HaMMon: update on WP4
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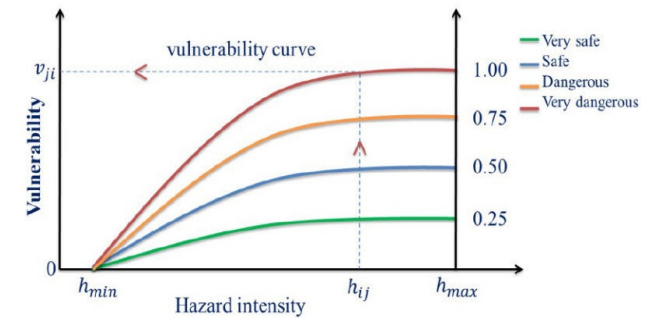
Missione 4 • **Istruzione e Ricerca**

HaMMon (Hazard Mapping and vulnerability Monitoring) : WP 4
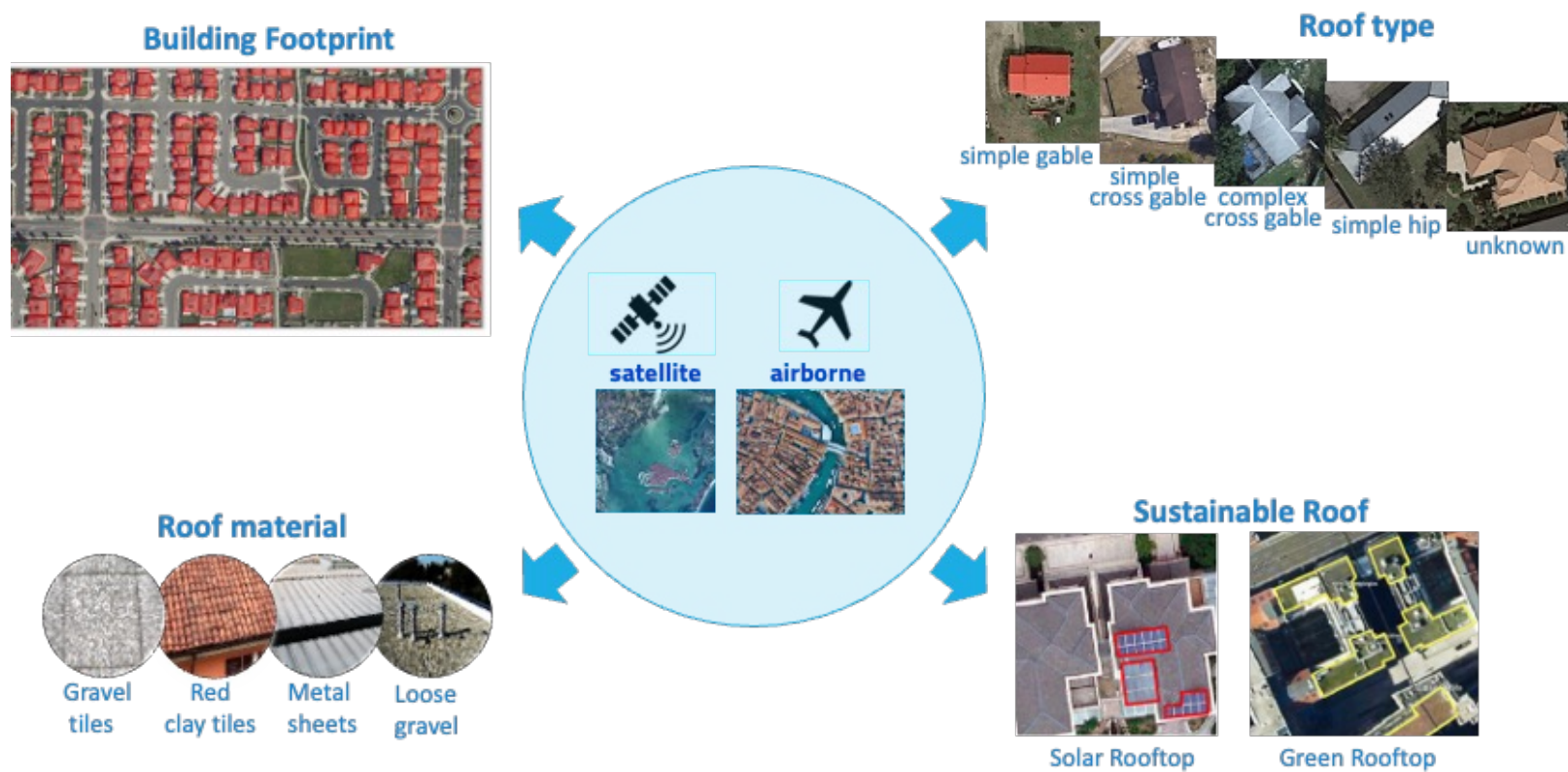
WP4 objective:

Developing vulnerability curves for flood, windstorm, hail, and seismic risks, utilizing the features of buildings that can be automatically identified from images through machine learning algorithms.
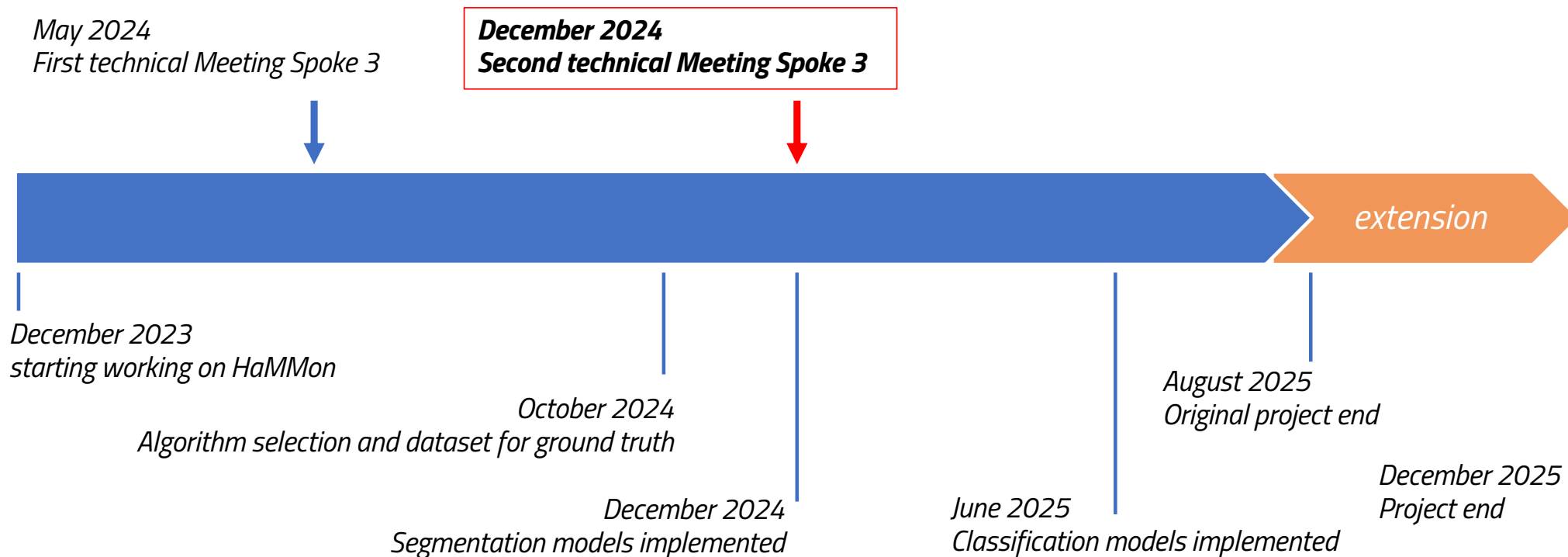
INAF focus on WP4

