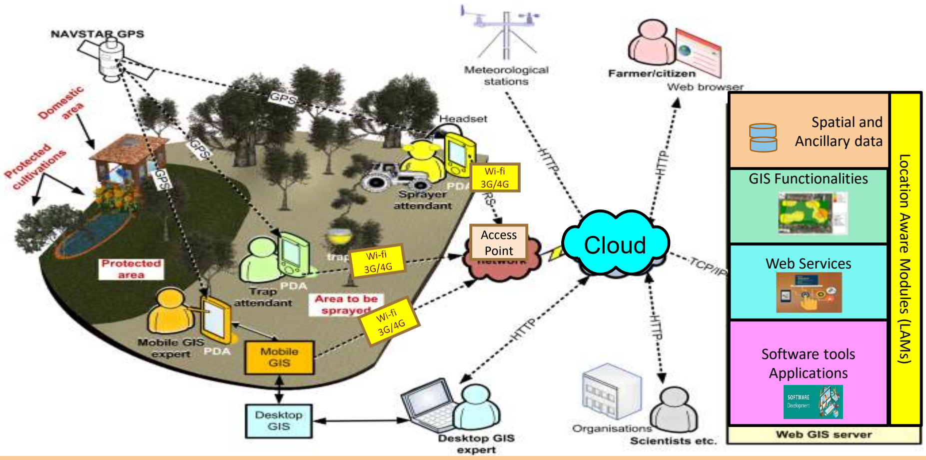
6

1. LAS: The Concept

Towards a solution



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7

1. LAS: The Concept

Towards a solution

- **e-trap development**: Each e-trap is equipped with a micro-processor, an image, and a temperature/humidity sensors, a battery, a solar panel, a 3G/4G USB stick and other electronics.
- **e-trap network establishment and operation**: Placement and operation of the e-traps in a form of Wireless Sensors Network (WSN), using Wi-Fi/3G/4G Communication protocols to transfer data (images and meteo data) from the site to the edge/cloud for processing.
- **Field Digitization**: Build a geo-referenced database (geodatabase) to store field data.
- **Pest Monitoring**: e-traps collect and transmit the field data (images and meteo data) to the edge/cloud and/or to a remote server.
  - **Semi-automatic system**: Field images are accessible online, by an expert for visual inspection and pest identification and count, to feed the geodatabase with the key-pest flies' information.
  - **Automated system**: Various approaches have been used so far with image-based techniques (machine learning, deep learning, and image processing) to be the dominating ones over spectroscopy and optoacoustic techniques.
- **Infestation Risk**: A decision support module provides decision-making spraying information.
  - Spatial interpolation tools are used to create scale-spraying risk maps.
- **Microclimatic Monitoring**: Microclimatic data (temp/humidity) and wind direction during spraying applications.
- **Monitoring spraying applications**: Recording system to trace the spraying path
- **e-guidance:** Real-time e-guidance spraying applications system.
- Mobile GIS tool integrates the various decision support modules

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8

2. LAS: Classification of the e-services

a. Group 1: User profile management and information.
b. Group 2: Area digitization and geospatial data collection.
c. Group 3: e-monitor of the micro-climatic parameters.
d. Group 4: Pest identification of the trapped insects and counting.
e. Group 5: Production of risk maps (Infestation Risk).
f. Group 6: Provision of spraying guidance and traceability.

- G1 provides the communication interface between the end users with the LAS e-services (G2-G5)

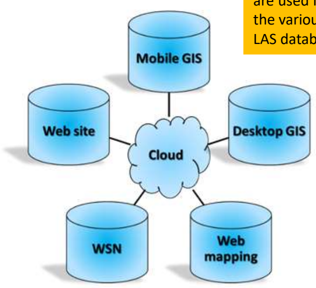
2. LAS: Classification of the e-services

Classification criteria by:

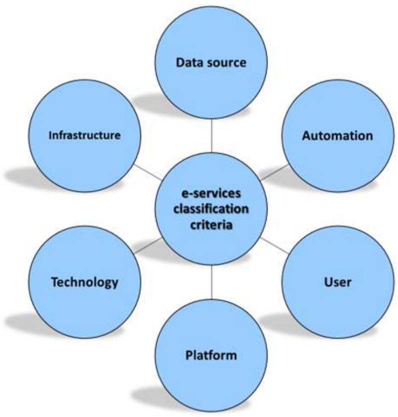
a. Data sources

Vector, Raster, Databases, Platforms, e-services, Users, Infrastructure.

Smart devices and software tools that exist in the cloud are used for synchronizing the various components of LAS database.



Components of the LAS database



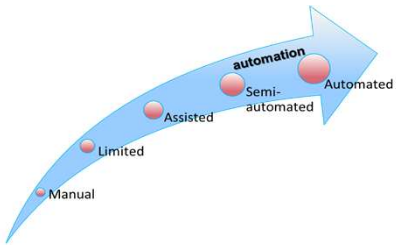
Data sources

2. LAS: Classification of the e-services

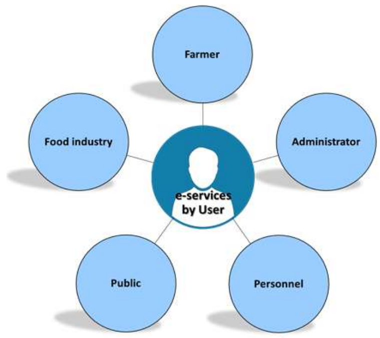
Classification criteria by:

b. Scale of automation.
   Manual, Limited, Assisted, Semi-automatic, Assisted, Automatic
c. Type of users.
   Administrators, Farmers, Personnel, Public, Food Industry
d. Running platform.
   .Net framework
   Android.

