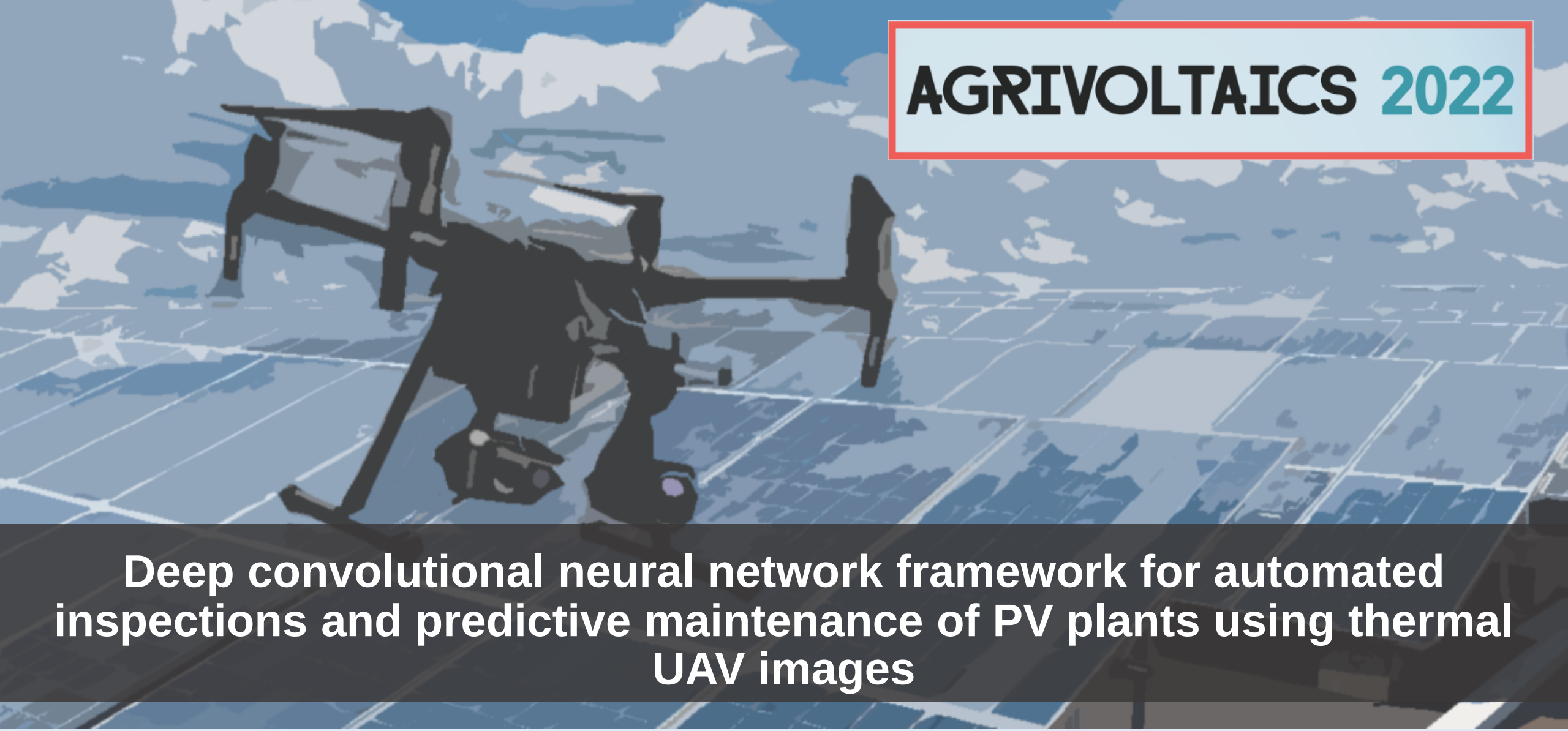

Deep convolutional neural network framework for automated inspections and predictive maintenance of PV plants using thermal UAV images

G. Terzoglou, M. Loufakis, G. Aswestopoulos, P. Symeonidis, D. Ioanidis, D. Tzovaras

Centre for Research and Technology Hellas, Information Technologies Institute

Information Technologies Institute

WHO WE ARE

CERTH:

