ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

SUMMER SCHOOL WORKSHOP

ACTION 2020-2-21:
COPERNICUS
FOR CULTURAL HERITAGE

Cyprus University of Technology

DLR

AI meets EO: developments and perspectives in the analysis and preservation of CH through satellite imagery

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CENTER FOR CULTURAL HERITAGE TECHNOLOGY

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PARCO REGIONALE DELL'APPIA ANTICA
Ex Cartiera Latina - Via Appia Antica, 42

AI meets EO: developments and perspectives in the analysis and preservation of CH through satellite imagery

Summary

- Introducing EO data in CH study and management
- Why do we need AI?
- What are the requirements and objectives of AI applications to EO?
- Case studies
- Final remarks

Introducing EO data in Cultural Heritage management

- Identification of new archaeological sites
- Management of CH and landscape planning
- Identification and monitoring of archaeological sites impacted by looting

Introducing EO data in Cultural Heritage management

➢ Identification of new archaeological sites

Soil and vegetation act as 'markers' of subsoil archaeological deposits

- Altering the growth of vegetation
- Altering the colour of bare soil
- Altering the morphology of the terrain

These traces are visible 'at a distance' and can be recorded by satellite sensors

Introducing EO data in Cultural Heritage management

- EO data Time Series enables to:
  - check tentative sites over different seasons and environmental conditions
  - detect changes in the status of tentative sites
  - provide robustness of tentative sites' traces by multiple observations

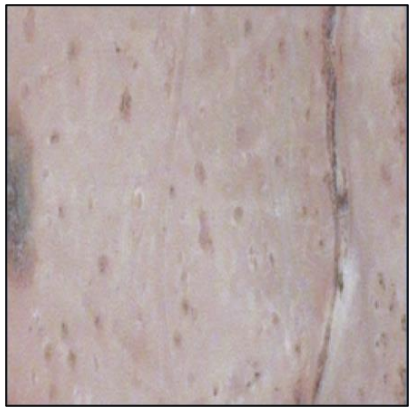
Introducing EO data in Cultural Heritage management

- Check large blocks of landscapes in a short timeframe
- Get a broader vision of the landscape
- EO can assist in adopting effective solutions for the management of Cultural Heritage and landscape planning

Introducing EO data in Cultural Heritage management

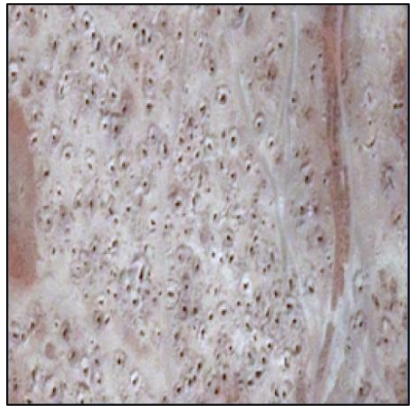
- Identification and monitoring of archaeological sites impacted by looting

26/05/2013

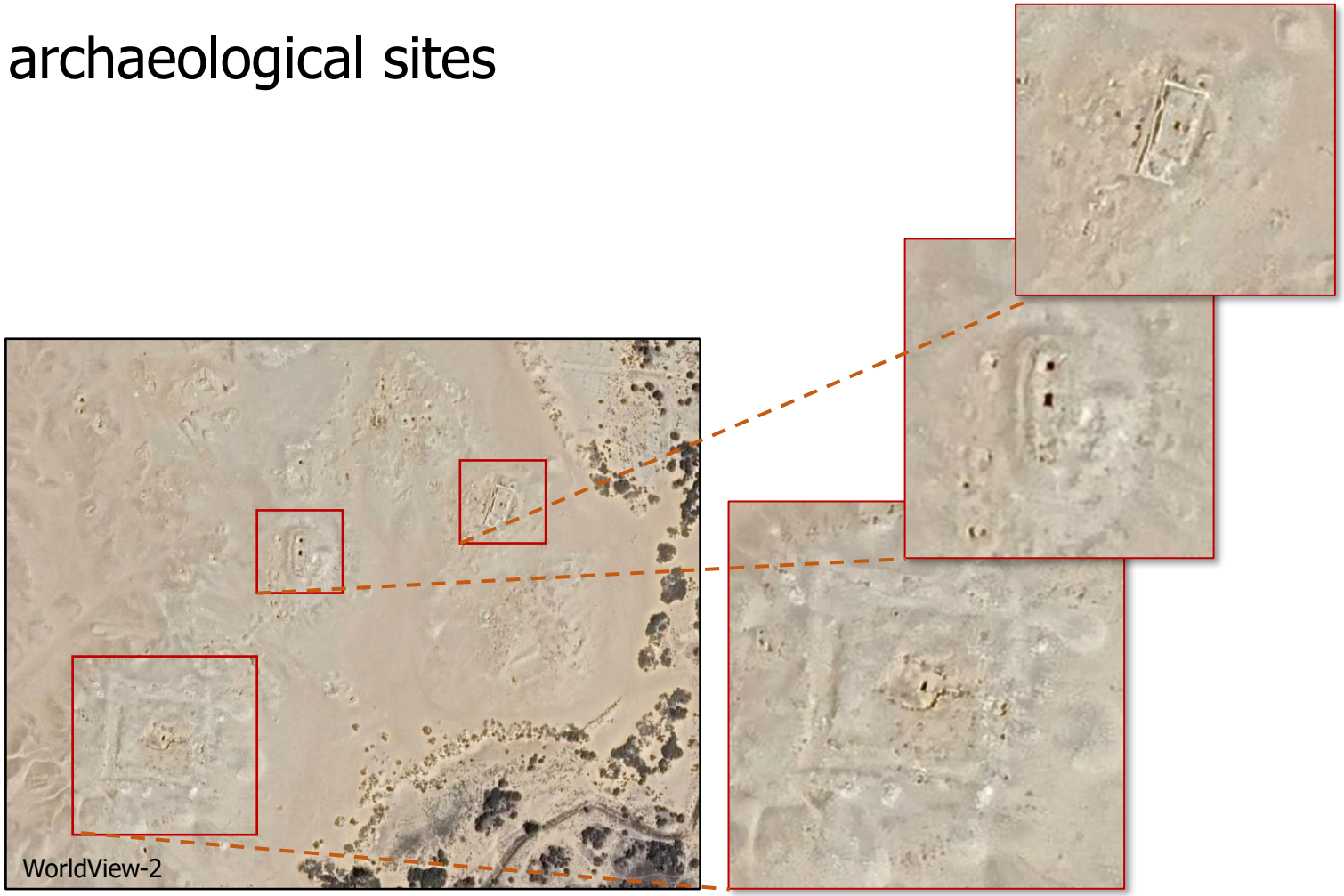


Pléiades

19/09/2014



Pléiades



Why do we need AI?