Scale of automation



Type of users

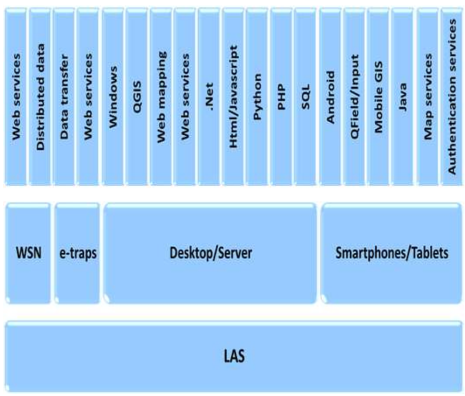


11

2. LAS: Classification of the e-services

Classification Criteria by:

e. Technology.
   The creation and the operation of the e-services of the LAS require:
   - e-trap developments.
   - GPS devices.
   - Smartphones or tablets.
   - Web services developments.



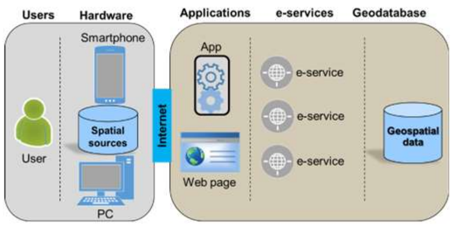
12

2. LAS: Classification of the e-services

Classification criteria by:

f. Infrastructure.
- The LAS e-services are web services which are using SOAP (Simple Object Access Protocol) or REST (Representational State Transfer) protocols running on local devices through standalone applications.
- The end-user is using a smartphone or a laptop/desktop, to access through Internet the applications and the web pages of the LAS.
- The applications and the web pages use the e-services to perform specific tasks and activities.
- The e-services retrieve data from the geodatabase and store the spatial data in it.
- Security and privacy, such as authentication is ensured by entering the user credentials.

General architecture



e-services communicate with each other by passing data or combine and collaborate to accomplish a common task.

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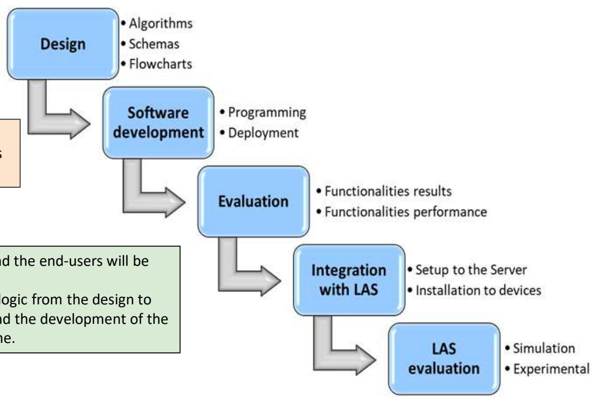
13

3. LAS: Implementation phases of the e-services

Already done in the previous and in the current program.
OliveFlyNet and *MedFlyNet* are using different algorithms mainly because of the different cultivations and pests considered.

The e-services can run as web services or as offline applications. At this phase, the e-services are stand-alone.

- The e-services are integrated with the LAS and the end-users will be able to use the tools developed.
- *OliveFlyNet* and *MedFlyNet* follow the same logic from the design to the complete implementation, the design, and the development of the two sets of e-services are not always the same.



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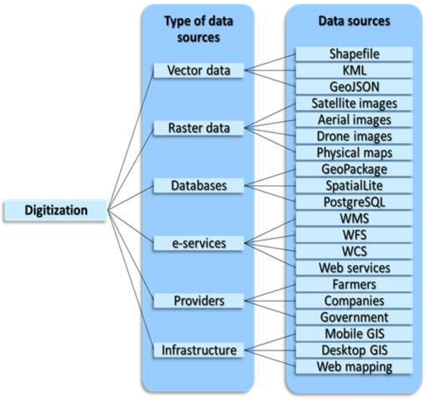
14

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization of the orchards/groves is an essential procedure for the pest monitoring and management.
  - The digitization process involves many complex and time-consuming sub-tasks or steps.
  - selection of the right spatial sources
    - ✓ background maps.
    - ✓ auxiliary GIS data of the area that will be digitized.
  - Digitized data sources are available for urban areas.
  - Limited digitized data are available for the non-urban areas and specifically for orchards and olive groves.
  - Selection of the most suitable sources of spatial data include:
    - ✓ the gathering of the most necessary data.
    - ✓ the cost of the selecting data.
    - ✓ the accuracy of this data.

Spatial data sources used for the digitization of orchards or groves that are compatible with development of the LAS e-services

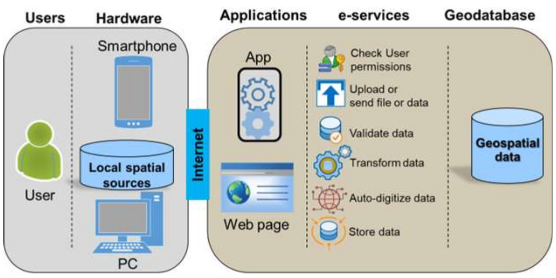


15

4a. LAS: Characteristics of e-services

Digitization of the LAS e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization of the LAS e-services include
    - ✓ User authentication
    - ✓ Procedures for spatial data upload
    - ✓ Validation of the uploaded data
    - ✓ Transformation of the spatial data
    - ✓ Automation of the digitization process
    - ✓ Store of the spatial data.