Founded in **2000** - one of the leading R&D centres in Greece

Includes 5 institutes:

- **Information Technologies Institute** (ITI)
- Chemical Process & Energy Resources Institute (CPERI)
- Hellenic Institute of Transport (HIT)
- Institute of Applied Bioscience (INAB)
- Institute of Bio-Economy and Agri-Technology (IBO)

Information Technologies Institute:

- Part of **CERTH since 2000**
- Leading Institution of Greece in the fields of Informatics, Telematics and Telecommunications, etc.
- A total budget of **135 M€**
- **~15 M€ funding per year** (last 3 years)

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FIRST in Greece for the last 5 consecutive years in participation at competitive research grants (FP7, H2020)

PVGNOSIS

PVgnosis “DiaGNOSIS, maintenance and operation of PV plants” is a **SOLAR-ERA.NET** Cofund 2 project implemented by **CERTH/ITI**, University of Cyprus, ENGAIA Renewable Energy Systems S.A. and Checkwatt AB

PVgnosis aims to create an ICT Platform integrating all the necessary tools for delivering advanced diagnosis, predictive maintenance and intelligent visual inspection on installed PV plants.

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AGRIVOLTAICS, UAVs AND DEEP LEARNING

Thermal images of solar panels collected from **UAVs** can provide valuable insights about **panel condition / faults**. This process, when supported by **deep learning** techniques, can significantly **reduce maintenance cost** and prevent **energy / turnover loss**.

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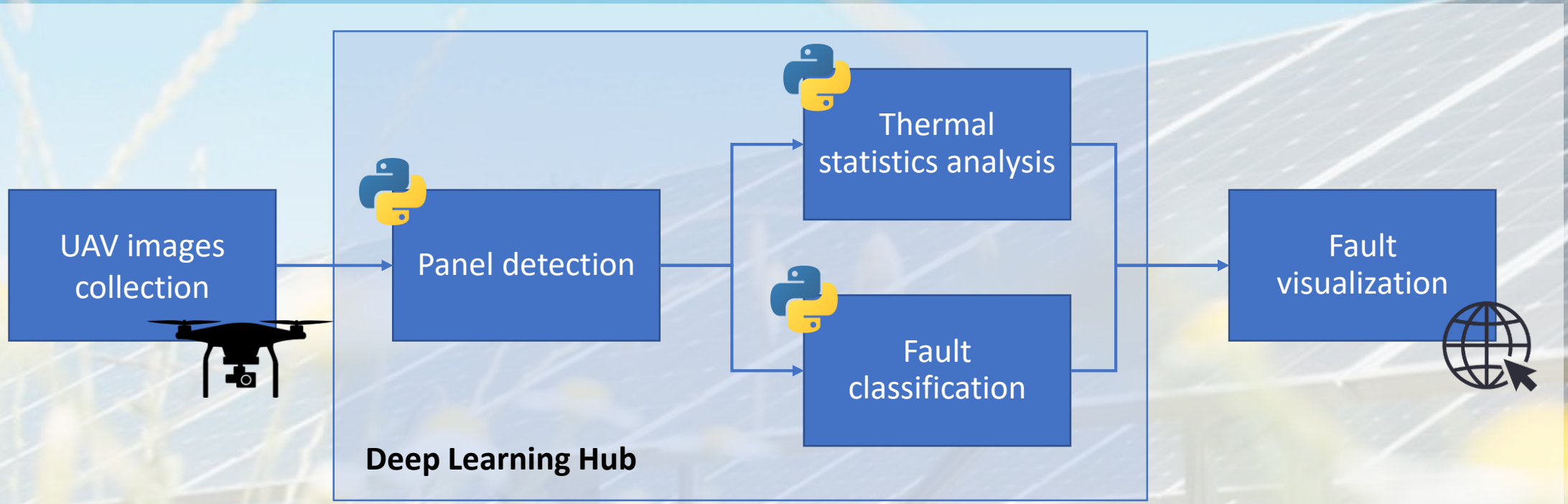
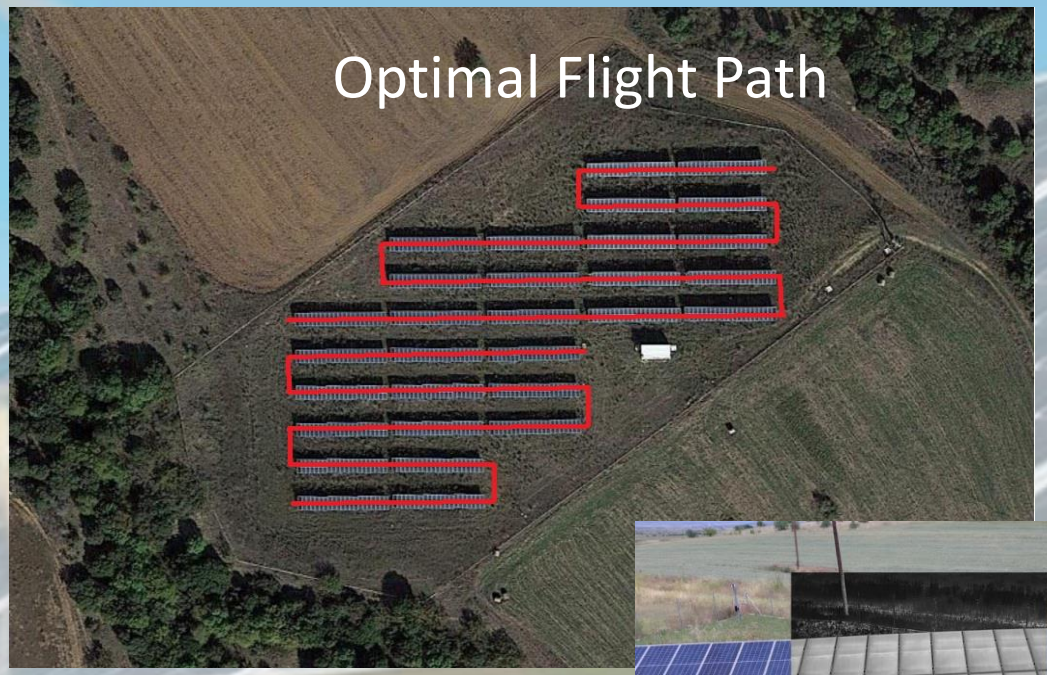
METHODOLOGY