satellite   airborne

Street view images

vulnerability curve

- Very safe
- Safe
- Dangerous
- Very dangerous

Vulnerability

v_{ji}

1.00

0.75

0.50

0.25

h_{min} Hazard intensity h_{ij} h_{max}

AI solutions for automatic extraction of building features

Building Footprint

Roof type

simple gable

simple cross gable

complex cross gable

simple hip

unknown

satellite   airborne

Roof material

Gravel tiles

Red clay tiles

Metal sheets

Loose gravel

Sustainable Roof

Solar Rooftop

Green Rooftop

WP4 Milestones with timelines

May 2024
First technical Meeting Spoke 3

December 2024
Second technical Meeting Spoke 3

extension

December 2023
starting working on HaMMon

October 2024
Algorithm selection and dataset for ground truth

December 2024
Segmentation models implemented

June 2025
Classification models implemented

August 2025
Original project end

December 2025
Project end

Recap of the First technical Meeting Spoke 3

Goals presented 6 months ago:

Evaluation of alternative solutions for image segmentation: pure convolutional (U-Net) or hybrid CNN with Transformer Networks (TransUnet)

Initial challenges:

acquisition of labeled dataset for investigating the effectiveness of ML approach
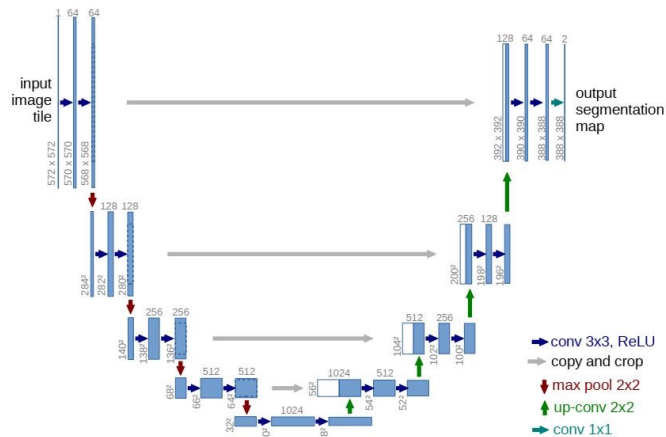
Ronneberger et al. "U-net: Convolutional networks for biomedical image segmentation." *Medical image computing and computer-assisted intervention– MICCAI 2015: 18th international conference*
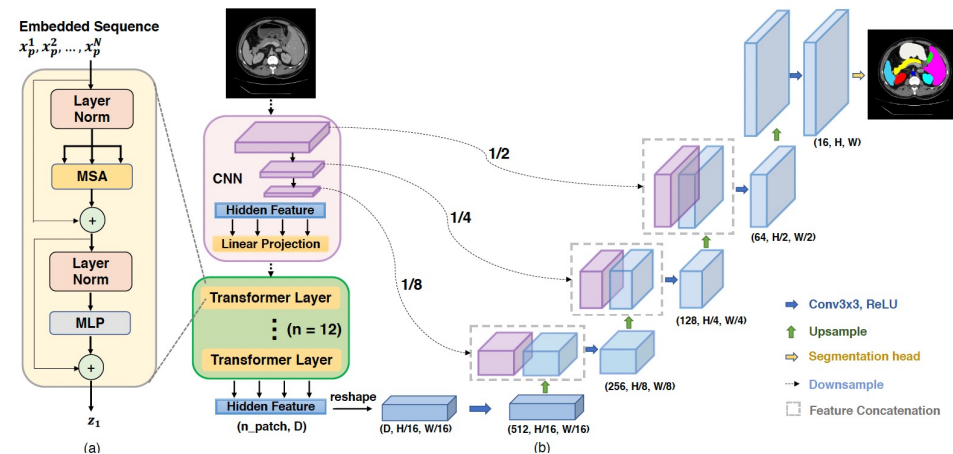
Chen, Jieneng, et al. "Transunet: Transformers make strong encoders for medical image segmentation." *arXiv preprint arXiv:2102.04306* (2021).

