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Od pixelů ke znalostem

Automatizace popisu archeologických fotografií pomocí počítačového vidění

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Archivy, knihovny, muzea v digitálním světě (AKM) 2025 (26. – 27. 11. 2025)

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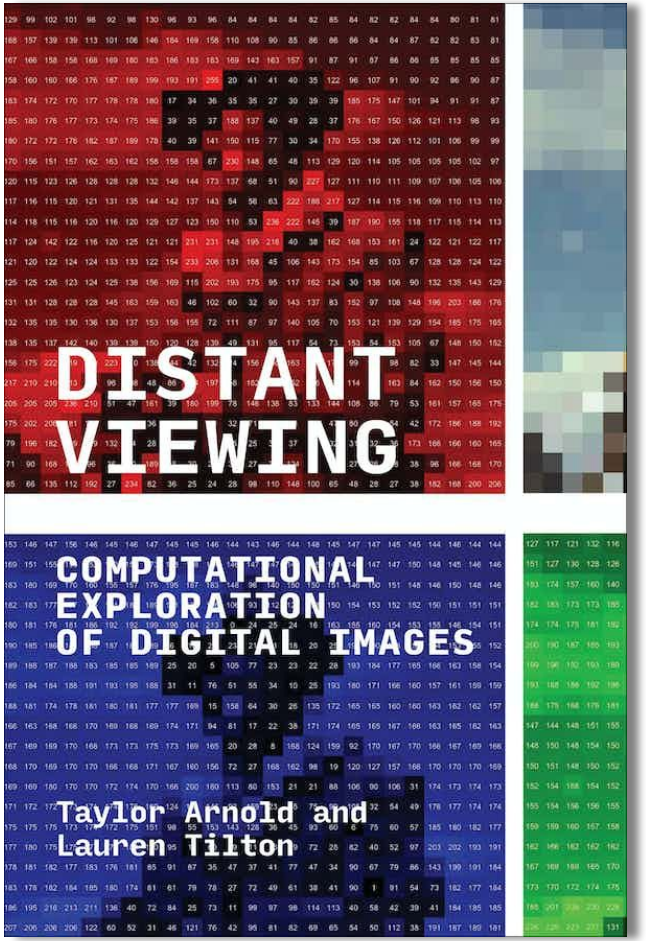
See poster for more information https://doi.org/10.5281/zenodo.17434302

Motivation and objectives

- **Manual processing** of archaeological archives is a tedious, time consuming, and **challenging task** prone to human errors and inconsistencies…
- This makes it a prime candidate for **automation**.
- Archives of **ARUP** & **ARUB** hold around:
  - **ca. 140k** documents, ie. **~1.5m** pages
  - **ca. 500k** of various photographs
- **Improve/enhance** metadata in the Archaeological map of the Czech Republic and ARIADNE services.

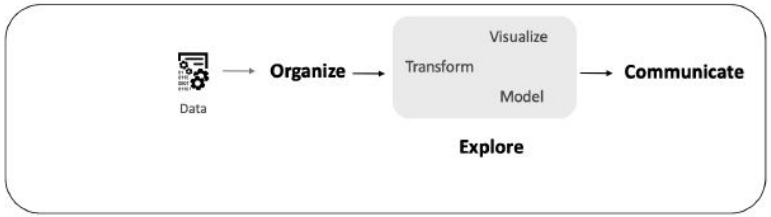
(Images: Archive of the Institute of Archaeology, Czech Acad. Sci, Brno)



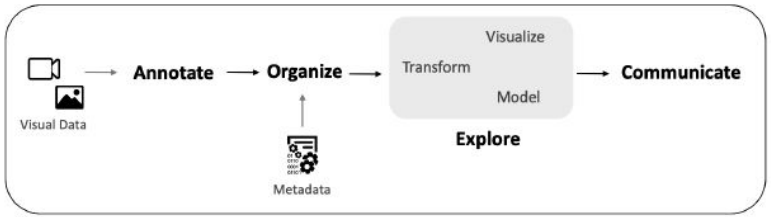
Distant viewing

*"The process of **distant viewing** applies **computer-vision algorithms** to **automatically interpret** a layer of **meaning within images** through the creation of **structured annotations**."*

Arnold & Tilton 2023: Distant Viewing. Computational Exploration of Digital Images. p. 25



Data Science Pipeline (Structured Data)