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16

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitizing methods of the LAS e-services

Digitization: objects	Digitization: methods
Orchards	Manual
Trees	Assisted
Traps	Semi-automatic
Sensors	Automatic
Protected areas	
Buffer zones	

e-services to facilitate farmers

County Month, Year

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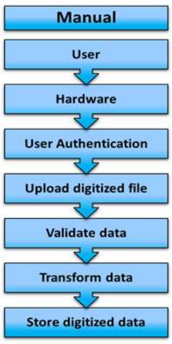
17

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed **manually.**



- The end-user uses a smartphone, or a laptop/desktop to:
  - ✓ Connect the LAS.
  - ✓ Upload the digitized data files of the orchards/olive groves.
- The e-services
  - ✓ Validate the uploaded data.
  - ✓ Transform data to spatial data.
  - ✓ Store spatial data in the LAS geodatabase.
    - ➢ The end-user has already digitized the orchards/groves before upload the data.
    - ➢ The digitized data has been created using external tools and not the LAS e-service.

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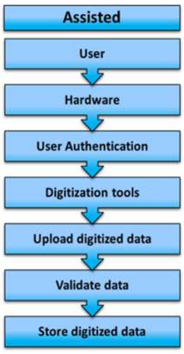
18

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed as **assisted**



- The end-user uses digitization tools installed in a smartphone or a laptop/desktop to:
  - ✓ Create the spatial data.
  - ✓ Connect the LAS.
  - ✓ Upload the digitized data of the orchards/olive groves.
- The e-services
  - ✓ Validate the uploaded spatial data.
  - ✓ Store the spatial data in the LAS geodatabase.
- The uploaded digitized data has the required format – data transformation is not needed.

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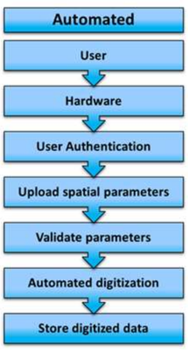
19

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed **automatically.**



- The end-user uses digitization tools installed in a smartphone or a laptop/desktop to:
  - ✓ Connect the LAS and
  - ✓ Enter the parameters needed to assign the area that must be the digitized.
- The parameters provide the following spatial information
  - ✓ Location.
  - ✓ Borders.
  - ✓ Extend of the orchards/olive groves.
- The e-services
  - ✓ Digitize automatically the assigned area.
  - ✓ Store the digitized data of the LAS geodatabase.
- No validation is needed (data geometry).
- Digitization process errors may occur.
- The accuracy of the created vector data is depended mainly on the initial raster data of the background of the orchards or the olive groves.

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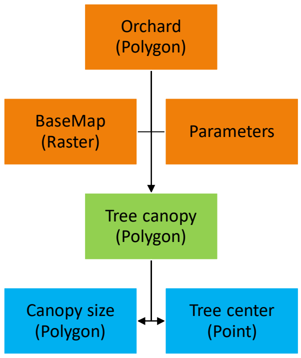
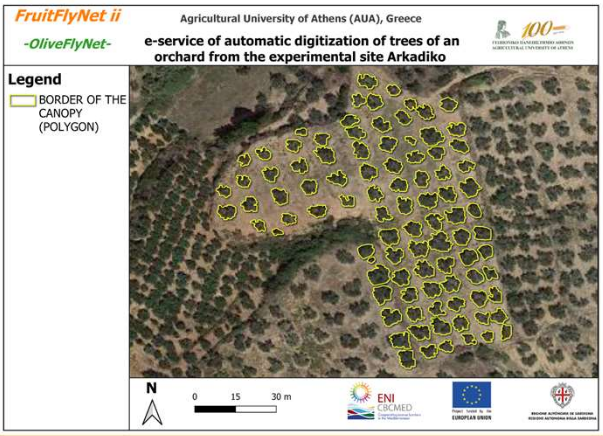
20

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed **automatically.**





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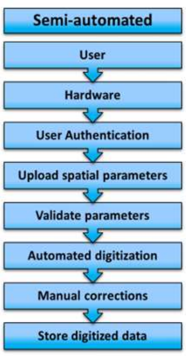
21

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed **Semi-automatically**



- The end-user uses digitization tools installed to a smartphone or a laptop/desktop to:
  - ✓ Connect the LAS
  - ✓ Enter the parameters needed to assign the area that must be the digitized.
- The parameters include spatial information such as
  - ✓ Location.
  - ✓ Borders.
  - ✓ Extend of the orchards/olive groves.
- The e-service
  - ✓ Digitizes automatically the assigned area.
- Correct manually (in some cases it is time consuming and costly) the digitized spatial data of the LAS geodatabase.
- Store the digitized spatial data of the LAS geodatabase.
- No validation is needed.
- Digitization processing errors still occur.
- Increase the accuracy of the created vector data is depended mainly on the initial raster data of the background of the orchards/olive groves.

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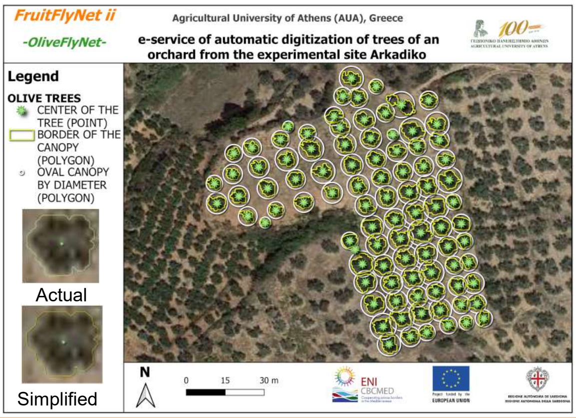
22

4a. LAS: Characteristics of e-services

- Group 2: Area digitization and geospatial data collection.
  - The digitization process of the LAS e-services can be performed either **semi-automatically** or **automatically**.

The algorithm

Input:
Raster images (maps) with true color
Output:
Polygons of the trees canopy.
Process:
1. Simplify the polygons' borders.
2. Obtain the centroid points, which show the position of the trees. The trees can be presented in the map either as polygons, or as oval polygons, or as simple points.
3. Calculate the diameter of the tree canopy from the length of the polygon or from its extent.