Workflow pipeline



UAV IMAGES COLLECTION

- Image collection is performed using drones equipped with **optical** and **thermal** cameras
- Images should be acquired under specific flight conditions (weather, height, speed, GSD, flight path)
- Currently supported images from **AUTEL** and **DJI** drones



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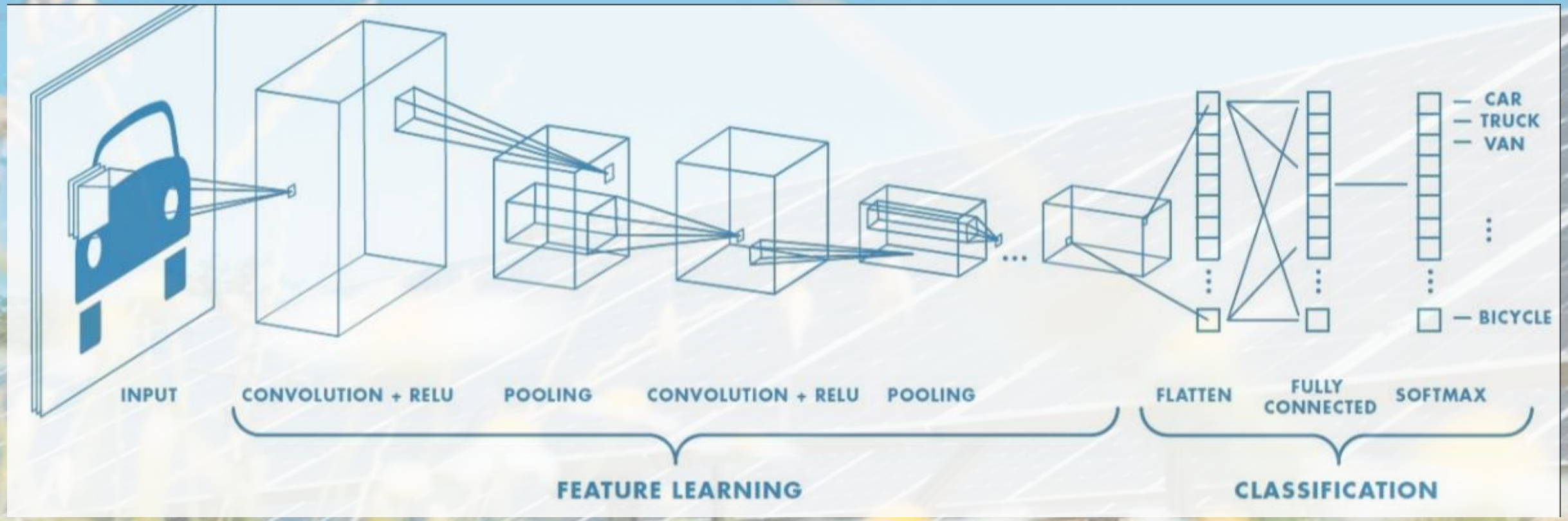
Convolutional Neural Networks (CNN)