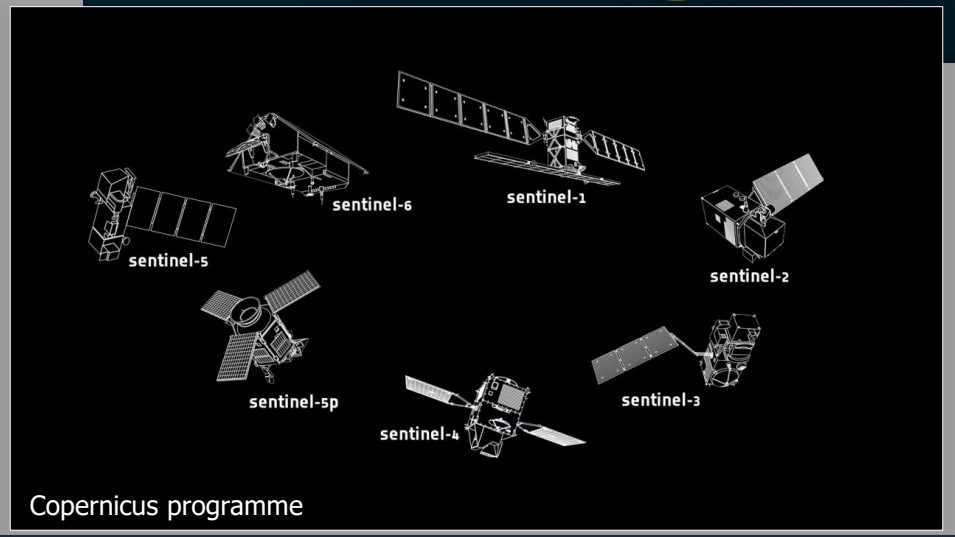
- Risk of data deluge

  - Availability of remote sensing datasets through platforms is unprecedented (e.g. Copernicus Open Access Hub)

- Data's enormous potential needs to be converted into useful information

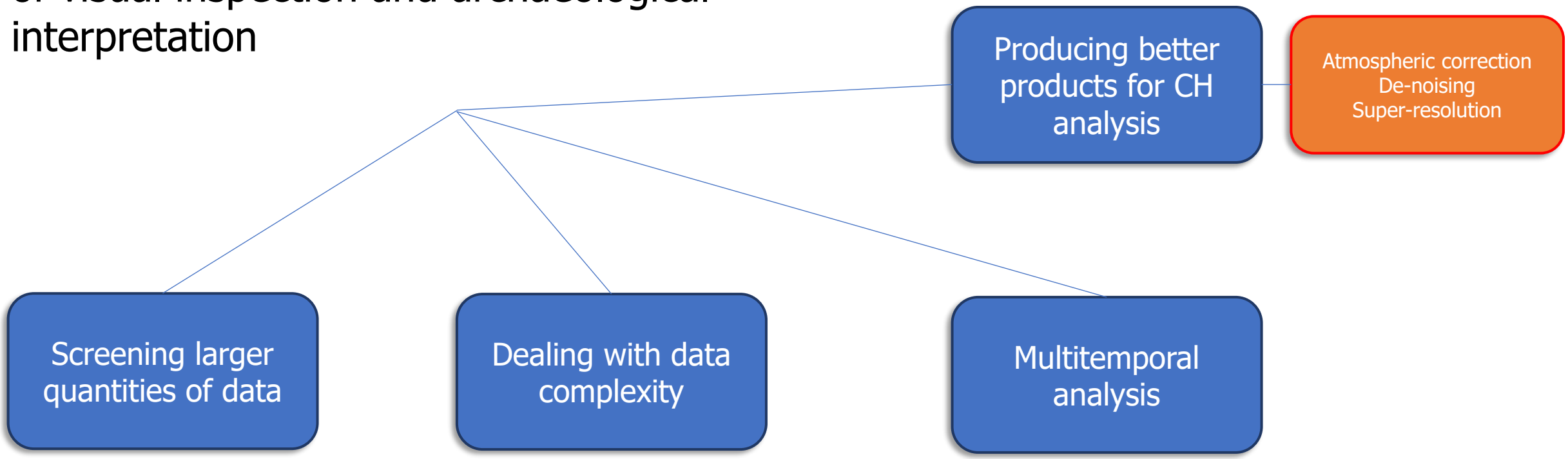
  - Dealing with larger areas and increased spatial and spectral resolution

  - Reducing processing time for near real-time applications



Why do we need AI?

- Automatic and semi-automatic analysis in support of visual inspection and archaeological interpretation

