AIDERS

Deliverable 6.6 Presentation on AI techniques for supporting RPAS in emergency response

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Project Name: **Real-time Artificial Intelligence for DEcision support via RPAS data analyticS**

Acronym: **AIDERS**

Grant Agreement: **873240**

Project Website: http://www.kios.ucy.ac.cy/aiders/

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Submission Date: **30/06/2020**

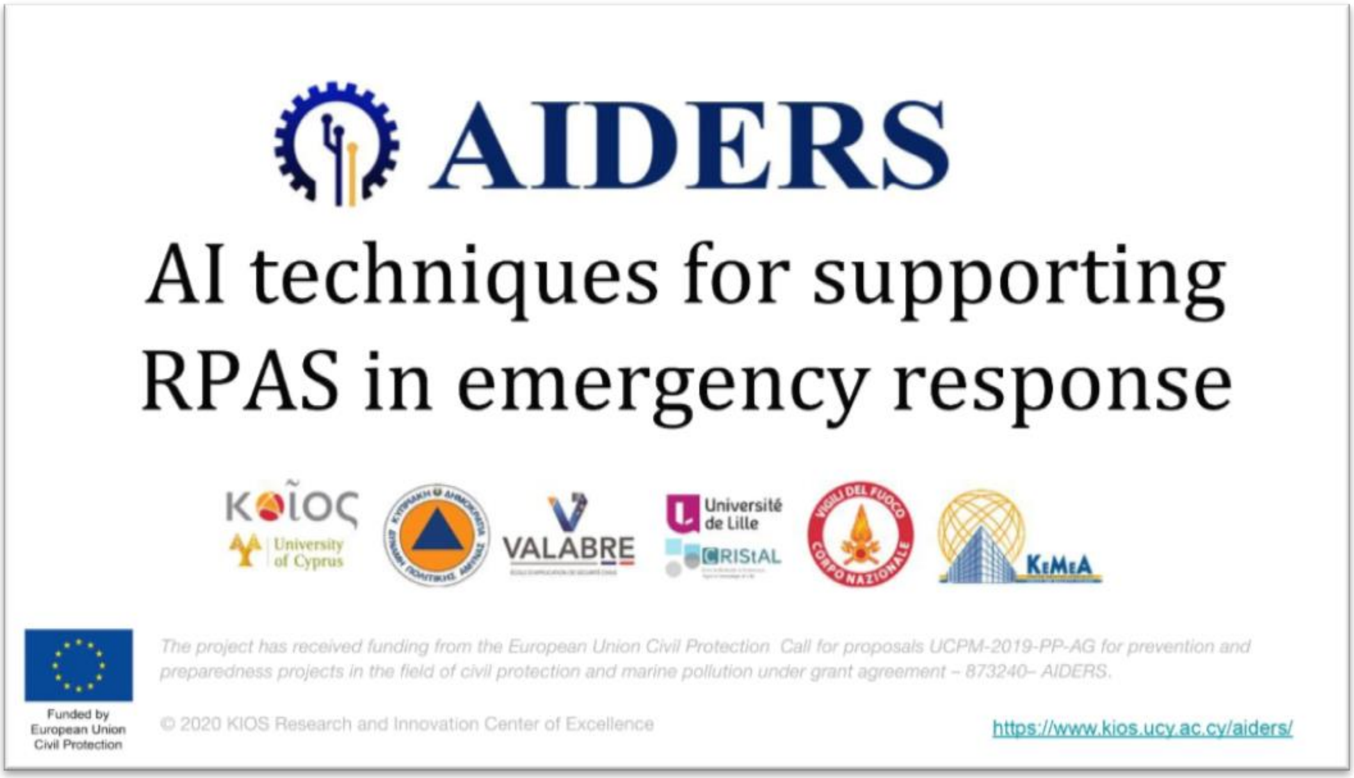
Dissemination Level: **Public**

Contents

Executive Summary

This deliverable provides the slides of a presentation on AI techniques for supporting RPAS in emergency response. The presentation is focused on how AI algorithms can be utilized to exploit multi-sensor data for improved emergency response. The presentation starts with an introduction to the DG ECHO AIDERS project and consortium. It provides insights regarding the requirements of the first responders (the end-users of this project) in handling emergency situations and maps the elicited requirements to machine learning algorithms. Further, it presents how we can collect data by attaching multiple sensors on the UAVs, and provides an overview of state-of-the-art approaches making predictions and recommendations in the area of emergency response using machine learning algorithms trained multi-sensor data. Finally, it discusses the main challenges of the automated processing of multi-sensor data collected by UAVs.

1. Presentation Slides



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Project consortium

CRISTAL, University of Lille, is a laboratory of the National Center for Scientific Research, University Lille and Centrale Lille in partnership Inria and Institut Mines Telecom with focus on

- **Big Data, software engineering, image and its uses, human-computer interaction, robotics, control and supervision of large systems.**

Corpo nazionale vigili del fuoco (CNVVF) is a State organization responsible for prevention, rescue and relief services in natural or manmade disasters.

- **Provide emergency planning, industrial risk management and training within the Ministry of Interior, in close cooperation with the National Civil Protection Department within the Prime Minister's Office**

Center for Security Studies (KEMEA) is a think tank on homeland security policies and an established research center since 2005 within the Hellenic Ministry of Citizen Protection, aiming to support security policy implementations in Greece.

- **A main objective of KEMEA is to bring together all national Law Enforcement Agencies (Police, Fire Service, Coast Guard, Civil Protection agency, etc.)**

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Area of Activity & Project objectives

Strengthening preparedness for responding to multi-sector emergencies, including health, CBRN, environment and marine pollution in Europe and its neighborhoods

- **Developing operational tools to facilitate emergency response**
- **Develop algorithms and tools that will harness the large volume of data collected using drones (including visual, thermal and multispectral cameras, LIDAR, CBRN sensors, etc.) and converting that data into actionable decisions for improved emergency response**
  - Identify which information needs to be extracted from the collected data
  - Design online machine learning algorithms to process and analyse the received data in real-time in order to build knowledge maps
  - Implement novel visualizations that higher-command can use to take intelligent decisions.
- **Test in small and large scale exercises**
- **Share knowledge through dedicated workshops and trainings**