PANEL DETECTION

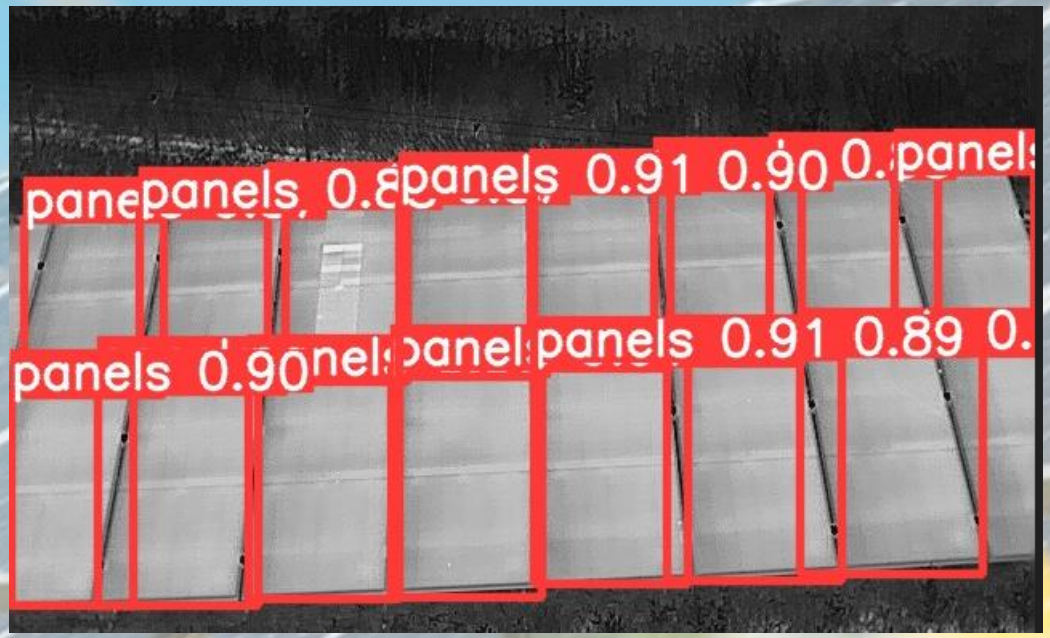
STEP 1: Initial Panel Detector

Goal:

- Rough detection of panels (Bounding box)

Implementation:

- **CNN** model based on **Yolo** architecture
- Insensitive in panel **rotations**
- **Very High accuracy >95%**