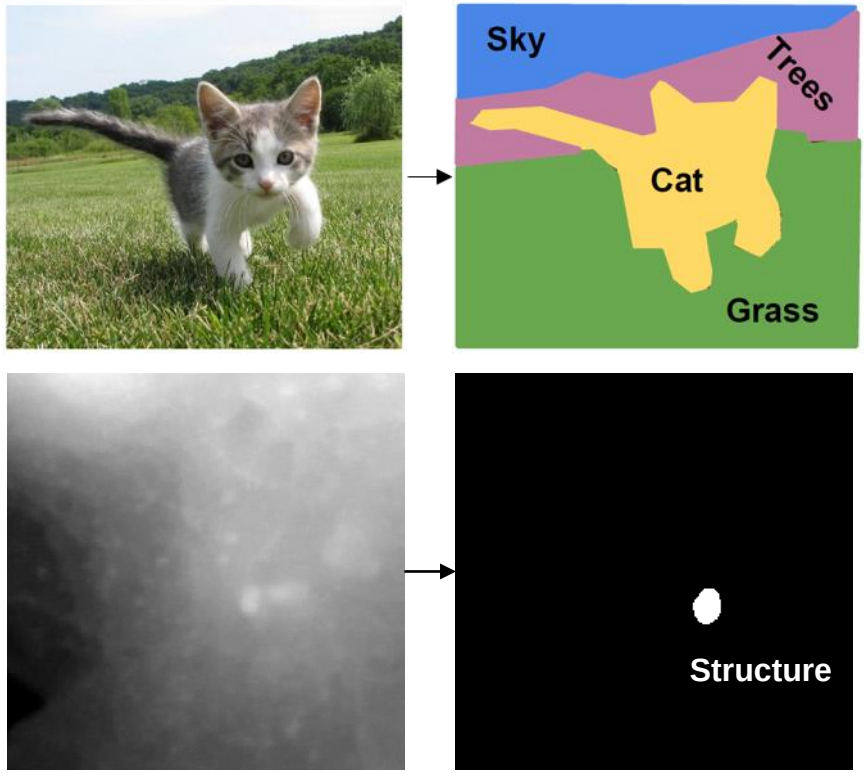


Requirements of AI supervised applications

- Large datasets of labelled data for training the models
  - Dataset creation is time-consuming and requires specialism in the field of application (i.e. archaeologists)
  - Transfer learning techniques from pre-trained models may not yield always good results
  - General purpose images (e.g. ImageNet, COCO datasets) are very different from remote sensing images
- Expertise in computer science

⇩

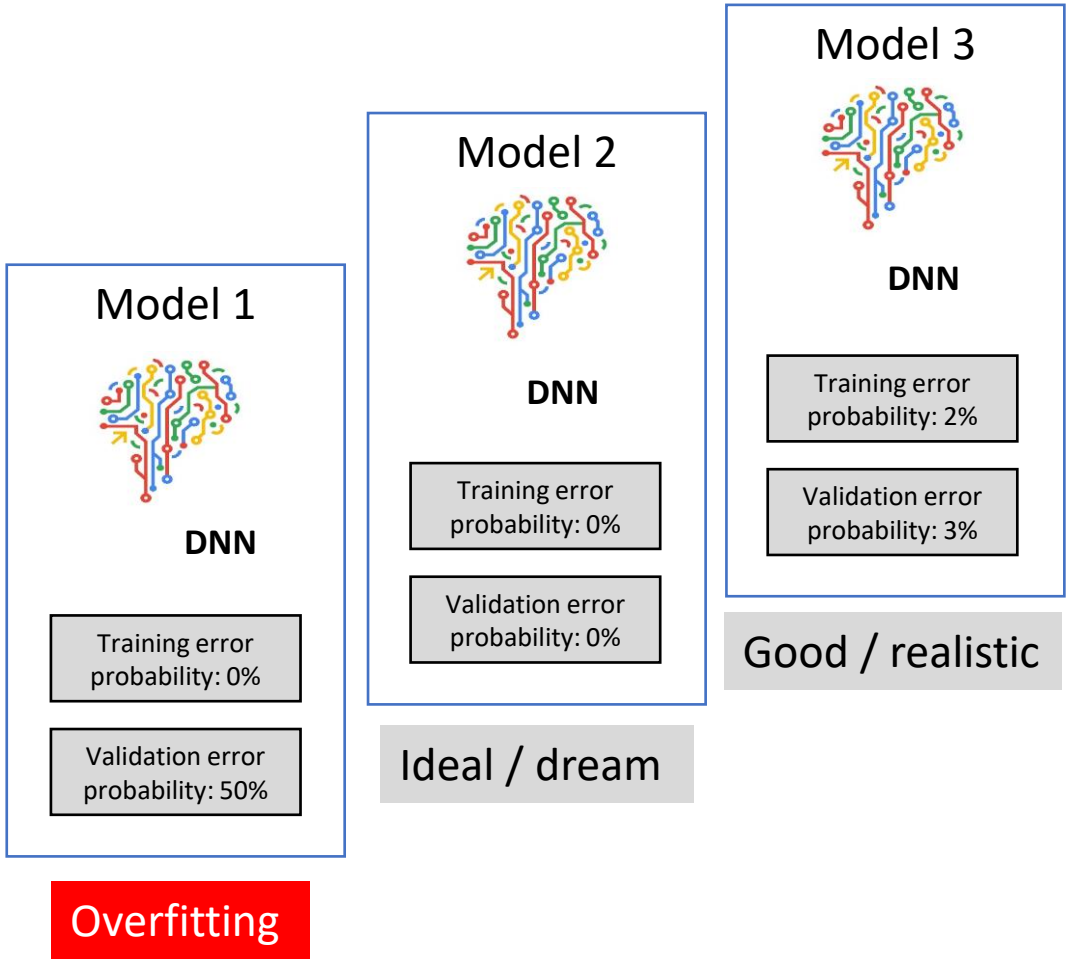
- Projects with synergic cooperations between archaeologists and computer scientists



Objectives of AI applications

- Model performance
  - How well the model is conducting a task

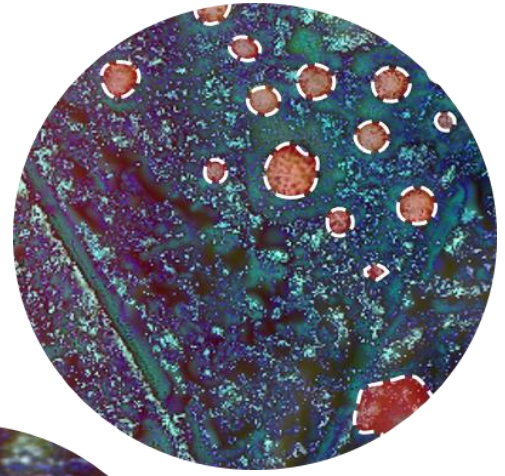
- Generalisation capabilities:
  - How well does the model perform on unseen data?
    - spatial-temporal splits (train-test set)
    - archaeological features with variable characteristics