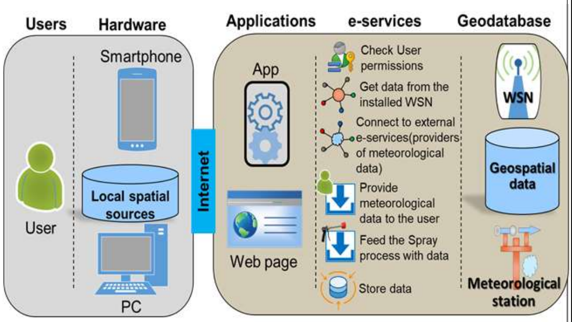


23

4b. LAS: Characteristics of e-services

- Group 3: e-monitor the micro-climatic parameters.

- Micro-climate monitoring LAS e-services include:
  - ✓ User authentication.
  - ✓ Connection with meteo-data providers.
  - ✓ Connection with an established WSN meteo-station in the field.
  - ✓ Upload meteo-data.
  - ✓ Validate the uploaded meteo-data.
  - ✓ Feed the spraying process with the meteo-data.
  - ✓ Store the meteo-data.

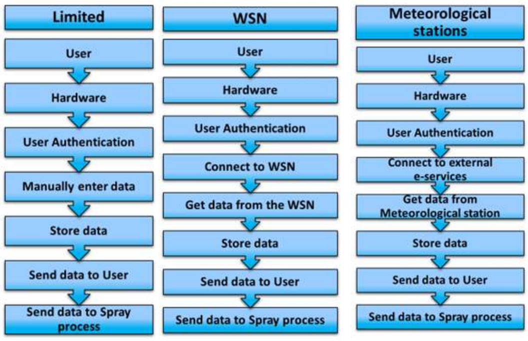


24

4b. LAS: Characteristics of e-services

- Group 3: e-monitor the micro-climatic parameters.

- Limited micro-climate monitoring
  - ✓ Meteo-data are collected from a meteo-station located in the wider area of the orchard/olive grove.
  - ✓ The end-user uses a smartphone/ laptop to:
    - Connect the LAS
    - Enter the parameters needed to assign the area that must be the digitized.
  - ✓ Manually upload the meteo-data collected from the external source.
  - ✓ The e-services
    - Validate the uploaded spatial data.
    - Store the uploaded spatial data.
    - Send the data to the end-user during spraying.



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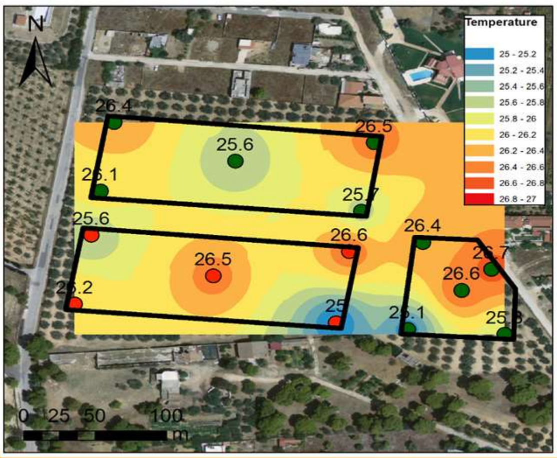
25

4b. LAS: Characteristics of e-services

- Group 3: e-monitor the micro-climatic parameters.

- e-services for:
  - gathering the meteo-data from:
    - ✓ Sensors (temperature, relative humidity, wind speed, etc.).
    - ✓ Meteo-stations.
- store the values of the meteorological parameters to:
  - the server.
  - the cloud.
  - feed a specific DSS of the LAS to perform a particular task.
- Example: Some tasks may:
  - cancel a spray application due the high temperatures.
  - create micro-climate maps, using interpolation.



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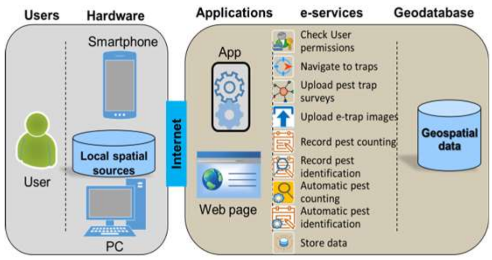
26

4c. LAS: Characteristics of e-services

- Group 4: Pests' identification and counting of the trapped insects.



- Pests' monitoring LAS e-services include:
  - ✓ User authentication.
  - ✓ In field e-trap navigation.
  - ✓ Upload e-trap images with captured insects.
  - ✓ Record pest identification pest counting and records.
  - ✓ Upload the data of the automatic pest counting and the automatic pest identification results.
  - ✓ Data storage.

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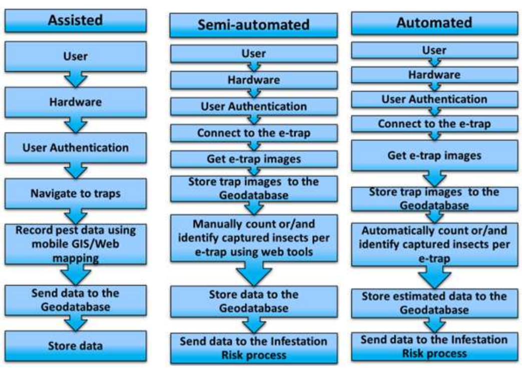
27

4c. LAS: Characteristics of e-services

- Group 4: Pests' identification and counting of the trapped insects.