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PANEL DETECTION

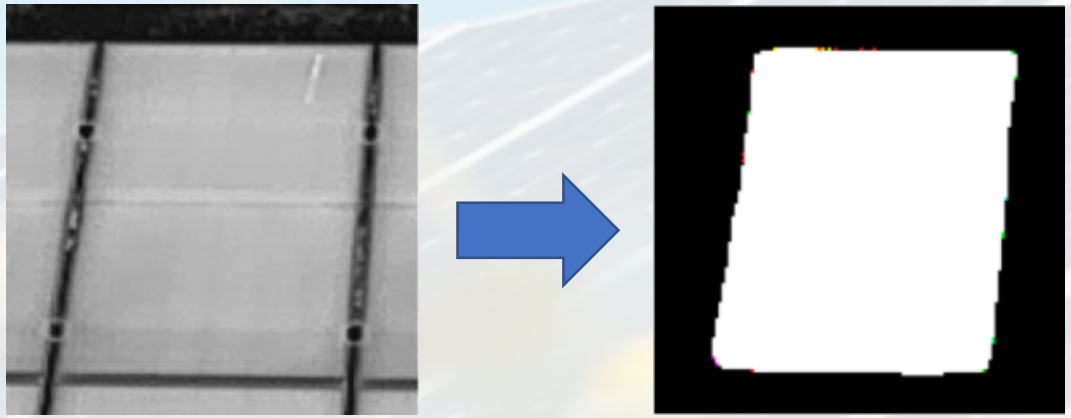
STEP 2: Semantic Segmentation

Goal:

- Isolate the region of interest
- Mask creation for every panel image

Implementation:

- **CNN** model based on **Unet** architecture
- Accuracy > 80%



Original image

Masked image

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PANEL DETECTION

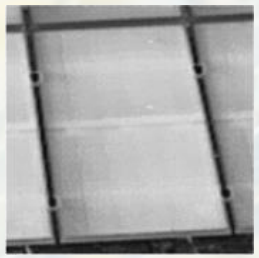
STEP 3: Computer vision techniques

Goal:

- Create thermal panel image for CNN classifier

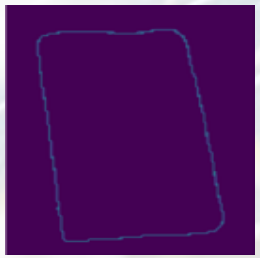
Implementation:

- Using **computer vision** techniques from the **OpenCV**'s python library (canny edge detection, houghLines, findContours, warpPerspective)

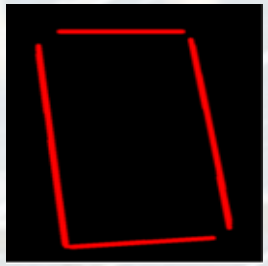


Original image

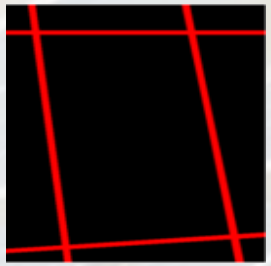
Mask image



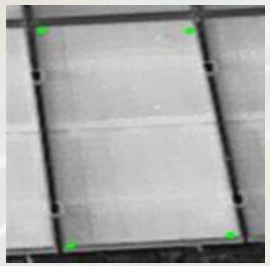
Canny image



Line image



Extended lines



Contours image

Final image

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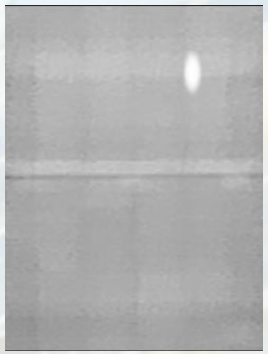
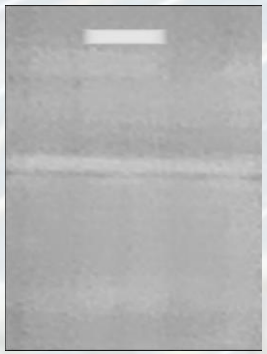
PANEL CLASSIFICATION

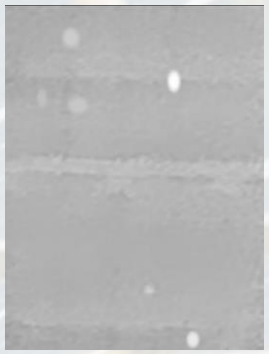
Training Dataset

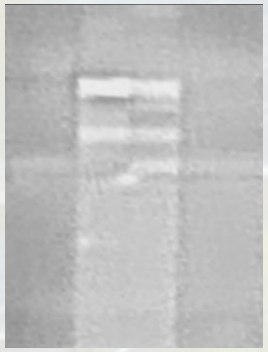
- Trained classifier with limited online datasets of solar panel faults resulted in low accuracy with real data