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End User Requirements
7- Most important use cases
Forest fires
Other vegetation fires
Urban Fires
Industrial fires
Flash floods
Plain floods
Building collapse (due to...
Pollutions
Rescue at sea
CBRN accident
SAR
other
8- Order of interest
Overall reconnaissance /...
Mapping/3D Reconstruction
Personnel supervision
Action check, monitoring and...
Search and Rescue
Delivery of Help/Aid
Restoring Communications
Data feedback and measures
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End User Requirements
14 Visualisation capacities -
Provide 3D despriction of incident scene
Visualization products in real time
View changes in incident scene over time
Integrate with digital images and video
Provide spatially accurate representation
Incorporate incident-specific data into...
Allow user to define which data is...
Other
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End User Requirements
15- Display with one monitor
80
70
60
50
40
30
20
10
0
Map with GPS
Real time video
Show det. POI
Involved objects
Display threats
Other
1 2 3 4 5 6
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End User Requirements
Three main areas of focus:
FIRES
FLOODING
EARTHQUAKES
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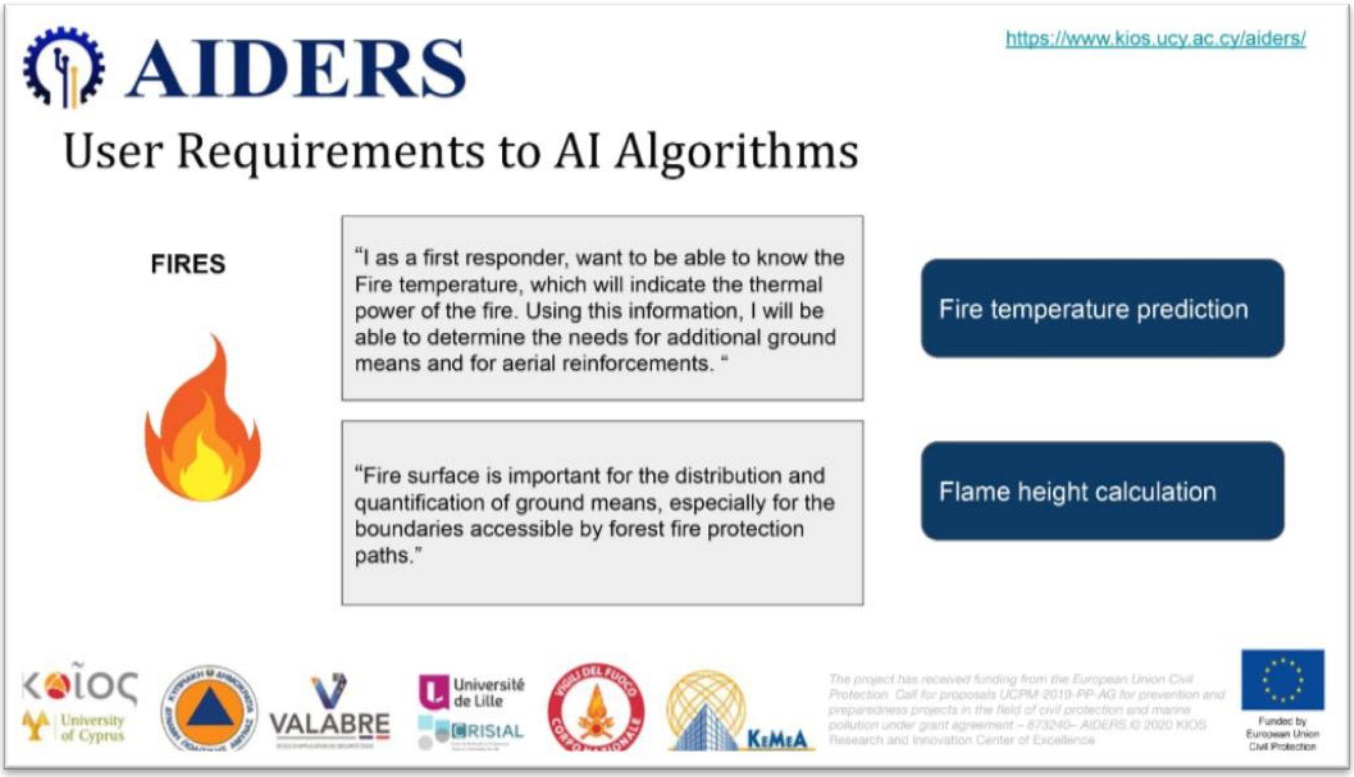

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User Requirements to AI Algorithms
FIRES
"I as a first responder, want to be able to know the Fire temperature, which will indicate the thermal power of the fire. Using this information, I will be able to determine the needs for additional ground means and for aerial reinforcements. "
Fire temperature prediction
"Fire surface is important for the distribution and quantification of ground means, especially for the boundaries accessible by forest fire protection paths."
Flame height calculation
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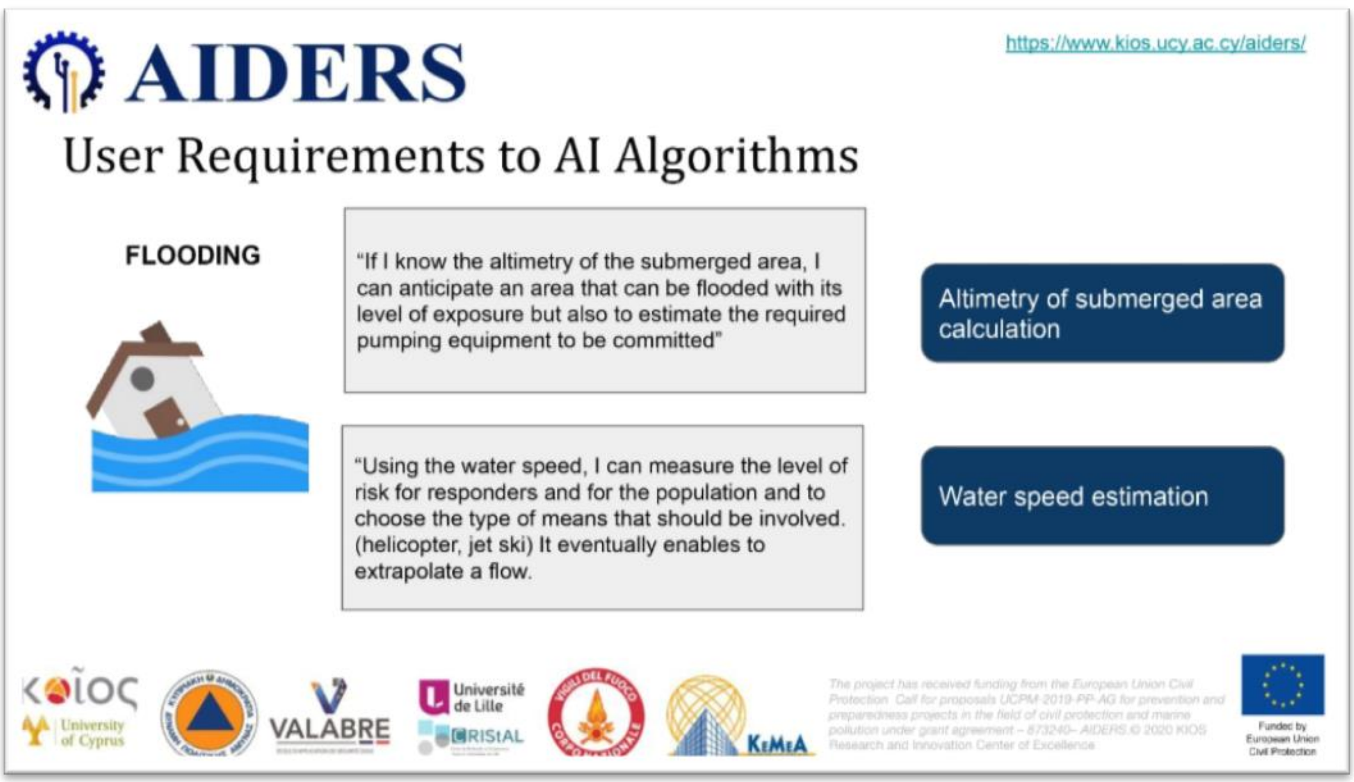