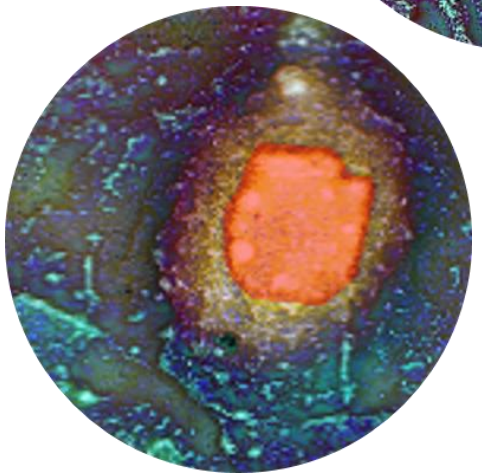


Case Study: CLS project

CLS (Cultural Landscapes Scanner)
funded by ESA

- Earth Observation and automated detection of subsoil undiscovered cultural heritage sites via AI approaches





CULTURAL LANDSCAPES SCANNER

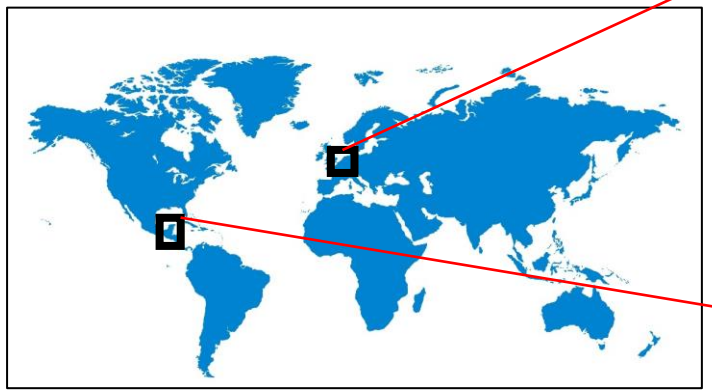
esa

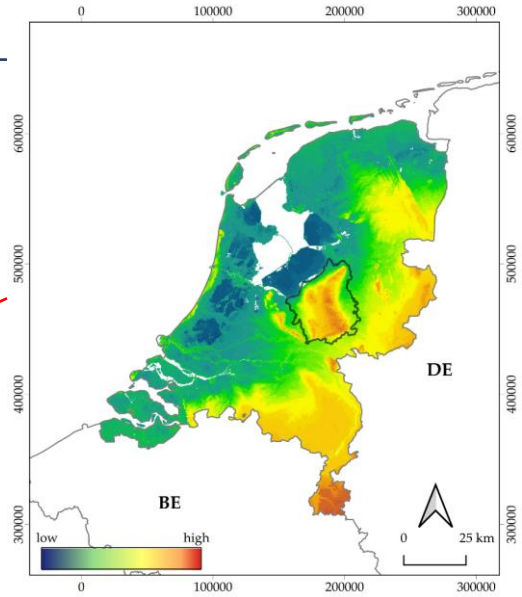
Sech G., Soleni P., Traviglia A., Verschoof-van der Vaart W.B., Kokalj Z., Fiorucci M. *Transfer Learning of semantic segmentation methods for identifying buried archaeological structures on LiDAR data*, IGARRS 2023.

Case Study: CLS project

Datasets

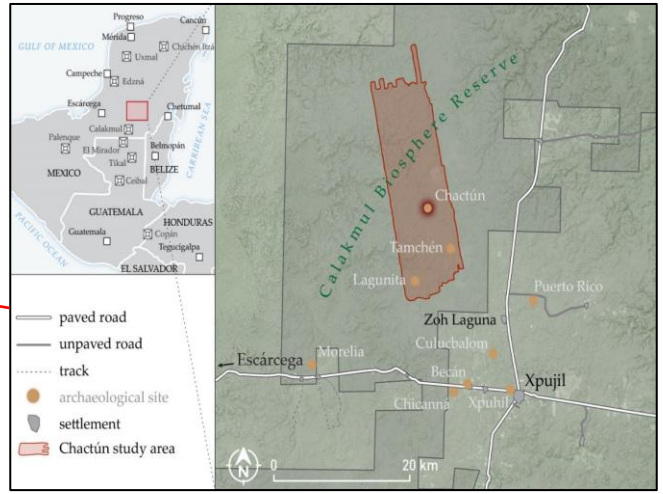
- LiDAR DTM 0,5m processed in Enhanced Multiscale Topographic Position (e2MSTP) visualization.
- Tiles of 256x256 pixels
- 3 classes of archaeological features / case study





1) De Hoge Veluwe National Park, Netherlands

Dataset from: Verschoof-van der Vaart at al. 2020 *Combining Deep Learning and Location-Based Ranking for Large-Scale Archaeological Prospection of LiDAR Data from The Netherlands*



2) Chactún, Campeche, Mexico

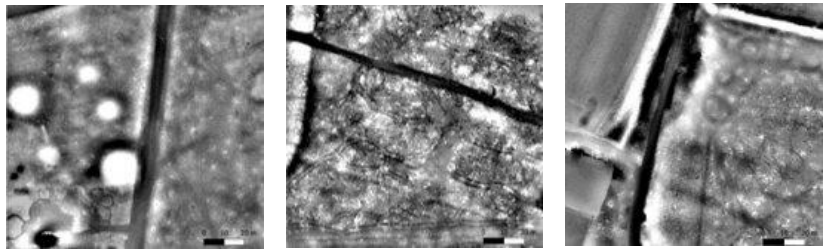
Dataset from: Somrak et al. 2020 *Learning to Classify Structures in ALS-Derived Visualizations of Ancient Maya Settlements with CNN*

