Interreg

Co-funded by the European Union

Italy – Croatia

STRENGTH

# D.1.2.3
# Report about acquisition of infrared measures of buildings

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| Project acronym | STRENGTH |
| Project full title | STRategies for assessing climate change and natural hazards' impact on urban ecosystems, increasing resilience to ENvironmental hazards, and promoting territorial GrowTH |
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| Deliverable Title | D.1.2.3. Report about acquisition of infrared measures of buildings |
| Activity | Digital monitoring to detect seismic vulnerability |
| WP | 1 |
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| Contributing Partners | FGAG, UNIFE |
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# Table of contents

# 1. Methodology

This phase of the project focuses on the acquisition and analysis of infrared (thermal) images of building facades in order to identify construction materials and support seismic vulnerability assessment. Thermal imaging enables non-invasive evaluation of buildings by capturing heat distribution patterns that correlate with material properties such as thermal conductivity and structural composition.

The developed system applies a deep learning-based approach to automatically classify facade materials and generate structured outputs for further engineering analysis.

## 1.1 Material Classification from Thermal Images

Thermal images are processed using a YOLOv8 segmentation model trained on a custom dataset. The model identifies facade regions and classifies them according to construction material types. Instead of generic object detection, the model is adapted for semantic interpretation of facade patterns and material classification as object classes.

For each image, the system outputs:

- Detected material class
- Confidence score for each detection

The main result is the average confidence per material class, calculated as:

$$\bar{c}_k = \frac{1}{N_k} \sum_{i=1}^{N_k} c_i$$

Where

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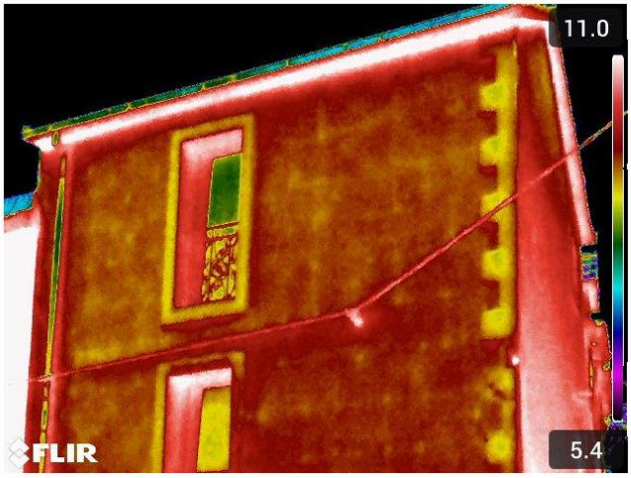
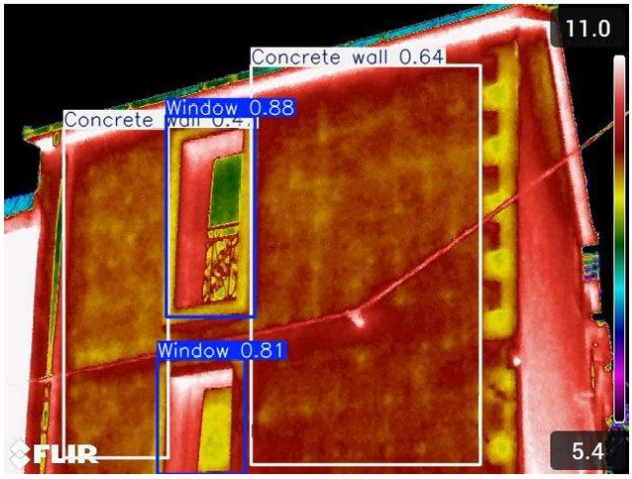
| $\bar{c}_k$ | average confidence for material class k |
| $c_i$ | confidence of individual detections |
| $N_k$ | number of detections of class k |
| k | material class |

This value represents the reliability of the predicted material classification.

Practical Meaning




The output:

Material: Concrete wall
Average confidence: 0.47

Material: Concrete wall
Average confidence: 0.64

Material: Window
Average confidence: 0.88

Material: Window
Average confidence: 0.81

is interpreted as:

The building facade most likely corresponds to „Concrete wall“.
The classification reliability is 47% and 64%.

### 1.2 Processing Pipeline

The image processing workflow is implemented as a batch pipeline:

1. Load images from the input directory
2. Perform YOLOv8 inference
3. Generate annotated images with detected regions
4. Extract image metadata (EXIF and GPS)
5. Compute detection statistics
6. Generate structured log files

The system is implemented in Python using libraries such as Ultralytics YOLO, OpenCV, and Pillow. It supports multiple image formats and recursive directory processing.

### 1.3 Metadata Extraction

In addition to visual analysis, the system extracts metadata from each image:

- EXIF data (capture time, technical parameters)
- GPS coordinates

If GPS data is not present in standard EXIF fields, a fallback method is used to retrieve coordinates from extended metadata sources.

## 2. Material Typology

The classification categories (construction materials) are defined according to established seismic vulnerability assessment methodologies. These include:

- Concrete wall
- Mansory wall
- Stone wall
- Cut stones of constant size wall
- Prefabricated concrete blocks
- Clay bricks

- Reinforced concrete beam
- ETICS (Exterior Thermal Insulation System)

These material types were selected based on their relevance in seismic analysis and their different mechanical behavior under seismic loading.

## 3. Application to Seismic Vulnerability Assessment

The detected construction material represents a key parameter in seismic risk evaluation.

The next stage of the project involves implementing the Vulnerability Index (Iv), defined as:

$$I_v = \sum w_j * p_j$$

where

$p_j$ are structural parameters (including material type)
$w_j$ are corresponding weights

The material class obtained from the YOLOv8 model is used to define one of the parameters $p_j$, with each material assigned a predefined vulnerability score.

## 4. Results

The system generates the following outputs:

- Annotated thermal images with detected material regions
- Log files containing:
  - Detection results
  - Confidence metrics
  - Extracted metadata (EXIF and GPS)

These results provide both visual and quantitative information for each analyzed building.

This phase of the project demonstrates a method for automated classification of building materials using infrared imagery. The approach enables efficient processing of large datasets and provides reliable input data for seismic assessment.

Future work will focus on implementing the full calculation of the Vulnerability Index (Iv) and integrating additional structural parameters required by the assessment methodology.