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User Requirements to AI Algorithms
FLOODING
"If I know the altimetry of the submerged area, I can anticipate an area that can be flooded with its level of exposure but also to estimate the required pumping equipment to be committed"
Altimetry of submerged area calculation
"Using the water speed, I can measure the level of risk for responders and for the population and to choose the type of means that should be involved. (helicopter, jet ski) It eventually enables to extrapolate a flow.
Water speed estimation
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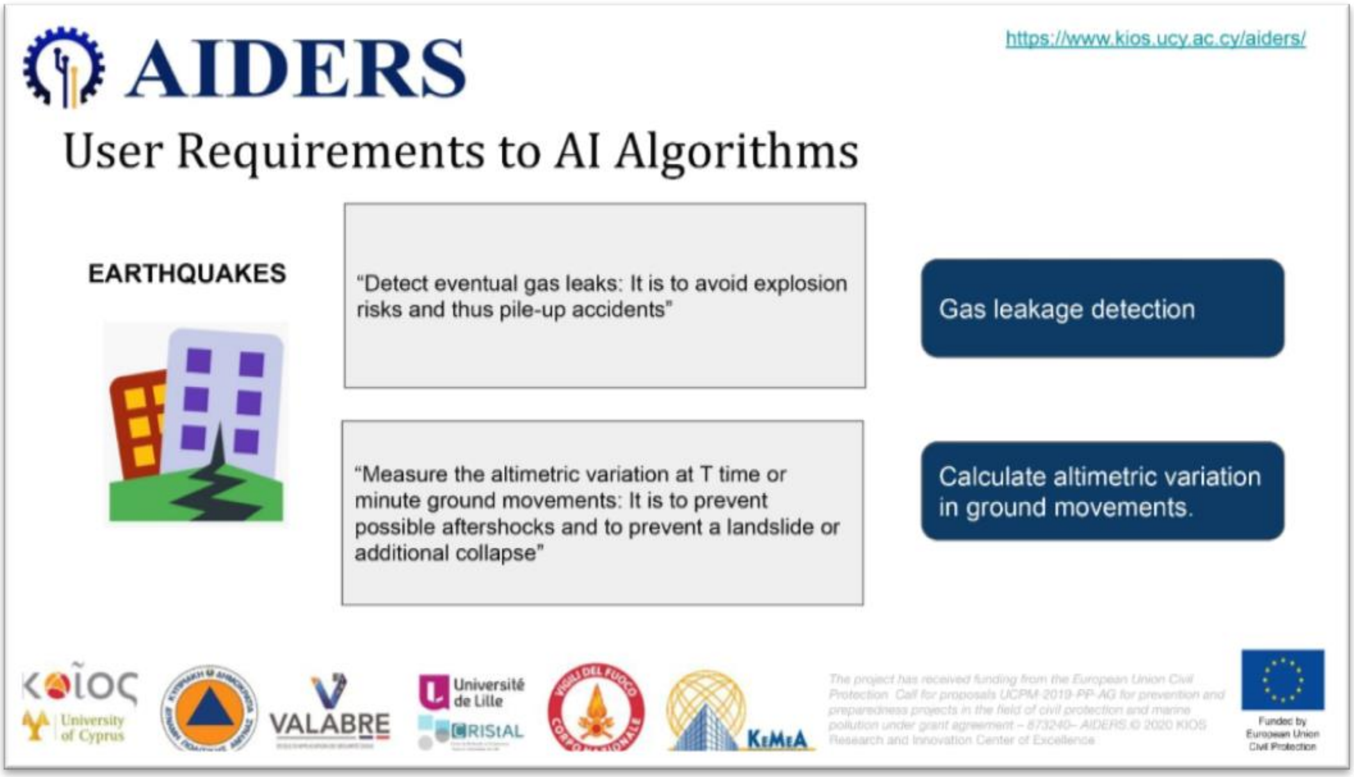
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User Requirements to AI Algorithms
EARTHQUAKES
"Detect eventual gas leaks: It is to avoid explosion risks and thus pile-up accidents"
Gas leakage detection
"Measure the altimetric variation at T time or minute ground movements: It is to prevent possible aftershocks and to prevent a landslide or additional collapse"
Calculate altimetric variation in ground movements.
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On-UAV data collection technologies
Camera
Conventional RGB Images
Thermal
Relative Temperature Data
Multispectral
Broad Spectral Data (between 3-5 bands)
RadioMetric
Thermal and Radiometric data
Lidar
Elevation and structural data
CBRNE
Multi-Gas detection data
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The advantages of using drones for data collection

1. Improving safety
2. Improved accessibility
3. Real-time progress monitoring
4. Applications potential unlocked

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Data processing - UAV Images

Object Detection

Image processing with machine learning models.