LAS e-services: Pests' monitoring

- ✓ The end-user uses a smartphone/ laptop to:
  - Connect the LAS.
  - Enter the parameters needed to assign the area that must be the digitized.
- ✓ Assisted.
  - LAS navigate the end-user to each e-trap.
  - The end-user manually records and/or uploads the spatial data using mobile GIS.
- ✓ Semi-automated/automated:
  - ✓ Connect the e-trap.
  - ✓ Take the e-trap images.
  - ✓ Store the e-trap images in the database.
  - ✓ Manually counts and/or identifies the pests captured using web tools.
  - ✓ Automatically counts and/or identifies the pests captured .
  - ✓ Validate the uploaded spatial data.
  - ✓ Store the uploaded spatial data.
  - ✓ Use the data to produce the infestation risk maps.



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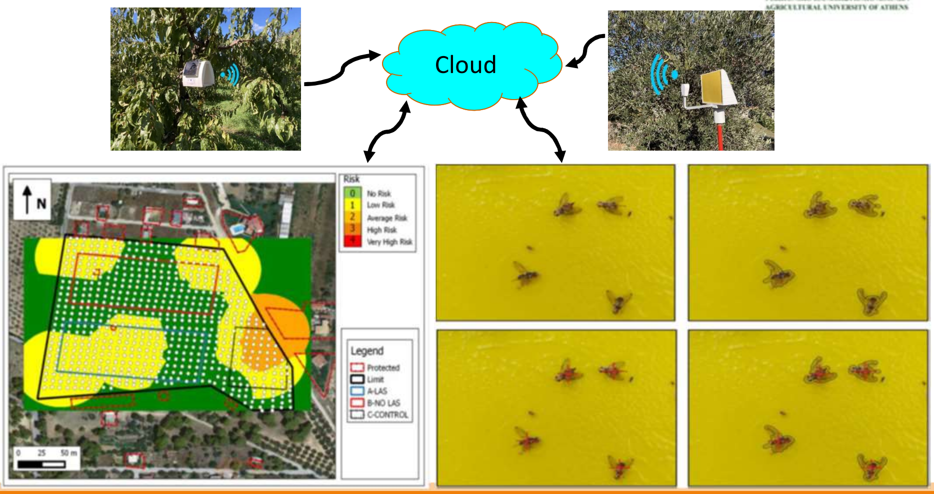
28

4c. LAS e-services : Pests' Identification and Count

- Group 4: Pests' identification and counting of the trapped insects.



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29

4c. LAS e-services: Pests' Identification and count
Mobile GIS

- Group 4: Pests' identification and counting of the trapped insects.

Layers toolbox

Trap entry form

Mobile GIS

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30

4c. LAS: Characteristics of e-services

- Group 4: Pests' identification and counting of the trapped insects .

Traps' position:
- Manual (empirical)
- Semi-automatic/Automatic
  - Randomly distributed
  - Regular(normal) grids
  - Grids of various sizes (according to the trees density)

Pests' identification and counting
- Manual (using web forms)
- Semi-automatic/Assisted (using GUI): Tools: mobile GIS, web mapping, desktop apps
- Automatic: Real-time identification and counting

31

4c. LAS e-services: e-trap position Spatial interpolation

Spatial Interpolation:

1. Interpolation predicts values for cells in a raster from a limited number of sample points.
2. It can be used to predict unknown values for any geographic point data, such as elevetion, rainfall, chemical concentrations, noise leveles, etc..
3. In all cases the attribute must be interval or ratio-scaled.
4. Interpolation cannot be done for
   - Cycled data
   - Counts and amounts
   - Nominal data
5. **Basis of spatial interpolation**: Value points close to sampled points are more likely to be similar than those that are further apart.
6. **Rational behind spatial interpolation:** Points closed together in space are more likely to have similar values than points far apart (Tobler's Law of geography).

Can interpolation be performed on the number of insect pests' catches in traps?

32

LAS e-services: e-trap position
Spatial interpolation

Spatial Interpolation:

Assumption: *Spatially distributed traps are spatially correlated*; i.e.,
the number of insect key-pests' catches in traps that are closed together in space are more likely (tend) to have similar number of insect key-pests' catches than those far apart

provided that the insect key-pests distribution remains unchanged in the study area.

–all the parameters affecting the distribution of the key-pests population remain the same.

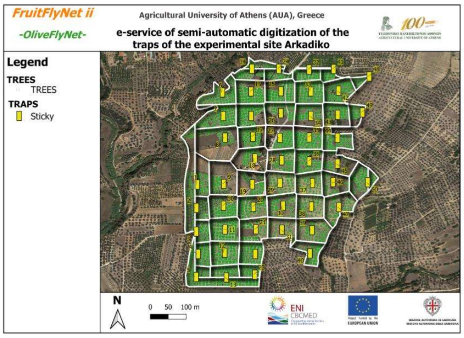
Algorithm: Semi-automatic e-service for e-trap positioning

- Define a regular grid 80m x 80m
- Locate the nodes of the grid to which the e-traps should be near by.
- For each e-trap use snapping technique to locate the nearest tree in which it must be positioned.
- At the end of the process manual modifications (move/remove some e-traps) can be made
- Use the final layer to feed the geodatabase.

33

LAS e-services: e-trap position
Spatial interpolation

Spatial Interpolation



Each trap defines an area of influence around it, called Voronoi (Thiessen) polygon, so that any location inside the polygon is closer to that trap than any of the other traps.

***OliveFlyNet*: Arcadicko case**

Voronoi polygons

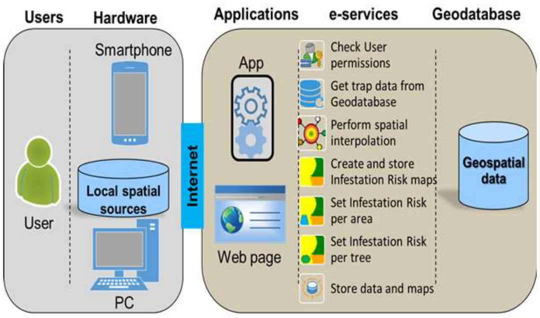
- Digitize the olive trees in the grove.
- Select the position of the e-traps in the grove.
- Construct the Voronoi polygons (white lines) based on the olive trees around each e-trap.
  - ✓ The e-traps are uniformly distributed in the olive grove.
  - ✓ The more a Voronoi polygon fits to its corresponding grid cell the smoother the distribution density of the olive trees is.
  - ✓ Each Voronoi polygon indicates its trap's influence on the distribution of olive flies' population in the respective polygon.