- Creation of a **synthetic dataset** with 4 fault categories (cell, diode, multi-cell, multi-diode)


Cell


Diode


Multi-Cell


Multi-Diode

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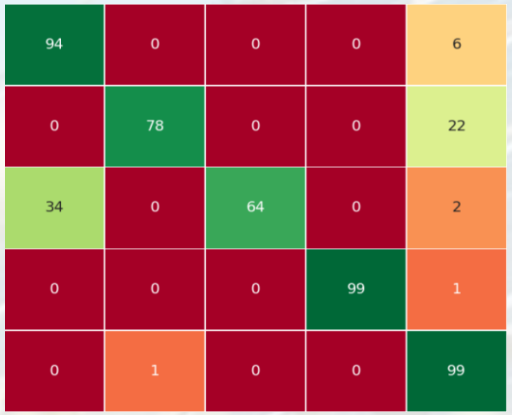
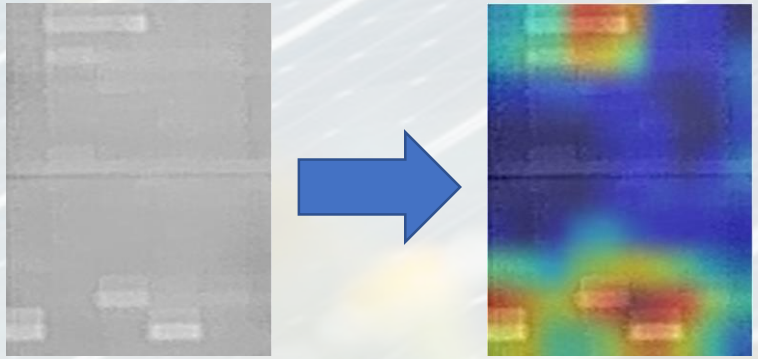
PANEL CLASSIFICATION

CNN Classifier

- **CNN** based on **EfficientNet**
- Train on **7000 images** for 25 epochs with batch size of 16
- Accuracy 89%



Confusion Matrix



Thermal image

Heatmap

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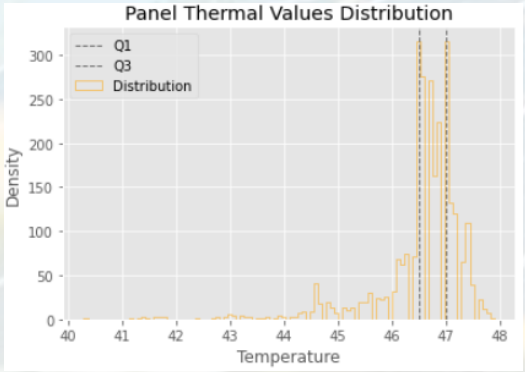
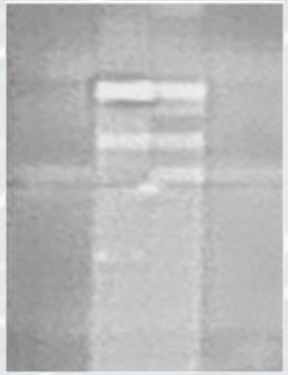
THERMAL STATISTICS

- Calculate **thermal statistics** for every panel (maximum value, minimum, mean, median, standard deviation, kurtosis, Skewness)
- Confirmation of anomaly (from image classification)
- Find problems that classifier is unable to detect (offline panels)