Build Map

Map layer created by UAV images

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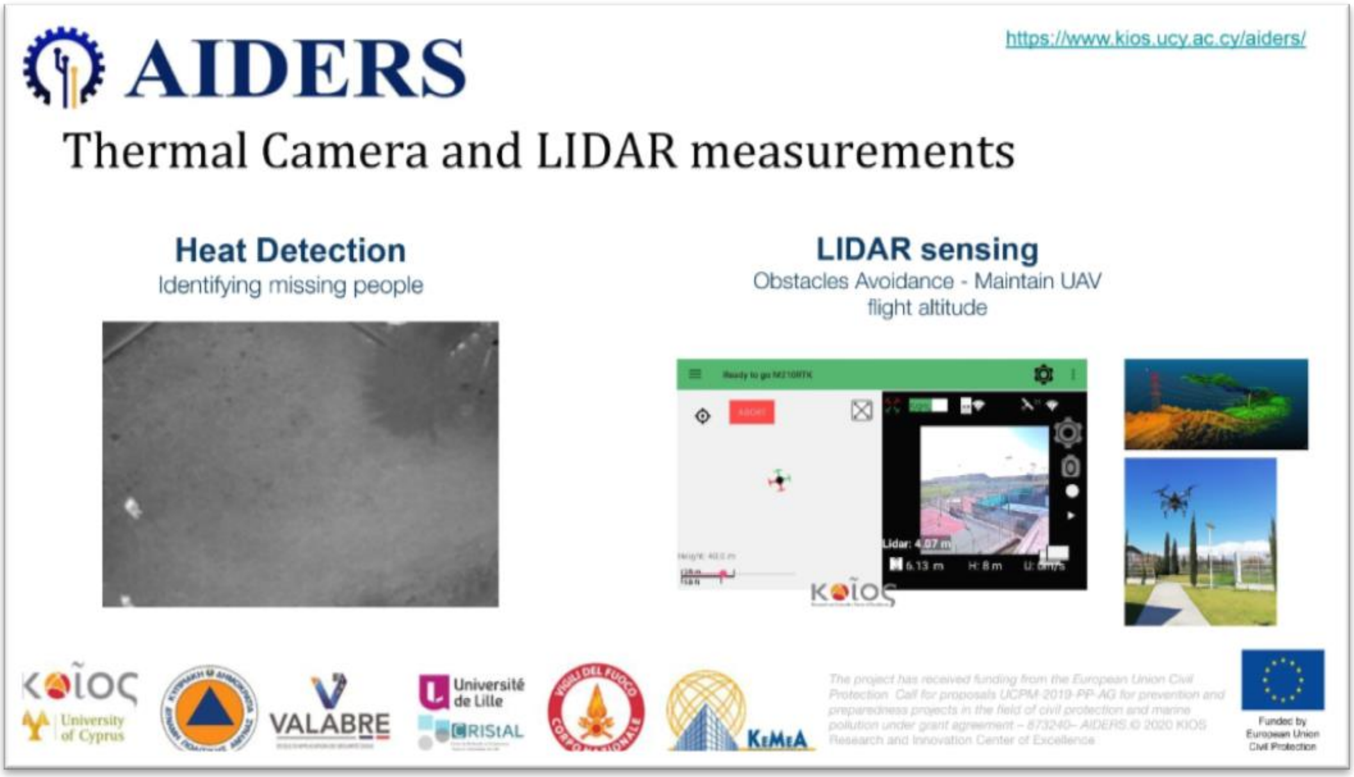
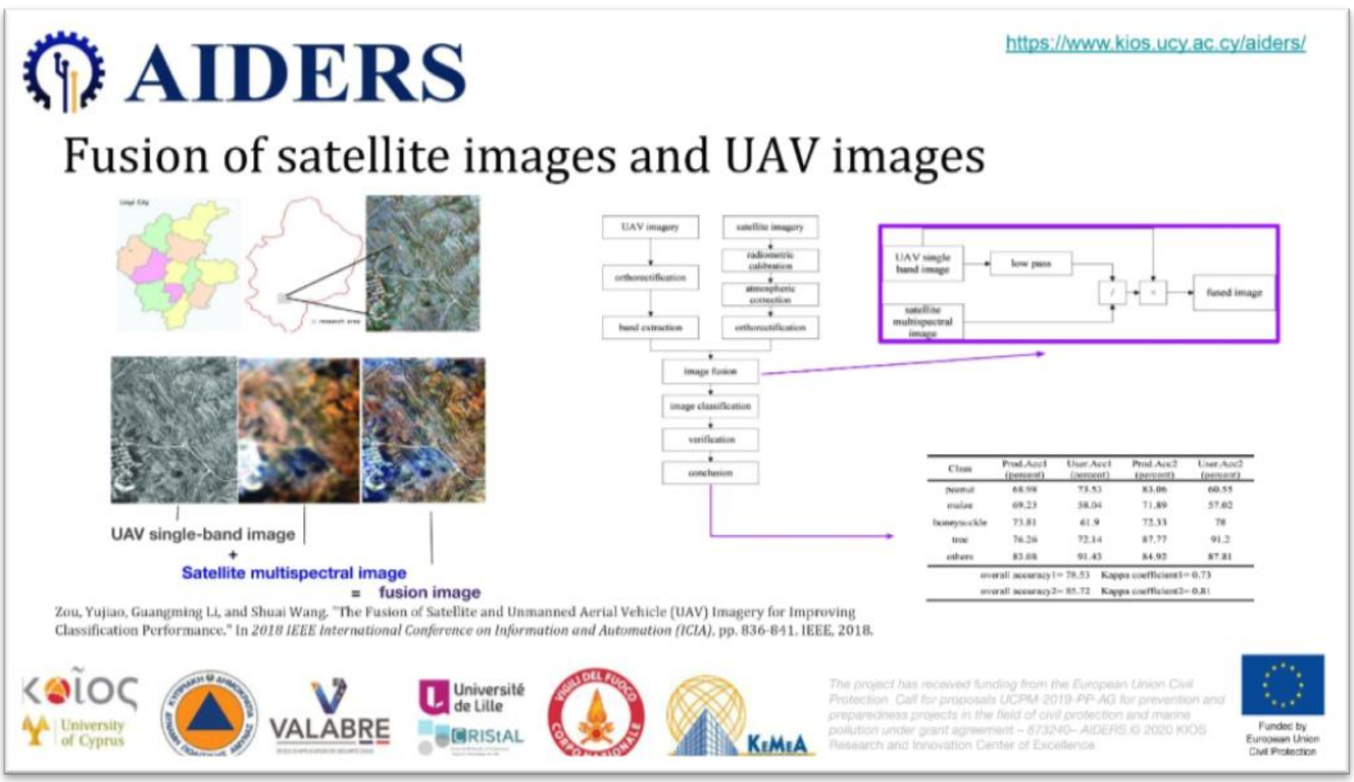
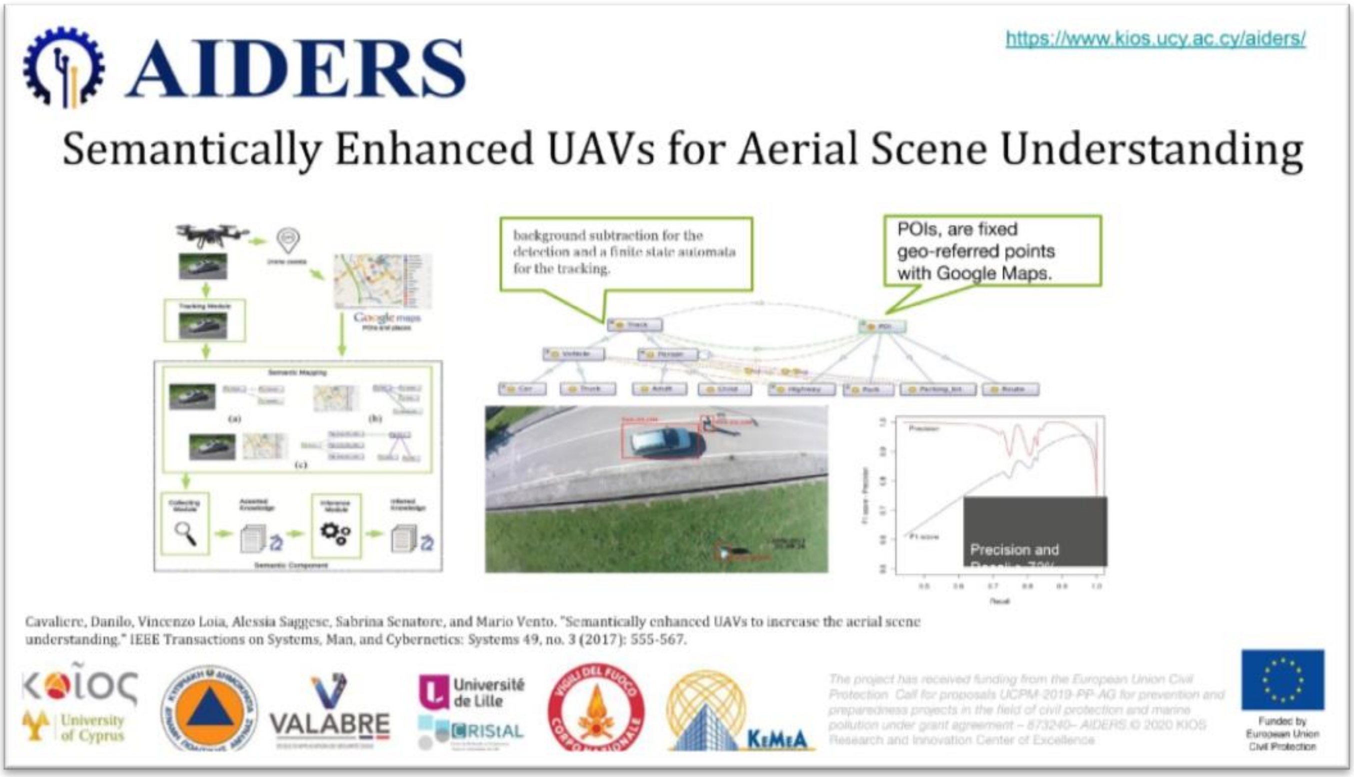