34

4d. LAS: Characteristics of e-services

Group 5: Production of infestation risk maps.

- Infestation risk maps of the LAS e-services include:
  - ✓ User authentication
  - ✓ Pest capture data from the geodatabase
  - ✓ Spatial analysis
  - ✓ Create pest risk maps
  - ✓ Store pest risk maps
  - ✓ Estimate infestation risk per area of the olive groves or orchards
  - ✓ Set infestation risk per tree.
  - ✓ Store the data and the maps.



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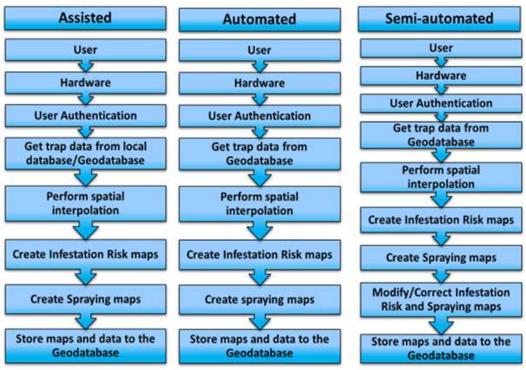
35

4d. LAS: Characteristics of e-services

- Group 5: Production of infestation risk and spraying maps.

- Infestation risk and spraying maps of the LAS e-services:
  - Assisted/Semi-automated/automated
    - ✓ The end-user uses a smartphone/ laptop to connect th LAS.
    - ✓ Get the pest data capture from the geodatabase.
    - Perform automatically (??) spatial interpolation analysis
    - Create infestation and spraying risk maps.
    - Create spraying maps using the LAS e-services.
    - Modify and/or correct the infestation risk and spraying maps.
    - Validate the spatial data and the created maps.
    - Store the data and the maps.



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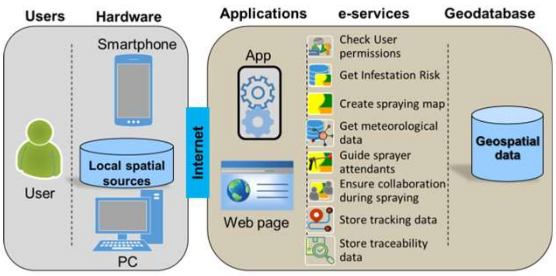
4e. LAS: Characteristics of e-services

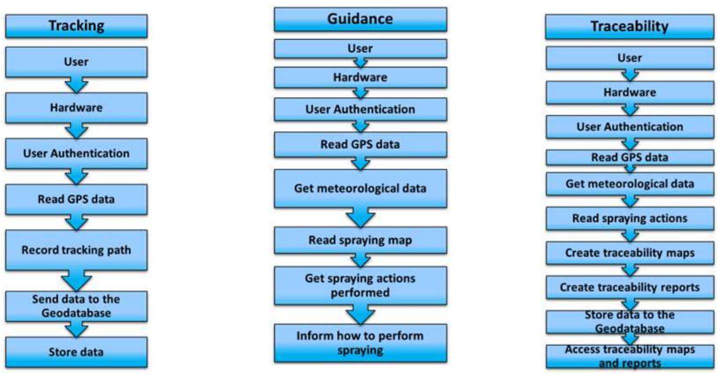
- Group 6: Provision of spraying guidance and traceability.

- Spraying process of the LAS e-services include:
  - ✓ User authentication.
  - ✓ Acquire the infestation risk maps.
  - ✓ Create the spraying maps.
  - ✓ Get the meteorological data.
  - ✓ Guide sprayer attendants.
  - ✓ Ensure collaboration of sprayers during spraying.
  - ✓ Store tracking data.
  - ✓ Store traceability data.



4e. LAS: Characteristics of e-services

- Group 6: Provision of spraying guidance and traceability.

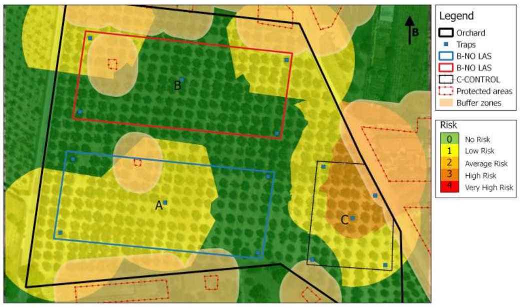


4e. LAS e-services: Infestation-scaled spraying map creation

Spatial Interpolation:

Inverse Distance Weighted (IDW) method:

- IDW is spatial, local, non-linear, deterministic, multivariate interpolation method.
- IDW uses spatial autocorrelation in its math. Closer values have more effect while farther away ones have less effect.
- IDW assigns values (no of pest catches) to unknown points (traps) calculated from a weighted average of the known sampled points (traps).