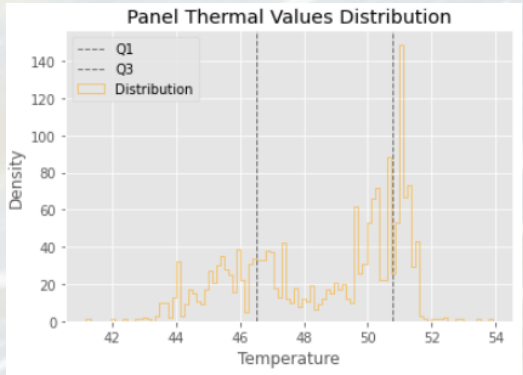
Panel without faults



No fault panel Histogram
Standard deviation = 0.82



Multi-Diode anomaly panel



Multi-Diode panel Histogram
Standard deviation = 2.42

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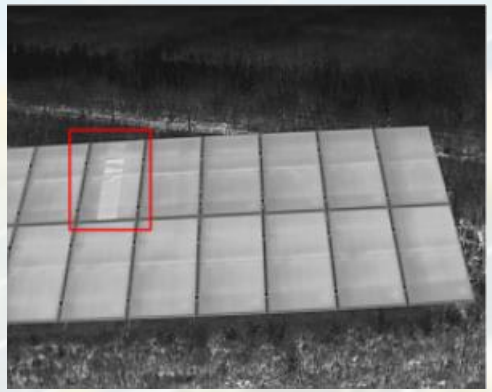
FAULT VISUALIZATION

- A **web application** for plant operators that will provide UI for the implementation of the **inspection workflow**
- **Map visualization** of panels with anomalies
- **Reporting** (maintenance, energy production, visual dashboard)



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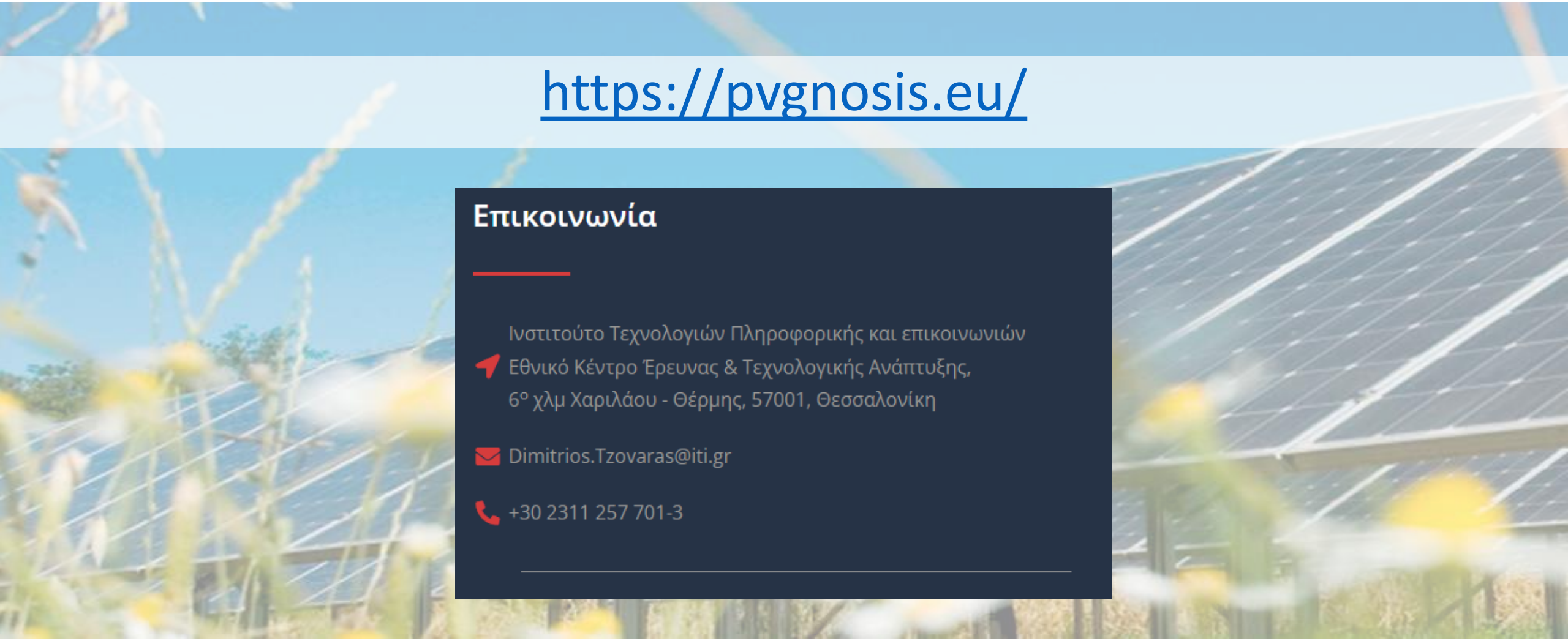
More Information

https://pvgnosis.eu/



Επικοινωνία

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