Class	Prod.Acc1 (percent)	User.Acc1 (percent)	Prod.Acc2 (percent)	User.Acc2 (percent)
peanut	68.98	73.53	83.06	60.55
maize	69.23	58.04	71.89	57.02
honeysuckle	73.81	61.9	72.33	78
tree	76.26	72.14	87.77	91.2
others	83.08	91.43	84.92	87.81

overall accuracy1= 78.53 Kappa coefficient1= 0.73
overall accuracy2= 85.72 Kappa coefficient2= 0.81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Semantically Enhanced UAVs for Aerial Scene Understanding
background subtraction for the detection and a finite state automata for the tracking.
POIs, are fixed geo-referred points with Google Maps.
Precision and
Cavaliere, Danilo, Vincenzo Loia, Alessia Saggese, Sabrina Senatore, and Mario Vento. "Semantically enhanced UAVs to increase the aerial scene understanding." IEEE Transactions on Systems, Man, and Cybernetics: Systems 49, no. 3 (2017): 555-567.
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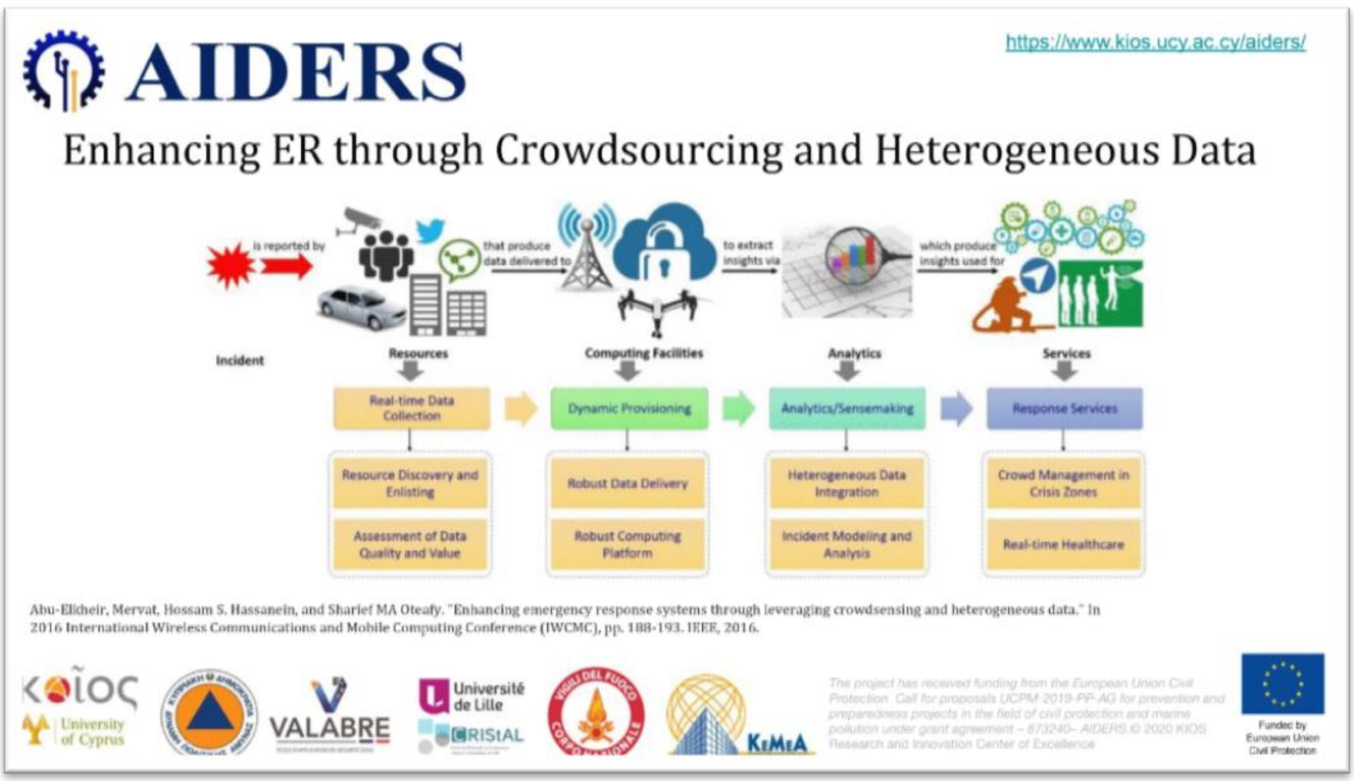
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Enhancing ER through Crowdsourcing and Heterogeneous Data
is reported by
that produce data delivered to
to extract insights via
which produce insights used for
Incident
Resources
Computing Facilities
Analytics
Services
Real-time Data Collection
Dynamic Provisioning
Analytics/Sensemaking
Response Services
Resource Discovery and Enlisting
Robust Data Delivery
Heterogeneous Data Integration
Crowd Management in Crisis Zones
Assessment of Data Quality and Value
Robust Computing Platform
Incident Modeling and Analysis
Real-time Healthcare