Achievements Over the Past 6 Months: Algorithm selections

Semantic Segmentation

- Footprints/roof: Hybrid architecture (Unet architecture+Vision Transformers), such as TransUnet
- Solar panels/skylight: Hybrid architecture (Unet architecture+Vision Transformers)
- Fence: Hybrid architecture (Unet architecture+Vision Transformers)

Classification

- Roof type: Vision Transformer-based models like BEitV2 (Bidirectional Encoder representation from Image Transformers) and/or Convolutional Neural Networks (CNN) such as EfficientNet
- Roof material: CNN-based architectures

Achievements Over the Past 6 Months: Preliminary segmentation analysis

Benchmarking and testing of the selected segmentation model on public dataset

- 38 high-resolution airborne images (6000 ×6000 pixels)
- training dataset 24 images, testing dataset 14 images
- spatial resolution of 5 cm.
- Near-infrared (NIR), RGB, orthorectified imagery
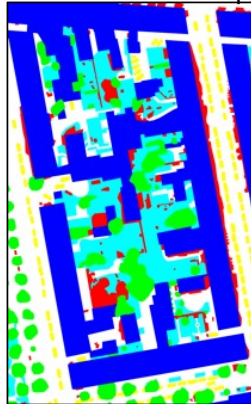- ground-truth comprising 6 classes
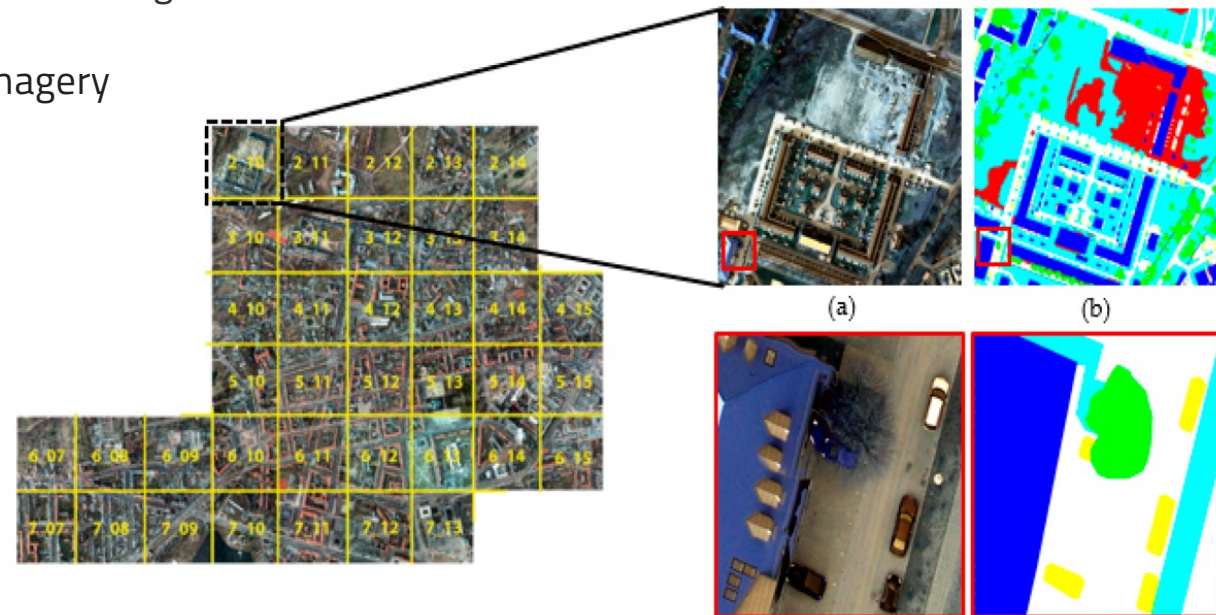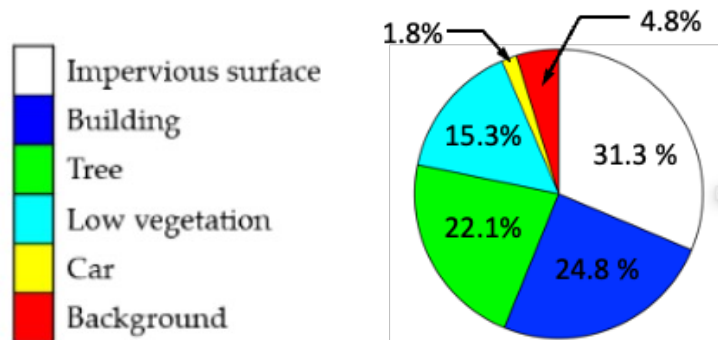
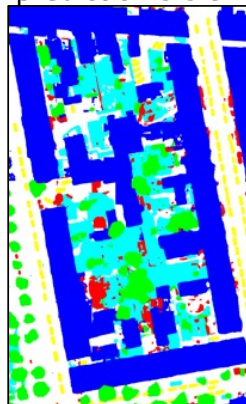# Achievements Over the Past 6 Months: Preliminary analysis
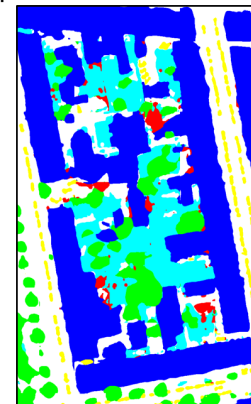
Comparison of performance across Resolutions