Pipeline for Distant Viewing

Fig 2.1, p 35

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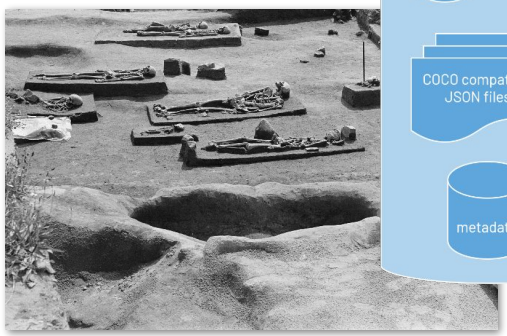
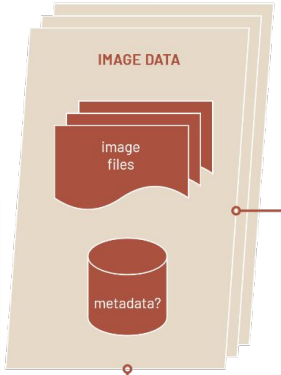
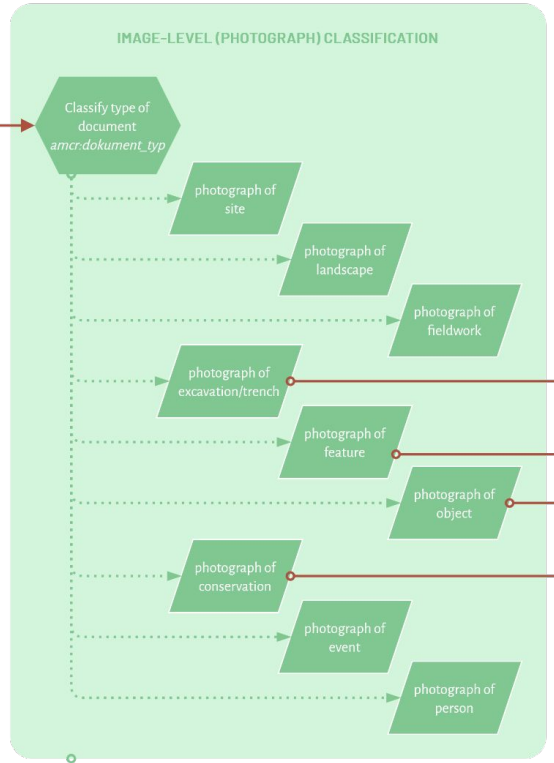
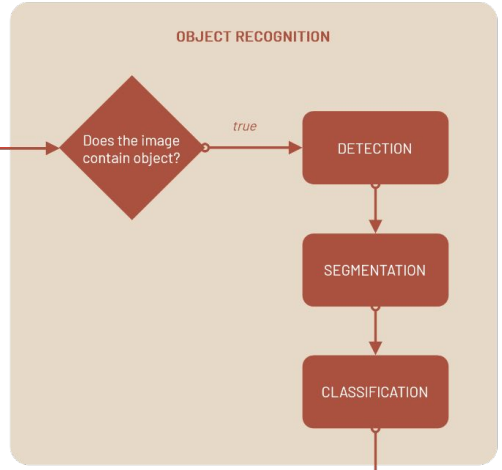
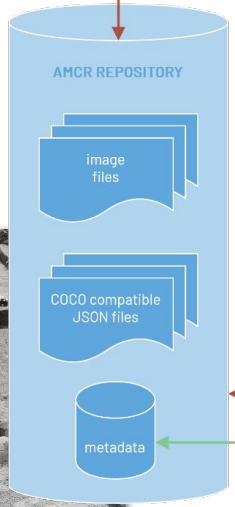
Workflow











(Image DOIs: 10.60585/M-FT-110736000, 10.60585/M-FT-660173300, 10.60585/M-FT-900144845)