Abu-Elkheir, Mervat, Hossam S. Hassanein, and Sharief MA Oteafy. "Enhancing emergency response systems through leveraging crowdsensing and heterogeneous data." In 2016 International Wireless Communications and Mobile Computing Conference (IWCMC), pp. 188-193. IEEE, 2016.
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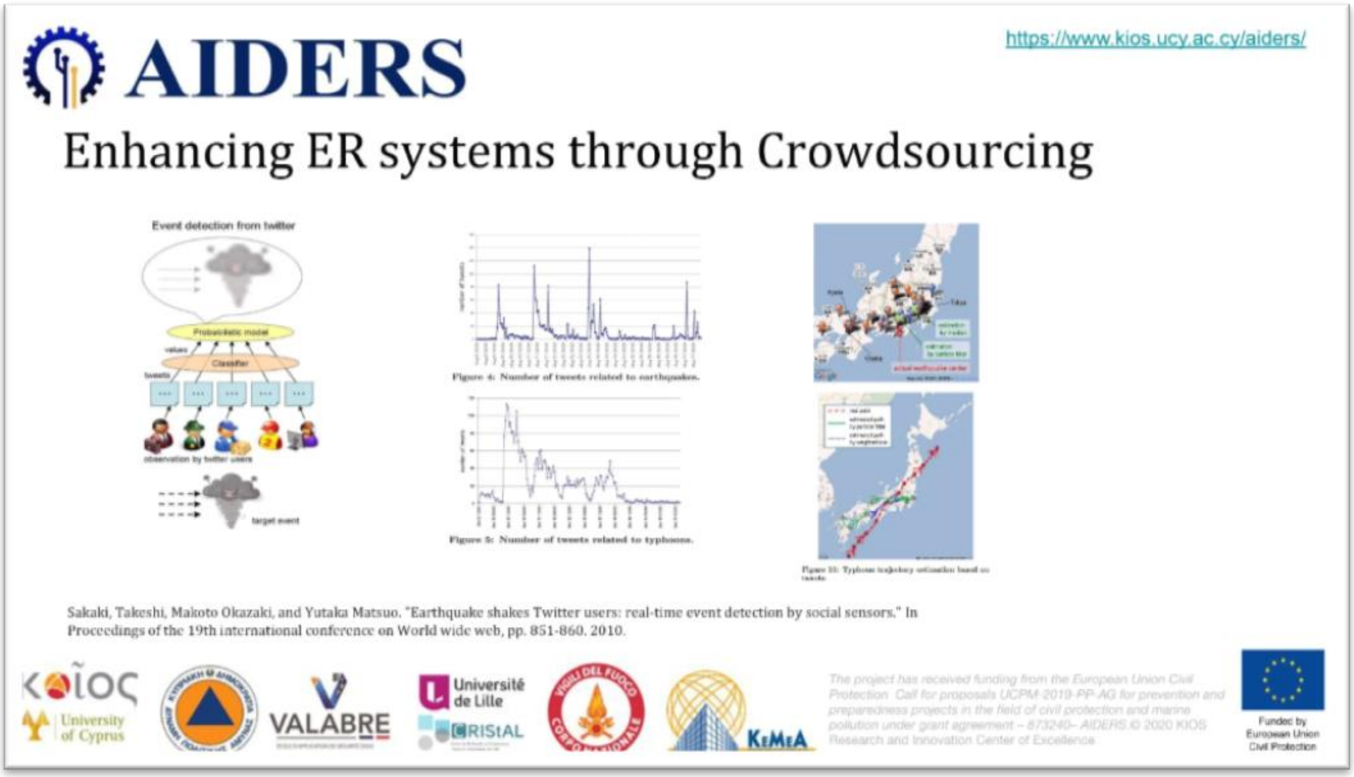
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Enhancing ER systems through Crowdsourcing
Event detection from twitter
Probabilistic model
Classifier
observation by twitter users
target event
Figure 4: Number of tweets related to earthquakes.
Figure 5: Number of tweets related to typhoons.
Sakaki, Takeshi, Makoto Okazaki, and Yutaka Matsuo. "Earthquake shakes Twitter users: real-time event detection by social sensors." In Proceedings of the 19th international conference on World wide web, pp. 851-860. 2010.
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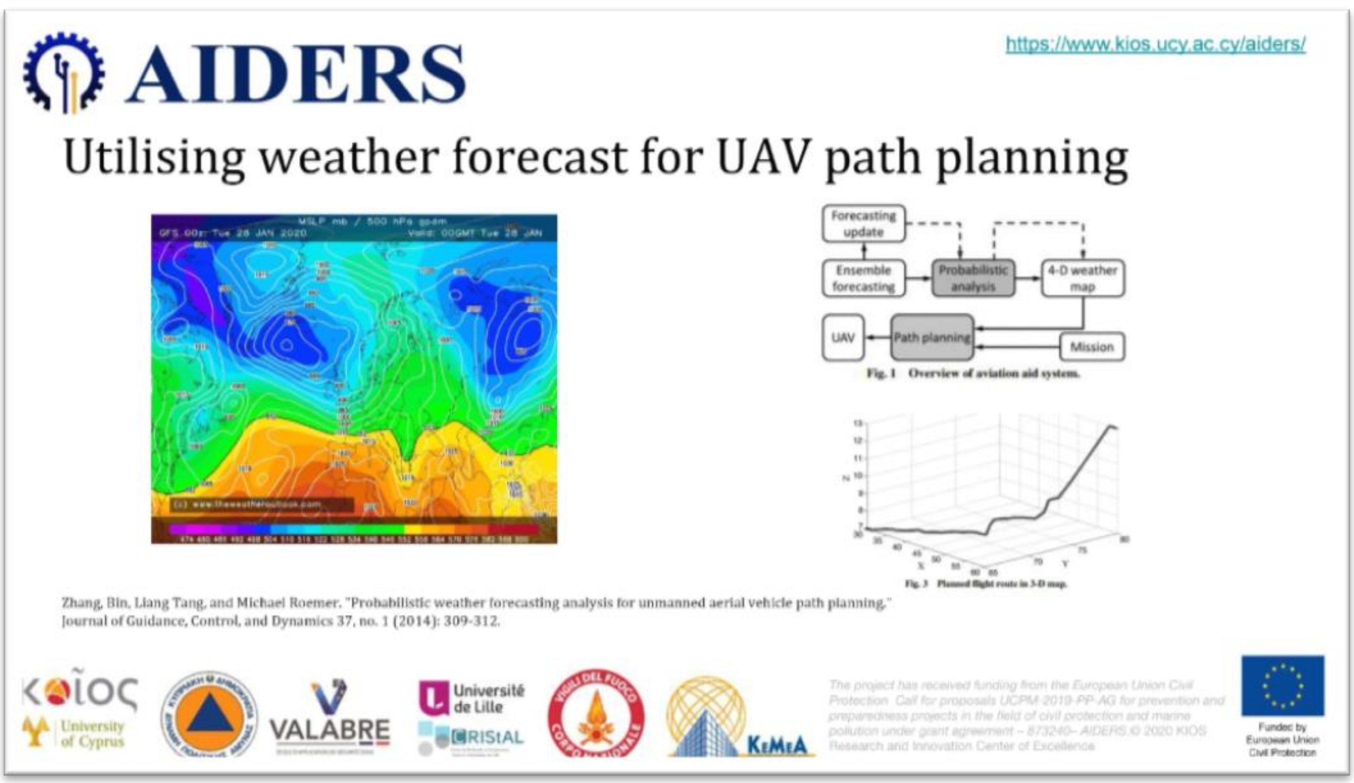
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Utilising weather forecast for UAV path planning
Forecasting update
Ensemble forecasting
Probabilistic analysis
4-D weather map
UAV
Path planning
Mission
Fig. 1 Overview of aviation aid system.
Fig. 3 Planned flight route in 3-D map.
Zhang, Bin, Liang Tang, and Michael Roemer. "Probabilistic weather forecasting analysis for unmanned aerial vehicle path planning." Journal of Guidance, Control, and Dynamics 37, no. 1 (2014): 309-312.
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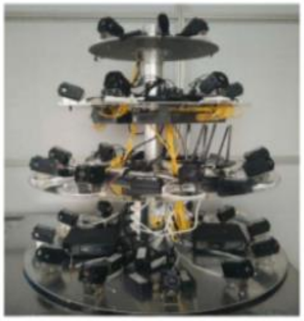
Drone Detection Based on an Audio-Assisted Camera Array