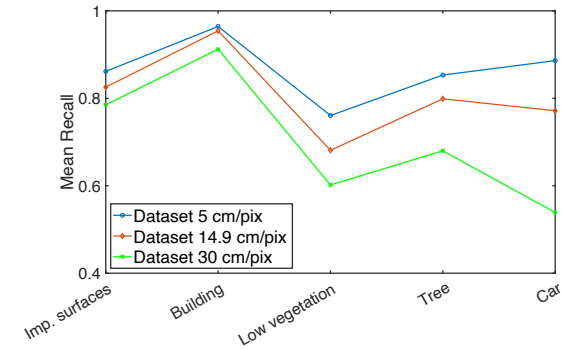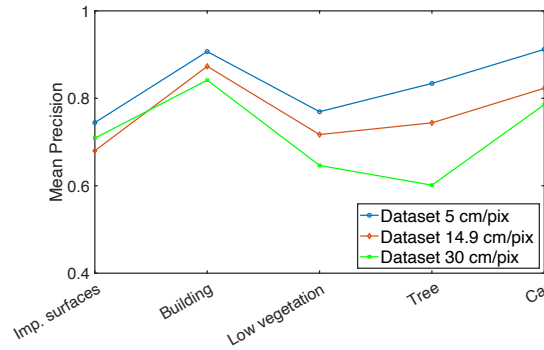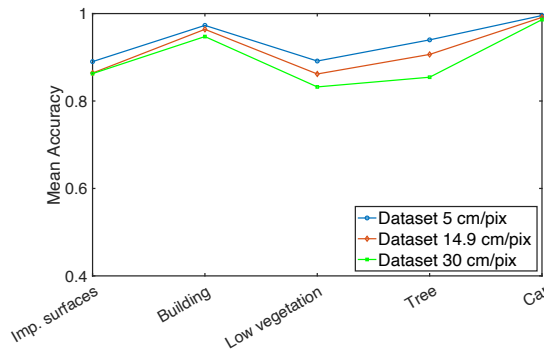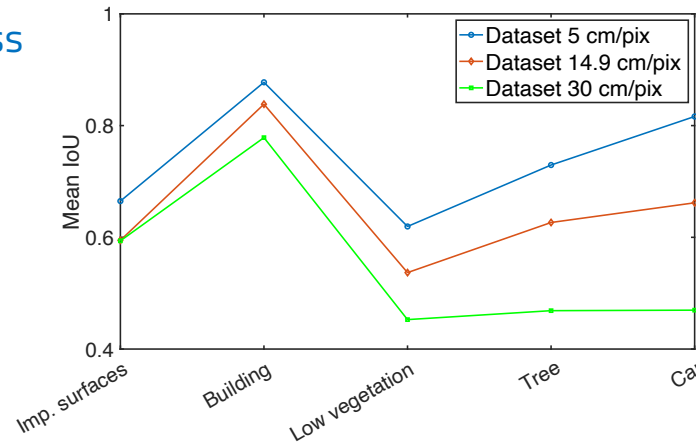ground truth 5.5 cm/pix   prediction 5.5 cm/pix   prediction 14.9 cm/pix   prediction 30 cm/pix
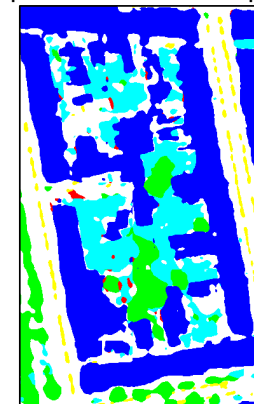
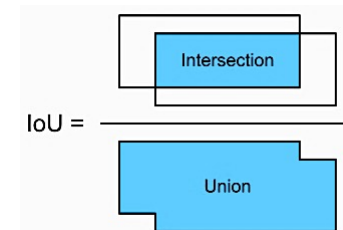# Achievements Over the Past 6 Months: Preliminary analysis