Case Study: CLS project

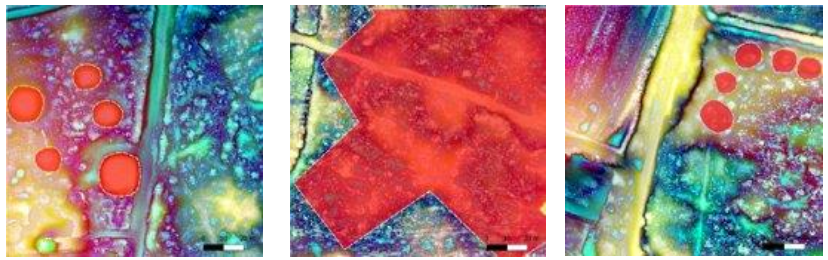
Veluwe

Archaeological class

LiDAR LRM

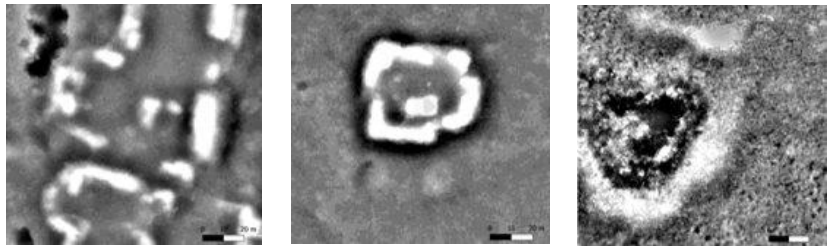


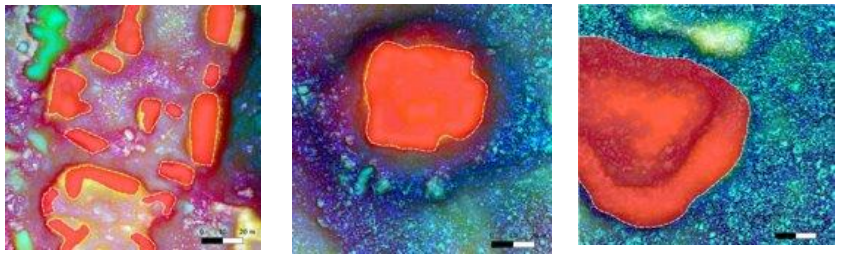
Segmentation masks on e2SMTP



Total: 3539 tiles divided in train-validation and test set (dataset 3k times smaller than ImageNet)

Chactún



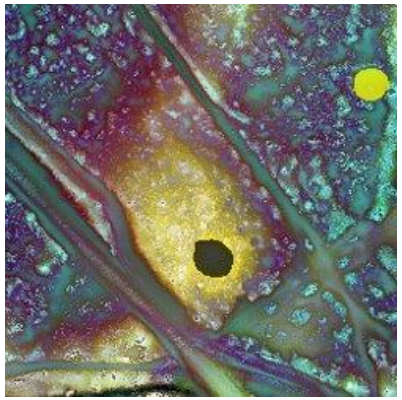


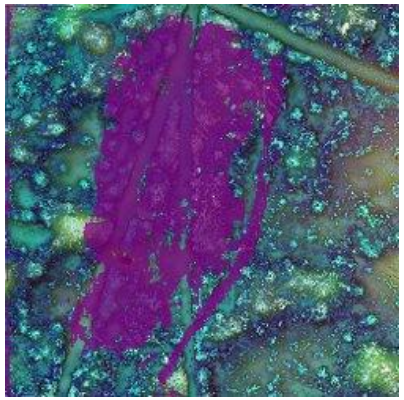
Total: 3868 tiles divided in train-validation and test set (dataset 3k times smaller than ImageNet)

Case Study: CLS project

Results

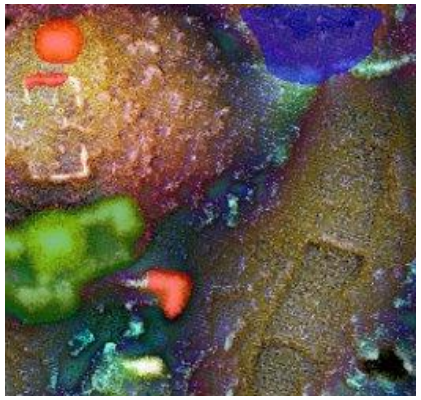
Veluwe



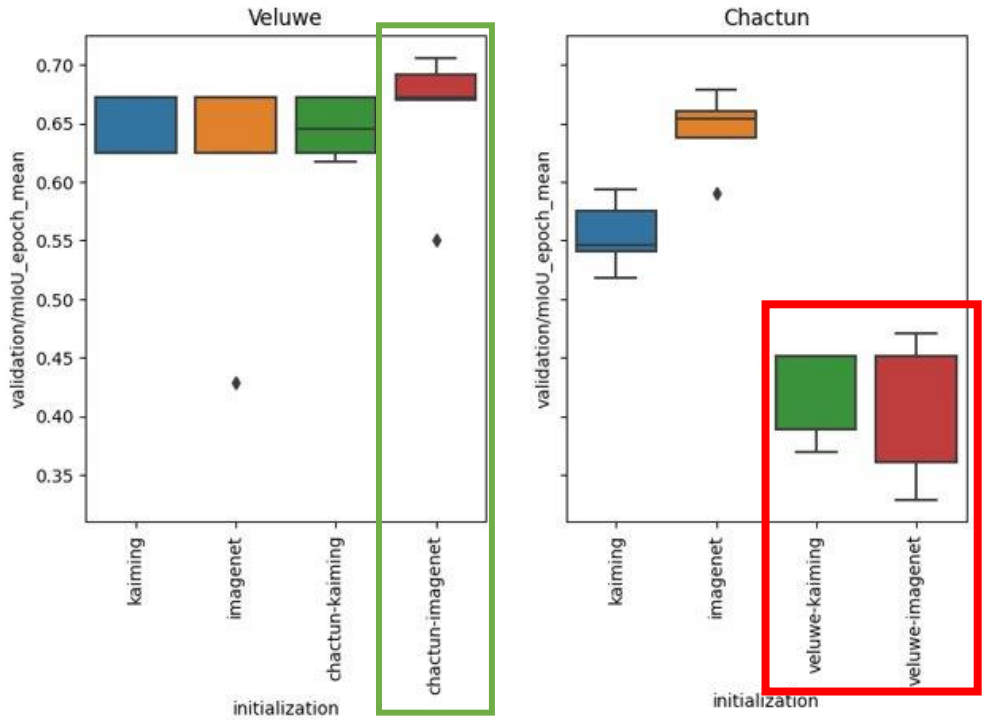


- Black: Barrow
- Yellow: Charcoal Kiln
- Purple: Celtic Fields

Chactùn:



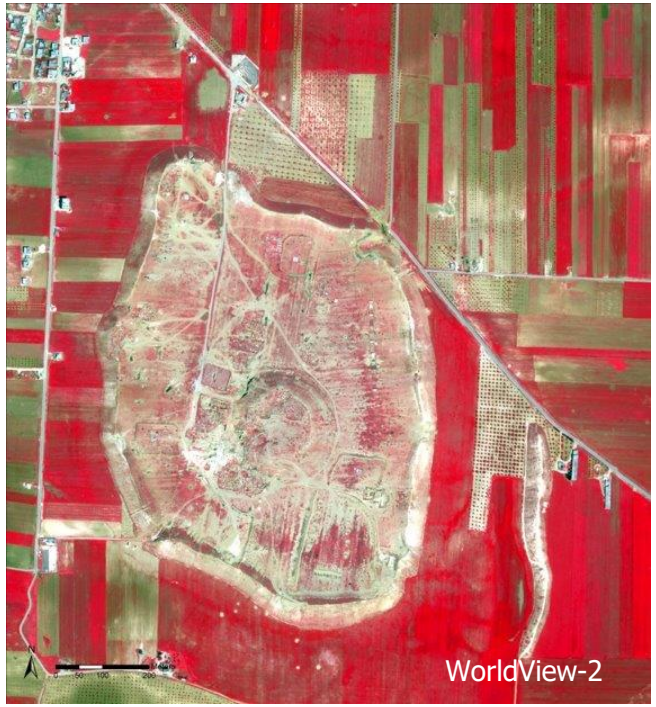
- Green: Platform
- Orange: Building
- Blue: Aguada



Case Study: ALCEO project

ALCEO (Automatic Looting Classification from Earth Observation)
funded by ESA

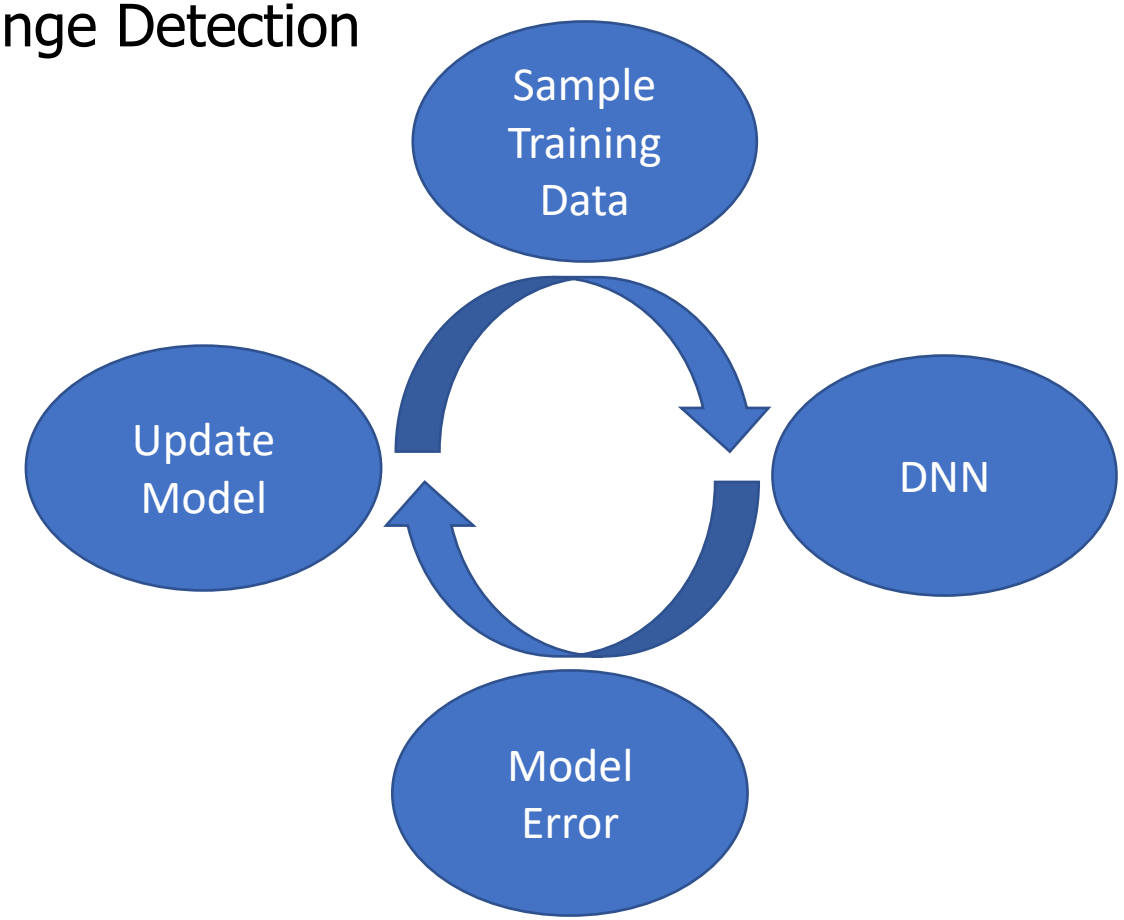
- Development of Artificial Intelligence methods for the automatic identification and classification of cultural heritage looted sites on EO data
- The aim is to provide intelligence on ongoing and past criminal activities and develop advanced methodologies to be also applied to other areas of surveillance