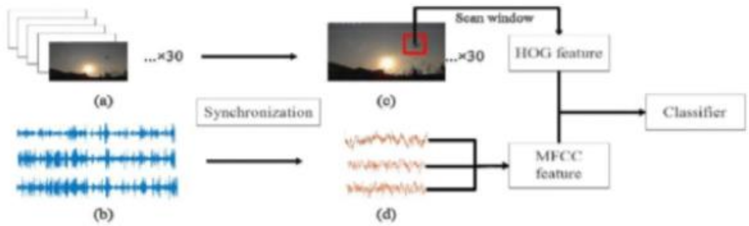


Table II. Precision of detection methods

Samples	Precision	
	Visual Based	*Sound Assistant*
Positive	79.54%	95.74%
Negative	47.67%	82.61%

Liu, Hao, Zhiqiang Wei, Yitong Chen, Jie Pan, Le Lin, and Yunfang Ren. "Drone detection based on an audio-assisted camera array." In 2017 IEEE Third International Conference on Multimedia Big Data (BigMM), pp. 402-406. IEEE, 2017.

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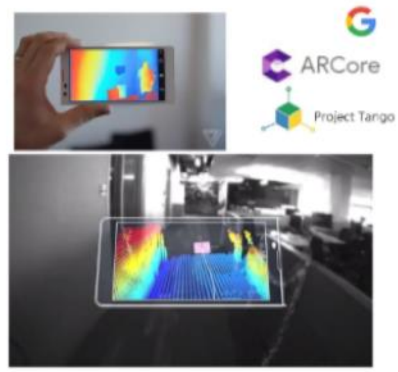
Finding Victims via Infrared Camera and Lidar Sensor Fusion



Lee, Seoungjun, Dongsoo Har, and Dongsuk Kum. "Drone-assisted disaster management: Finding victims via infrared camera and lidar sensor fusion." In 2016 3rd Asia-Pacific World Congress on Computer Science and Engineering (APWC on CSE), pp. 84-89. IEEE, 2016.