Comparison of performance across Resolutions

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

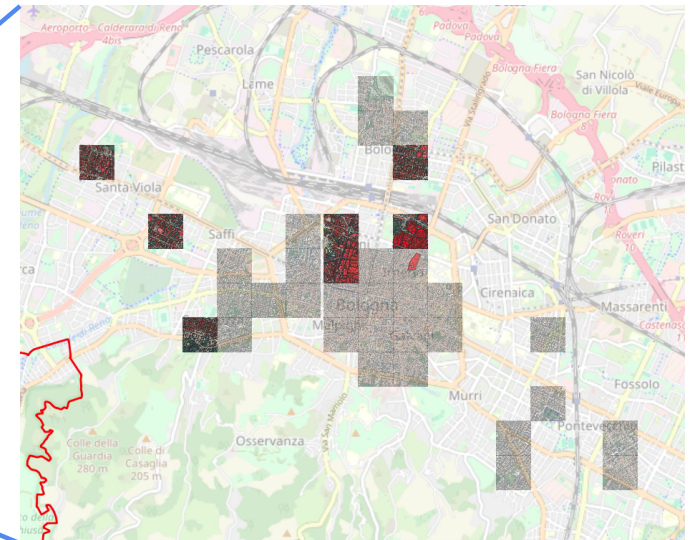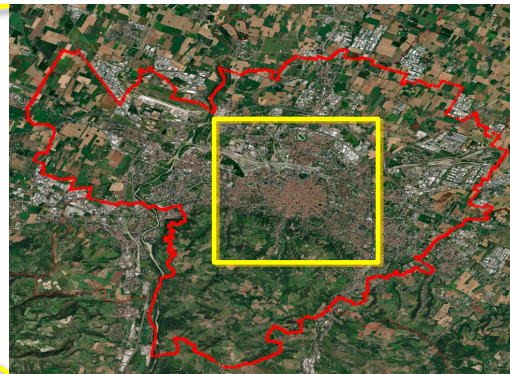$$\text{IoU} = \frac{\text{Intersection}}{\text{Union}}$$