Production of risk map
- When, where to spray
- Method of interpolation (IDW, Kriging)
- Semi-automatic or automatic map production

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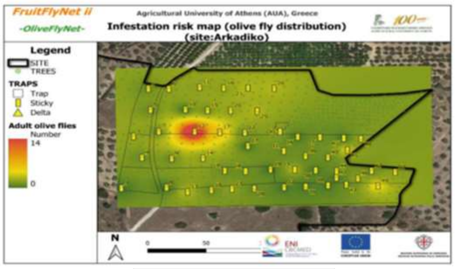
39

4e. LAS e-services: Infestation-scaled spraying map creation

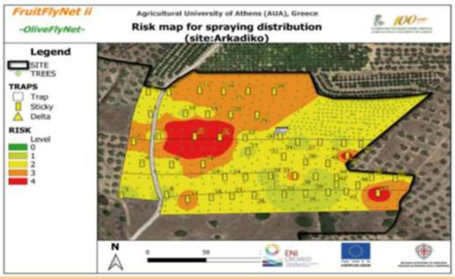
Spatial Interpolation



Infestation-scaled risk level	
0	No risk
1	Low risk
2	Average risk
3	High risk
4	Very high risk

***OliveFlyNet*: Arcadiko case**

- ✓ According to the number of flies captured a map is created showing the pest infestation risk in appropriate colors.
- ✓ The maps show the layer of borders, the traps, the major and minor hotspots, and the infestation-scaled (risk) spraying levels.



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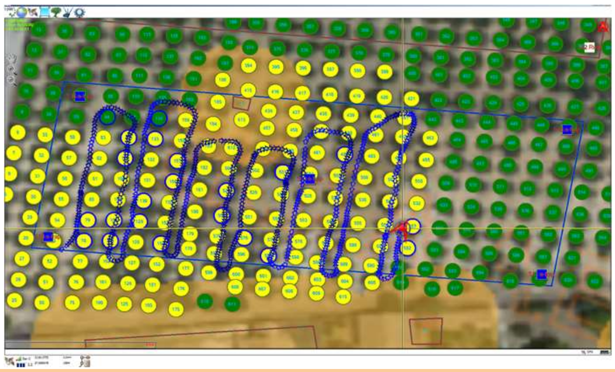
40

4e. LAS e-services: Infestation-scaled spraying map creation

- Provision of spraying guidance and traceability
  - Guidance of the tractor/sprayer
  - Tracking
  - Traceability



41

4d. LAS e-services: Spraying e-guidance and tracing

1. Spraying routes tracking
2. Spraying solution recording
3. Real-time e-guidance to help/advice spraying operators
4. Web-based monitoring and interventions of spraying authorities

42

6. Conclusions

- Dacus and Medfly are two of the most significant problems in Med Basin countries and needs urgently to be faced as it is costly in both, the environment and the production in qualitative and quotative terms.
- As the problem is spatiotemporal, IoT can significantly contribute and enhance IPM practices regarding the monitoring, decision making and control approaches of the two key areas.
  - Smart e-traps devices
  - Image identification and counting
  - Digitization and spatial interpolation
  - Decision-making, Tracing and e-guidance
- Producers facing problems with the Olive fruit fly and the Medfly need new approaches enriched with tools, like LAS to provide readability
  - In spraying applications (mostly reduction)
  - In areas to be sprayed (mostly reduction)
  - In of spraying duration (mostly reduction)
  - Off-target spraying (mostly reduction)

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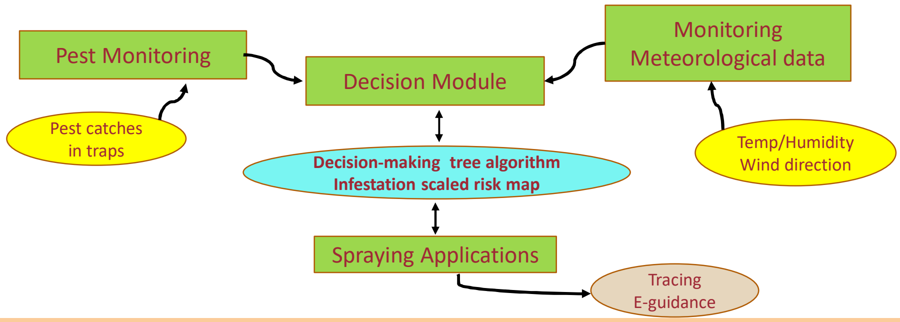
Thank you!!!

LAS: Implementation of the Decision Support module

- A decision support module is based on a decision-making algorithm which provides critical parameters affecting the bait spraying applications
  - Decision tree algorithm (when, where to spray)
  - The infestation-scaled spraying map (where to spray with what spraying intensity)



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45

LAS: Classification of e-services

	Packages				
E-services	**Basic**	**Standard**	**Balanced**	**Advanced**	**Premium**
Field digitization	Manual	Assisted	Assisted	Automated and Assisted	Semi-Automated
Micro-climate monitoring	Limited	Meteorological stations	Meteorological stations	WiFi/3G/4G	WiFi/3G/4G
Pest Monitoring	Assisted	Assisted	Assisted and Semi-automated	Automated	Semi-Automated
Infestation Risk	Assisted	Assisted	Automated risk and map creation	Automated risk and map creation	Semi-automated risk and map creation
Spraying Process	Tracking	Tracking and Guidance	Tracking and Guidance, Traceability	Tracking and Guidance, Traceability	Tracking and Guidance, Traceability

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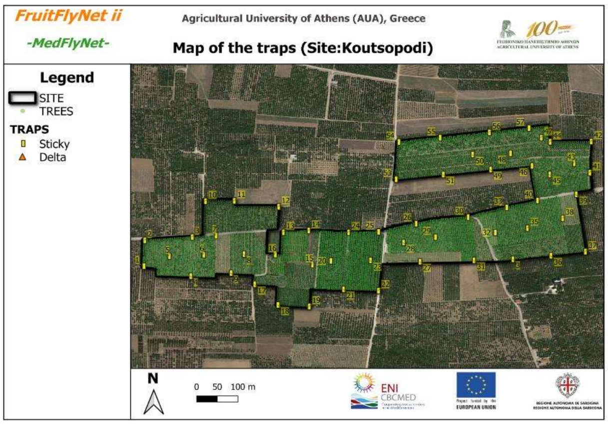
46

4a. LAS: Characteristics of e-services

Group 2: Area digitization and geospatial data collection.