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UAV LIDAR and hyperspectral fusion for forest monitoring

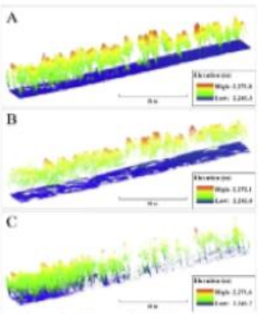
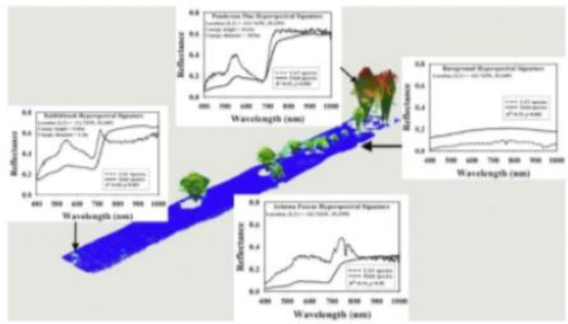


Fig. 5. Examples of the same forested area in the octocopter UAV lidar data (Panel A), fixed-wing UAV-derived structure from motion (SfM) point cloud data (Panel B), and the Riegl VZ-1000 terrestrial laser scanner data (Panel C).

Fig. 4. Examples of the octocopter UAV lidar point cloud, where individual tree and shrub canopies are delineated with canopy height and diameter estimates (represented by the green 3D shapefiles), and hyperspectral reflectance of the target species: Ponderosa pine (*Pinus ponderosa*), rabbitbrush (*Chrysothamnus viscidiflorus*), Arizona fescue (*Festuca arizonica*), and bareground.



Sankey, Temuulen, Jonathon Donager, Jason McVay, and Joel B. Sankey. "UAV lidar and hyperspectral fusion for forest monitoring in the southwestern USA." Remote Sensing of Environment 195 (2017): 30-43.

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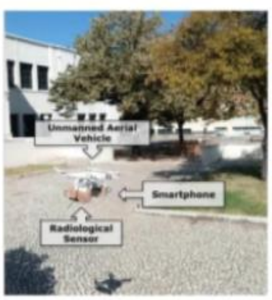
Radioactive Hot-Spot Detection using UAVs



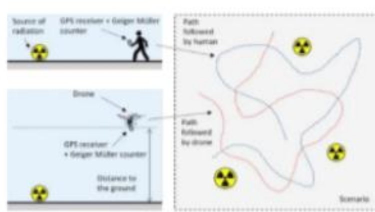


Fig. 2. 2D and 3D experiments associated to a human walking and a drone flying over the scenario, respectively (left images). The scenario, the sources of radiation and the described paths (right image).

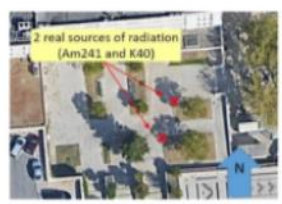


Fig. 14. Map view illustrating the source positions and the origin of the reference frame (yellow circle). Map provided by Google Maps™.

Brouwer, Yoeri, Alberto Vale, Duarte Macedo, Bruno Gonçalves, and Horácio Fernandes. "Radioactive Hot-spot Detection Using Unmanned Aerial Vehicle Surveillance." In EPJ Web of Conferences, vol. 225, p. 06005. EDP Sciences, 2020.

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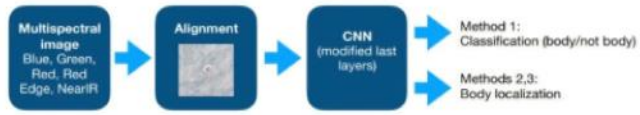
Detecting bodies in maritime operations



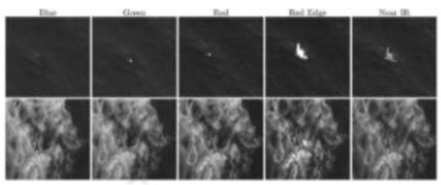


FIGURE 3 Two samples (five spectral bands) acquired by the MicaSense RedEdge camera mounted on the drone

Table 6: Classification results using different channel comb

Camera	Channels (BLUE, GREEN, RED, REDGE, NIR)	Precision	Recall	F_1
ILCE-6000	●●●○○	68 ±16.23	67.55 ±17.48	67.77 ±16.56
Aligned	●●●○○	75.24 ±7.06	72.46 ±8.12	73.82 ±7.45
	●●○●○	75.13 ±10.8	72.77 ±10.77	73.93 ±10.64
	●●○○●	75.64 ±6.99	71.98 ±6.57	73.77 ±6.59
	●○●●○	76.14 ±2.53	72.55 ±2.4	74.30 ±1.57
	●○●○●	72.50 ±9.85	70.97 ±6.64	71.73 ±8.25
	●○○●●	72.58 ±12.96	71.07 ±11.7	71.82 ±12.23
	○●●●○	73.42 ±9.6	71.97 ±8.69	72.69 ±8.99
	○●●○●	75.64 ±7.55	72.71 ±4.83	74.14 ±5.97
	○●○●●	77.92 ±9.72	76.74 ±9.47	**77.33** ±9.48
	○○●●●	75.87 ±19.81	72.88 ±11.42	74.34 ±16.13
	●●●●●	75.86 ±6.54	74.53 ±7.41	75.15 ±6.79

Gallego, Antonio-Javier, Antonio Pertusa, Pablo Gil, and Robert B. Fisher. "Detection of bodies in maritime rescue operations using unmanned aerial vehicles with multispectral cameras." Journal of Field Robotics 36, no. 4 (2019): 782-796.

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Data processing models and processing challenges

	UAV local execution	Cloud Execution	Hybrid Execution
Time limitation	Real time applications. Low delay.	Non real-time applications. High delay	Inputs are not necessarily acquired by UAV. Medium delay
Computing Intensity	Non-intensive processing.	High Intensive processing.	Modular. Send less complex tasks to UAV.
Bandwidth	Low bandwidth for inputs.	High bandwidth for inputs.	Medium bandwidth for inputs.
Scalability	Depends on number of UAV/ UAV networks	Depends on server performance and parallel computing	Less scalable than cloud execution

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