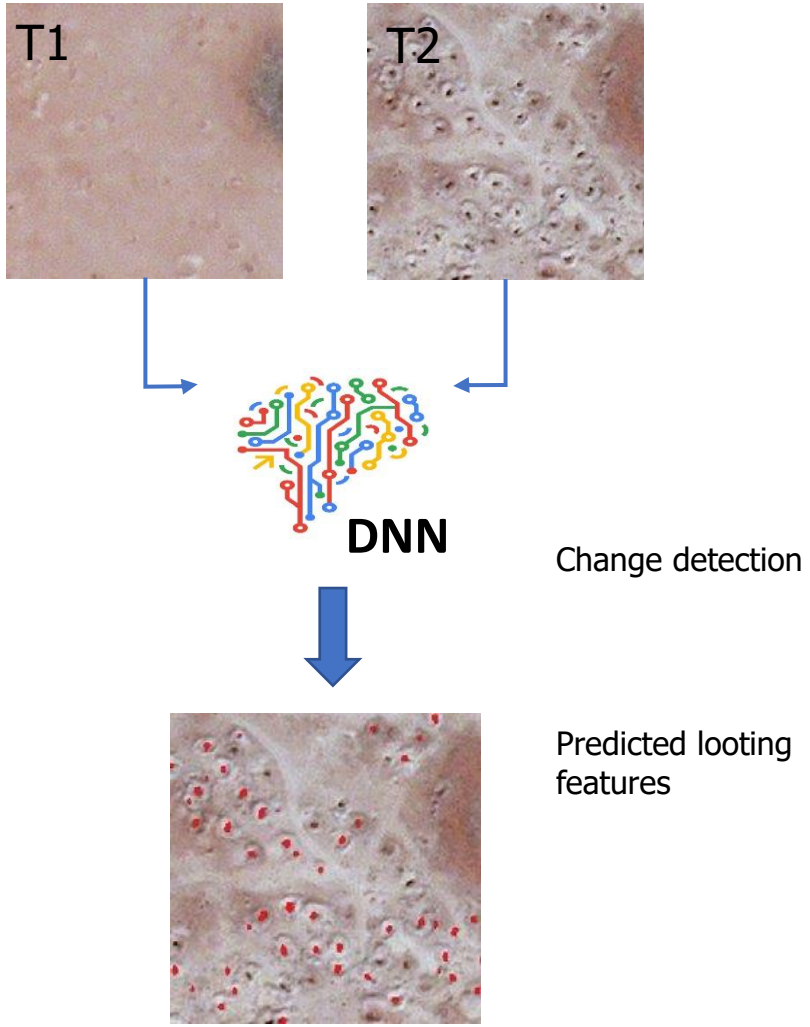


Credits to Gregory Sech, Maria Cristina Salvi and Ayesha Anwar

Case Study: ALCEO project

Supervised Deep Neural Network for Change Detection

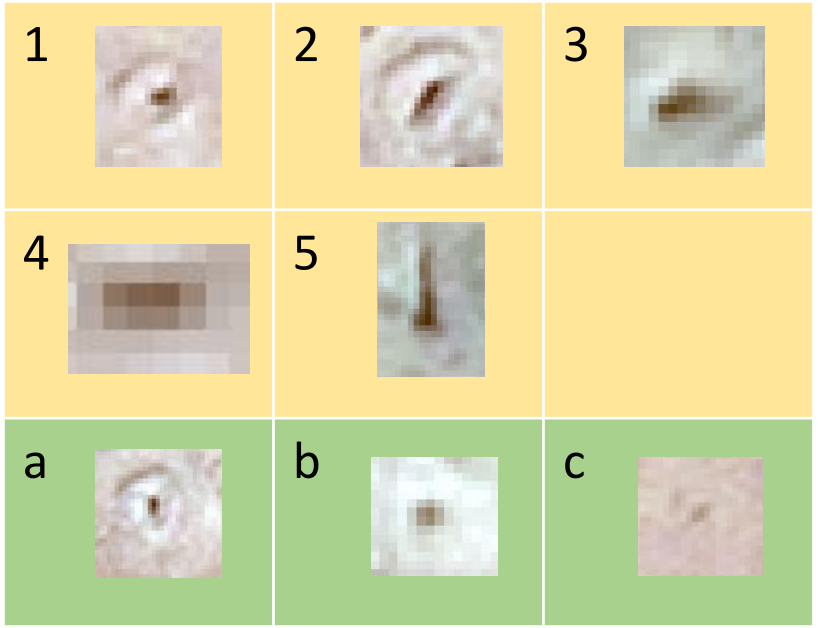




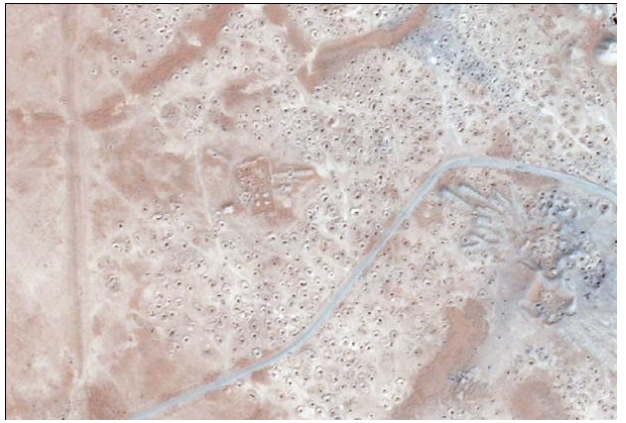
Case Study: ALCEO project

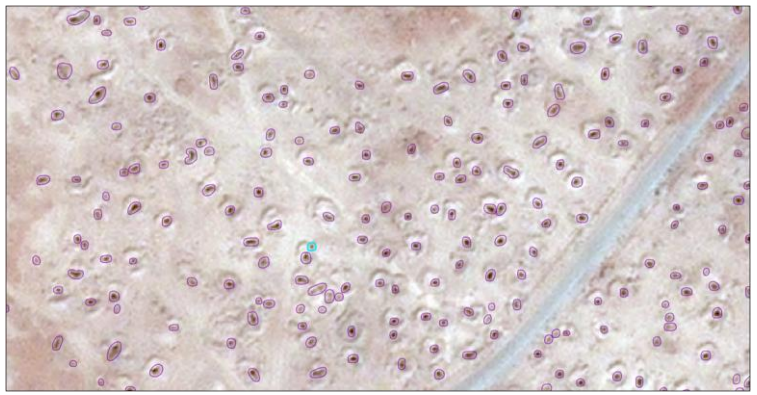
Building a training dataset for looting

- Date of acquisition
- Site name
- Pit appearance
  - 1)Pit
  - 2)Elongated Pit
  - 3)Extended Pit
  - 4)Trench
  - 5)Excavation
- Confidence Level
  - a)Highly likely
  - b)Likely
  - c)Uncertain
- Date of detection
- Operator