- Geospatial Layers
  - Position of trees
  - Position of traps
  - Position of sensors
  - Protected areas
  - Buffer zones
  - Road Network
  - Base Maps
- Field data is stored in geo-referenced database.
- e-traps are placed in the field according to a pattern.
- e-traps collect and transmit the field data (images, meteo data) to the cloud and/or a remote server.



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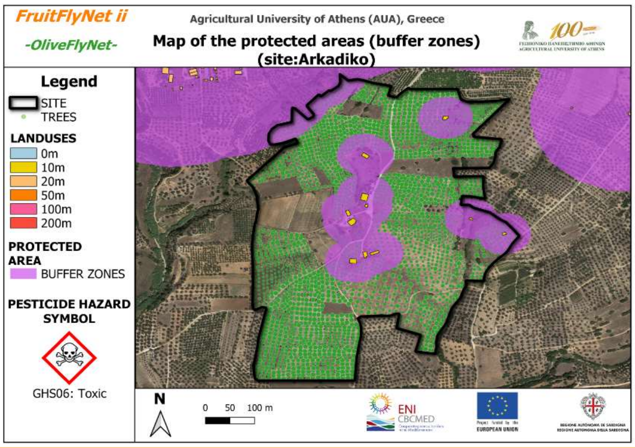
47

4a. LAS: Characteristics of e-services

Group 2: Area digitization and geospatial data collection.

- Field data is stored in geo-referenced databases.
- According to the pesticide used different protected areas and buffer zones are displayed.



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48

4c. LAS: Characteristics of e-services

Group 4: Pests' identification and counting of the trapped insects.

1. Image processing and computer vision have been applied for automatic insect identifications in:
   - ✓ *Plutella xylostella* L.(Lepidoptera: Plutellidae)
   - ✓ Queensland fruit fly *Bactrocera tryoni Froggatt* (Diptera: Tephritidae)
   - ✓ *Leptocorisa chinensis* Dallas (Hemiptera: Alydidae)
   - ✓ ***Bactrocera oleae* (Dacus), (Diptera: Tephritidae)**
   - ✓ ***Ceratitis capitata* (MedFly), Diptera: Tephritidae)**

   Procedure
   - Collect the images to be processed
   - Auto-brightness correction: Eliminate the effect of light changes:
     - Magnify the difference between the dark insect and the bright background.
     - Extract the luminance (Y channel) and estimate the backgound image by applying a median filter to the luminance image.
   - Remove the noise by computing a threshold and maximizing the inter-class variance on the gray levels (assume two classes: insects and background).
   - Determine the bounds of the image to be processed. Segmantation may also applied.
   - Detect the blobs (groups of under-threshold pixels).
     - Compute blobs number, centroid and size
     - Remove blobs smaller than 2 pxls and larger than 30 pxls
2. Optoacoustic spectrum analysis
3. Spectroscopy: Infrared sensors generating electrical signals count fruit flies automatically (B. dorsalis, C. capitata).

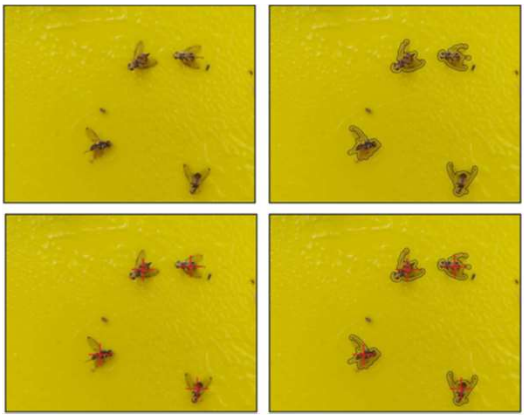
49

4c. LAS: Characteristics of e-services

Group 4: Pests' identification and counting of the trapped insects.

Image processing and computer vision

Olive fruit fly identification and count using yellow sticky trap.



A first effort for the automatic pest monitoring e-service.

- The olive fruit fly adults captured on the surface of the sticky trap have been identified by detecting the boundary of its fly body.
- The results are encouraging, and efforts will continue using this or other approaches.

50

4c. LAS: Characteristics of e-services

Group 4: Pests' identification and counting of the trapped insects.
Machine Learning – Deep Learning

Generally Image Processing performs less than DL and semi-automatic. Experts have to distiguish visually similar insects atracted by the same/similar trap. Verification and validation by experts is required.

Insect Dataset → Image Augmentation ↓
Machine Learning → Deep Learning
Machine Learning ↓ Shape Feature manual extraction → Convolutional Neural Network (CNN) model
Shape Feature manual extraction ↓ Insect Classification ANN, SVM, k-NN, NB → CNN Insect Classification
Deep Learning ↓ Convolutional Neural Network (CNN) model ↓ CNN Insect Classification

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51

FruitFlyNet-ii: Living Labs Platform

- Living Lab I: Smart (Olive, Med)*FruitFlyNet-ii* e-trap

Desired developments

- Compact module.
- Autonomous (energy savings, advanced network connections).
- Easy handling setup.
- Long-lasting.
- Self-functioning.
- Self-feeding.
- Component for self-tracking.
- Component for self-repairing.
- Support plug and operate components.
- Easy components' housing and replacement.
- Spraying mechanism optimization.
- Georeferenced spraying apparatus specially designed for automatic recording of the volume sprayed or able do not permit out-of-target spraying. surface
- Spraying with gel insecticide formulations for less weight and higher orchard coverage.
- UAV technology in LAS developments for fruit sampling
- Other improvements will be decided based on Living Lab suggestions.

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52

52