Achievements Over the Past 6 Months: Preliminary analysis on on the region of interest (Municipality of Bologna)

Bologna HaMMon dataset:

- 36 images 4116x4116 pixels at 15 cm/pixel, total area ~ 13.7 km^2

- tagging completed on 6 images

Municipality of Bologna

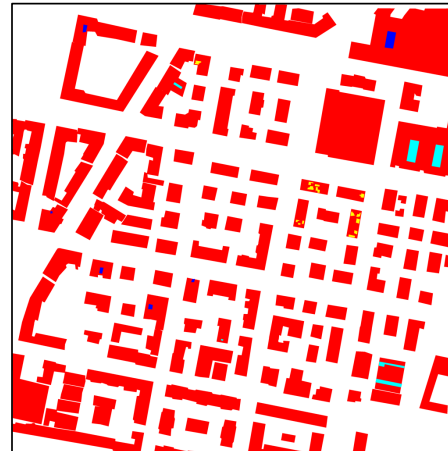# Achievements Over the Past 6 Months: Preliminary analysis on on the region of interest (Municipality of Bologna)

Bologna HaMMon dataset "very preliminary" results with TransUnet :
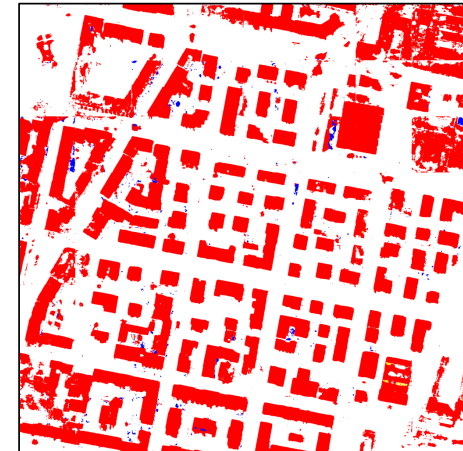
- training on 5 images
- testing on 1 image

ground truth

prediction

background

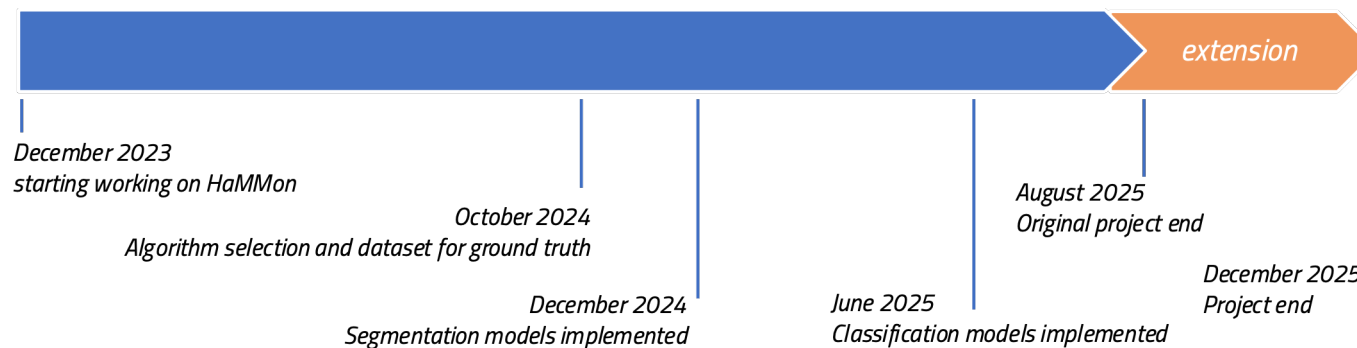solar panel

skylight

footprint

fence

Conclusions

Main achievements:

- Algorithms selection completed
- Segmentation network implemented
- Segmentation tested on the first batch of Bologna dataset images

Next steps:

- Testing of segmentation network on the full dataset of Bologna images
- implementation of networks for classification

extension

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Thanks for your attention!