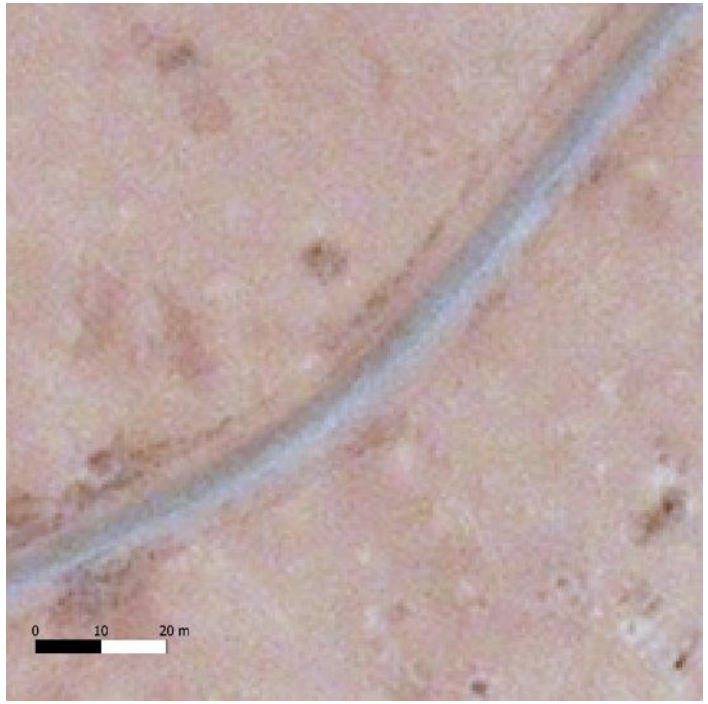
1-5: Pit appearance
a-c: Confidence level





Case Study: ALCEO project

Results



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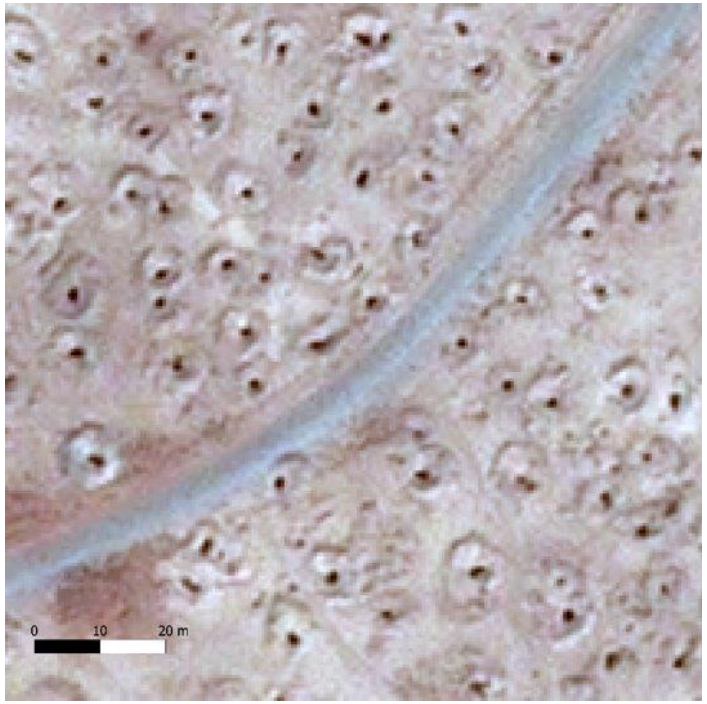

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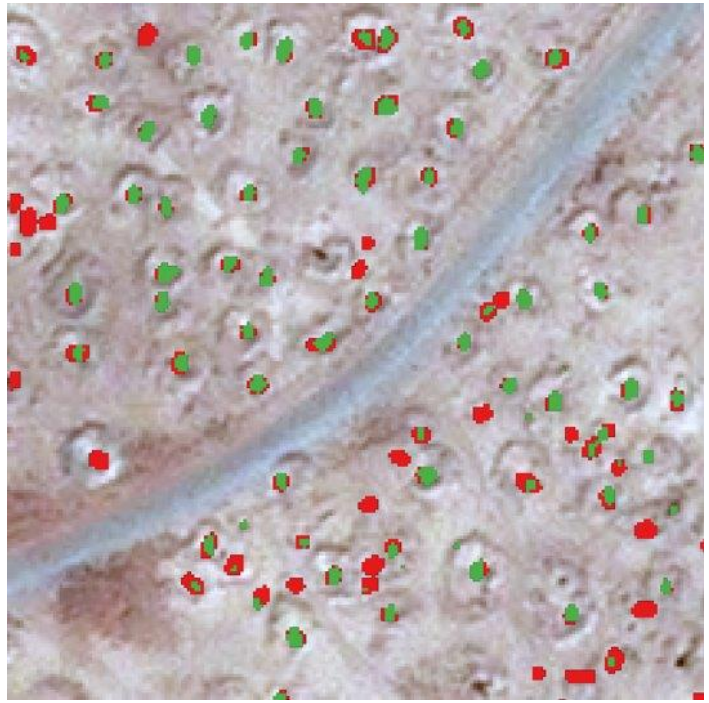

Neural Network segmentation masks: correct / error

Final Remarks

Future perspectives in AI applied to EO for CH management:

- Need to improve general sensibility in sharing datasets and models to enable the use of "archaeological" Transfer Learning
- More involvement of CH specialists in the "loop":

  - Speeding up and improve the quality of labelled datasets
  - Involvement in analysis and discussion of the results

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Thank you for your attention

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