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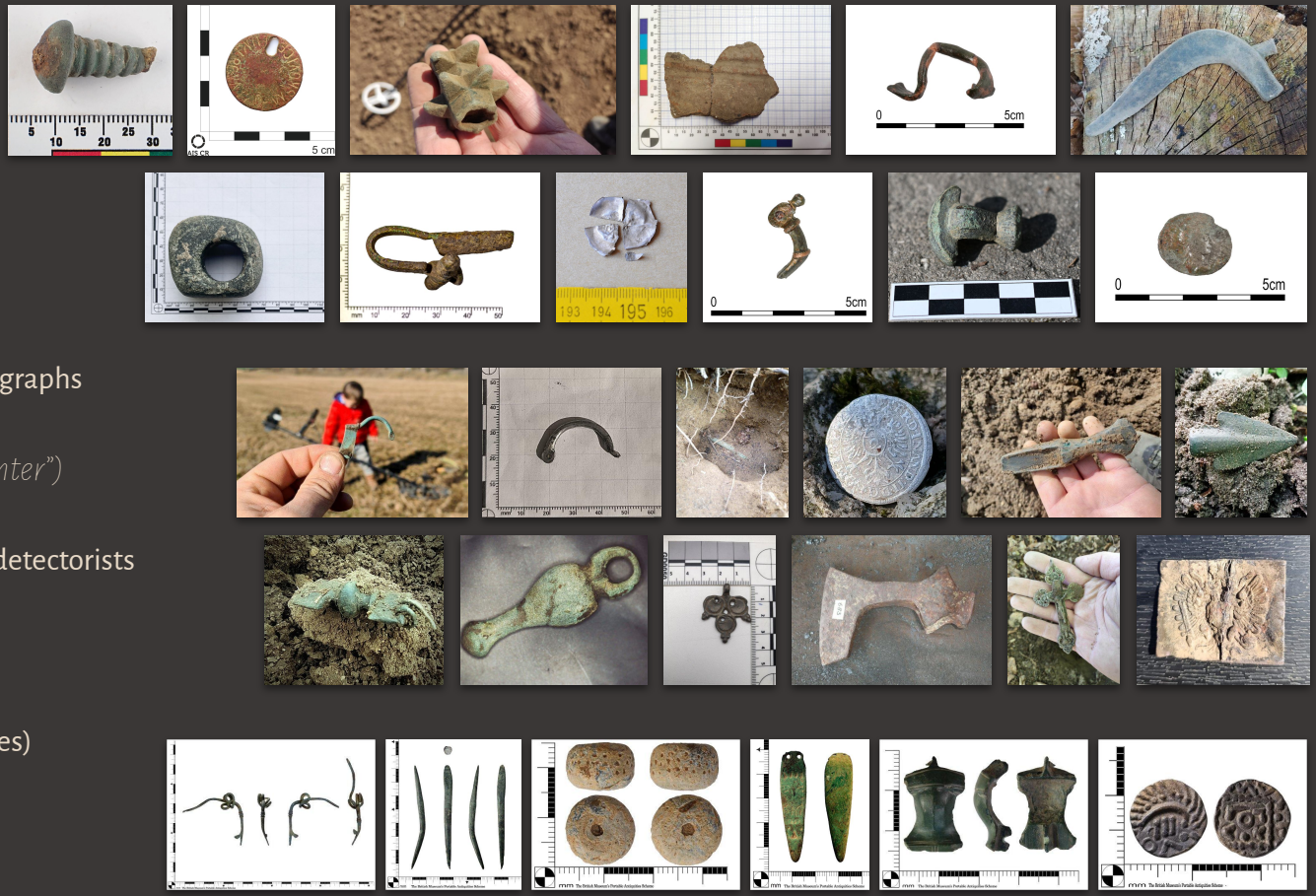
Datasets /1

*Photographs of **finds***

- *AMCR-PAS*
  - **>7.5k** finds, **~10k** photographs
- *"Lovec pokladů" ("Treasure hunter")*
  - **>300k** finds
  - photographs by metal detectorists
  - quality varies greatly
- *Portable Antiquities Scheme*
  - **>750k** finds (with images)
- *Montelius dataset*
  - includes drawings and images scanned from published resources



(Images: AMCR-PAS, Lovec pokladů, Portable Antiquities Scheme – PAS)

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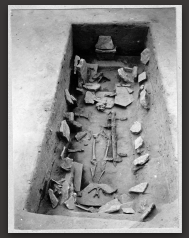
Datasets /2

*Photographs of **fieldwork***

- *ARUP digital photographs of fieldwork collection*
  - **>60k** photographs

- *ARUP & ARUB archival photographs*
  - **~300k** photographs
  - various scenes, fieldwork, people, finds, sites etc.
  - a lot of legacy b/w photographs

(Images: Digital Archive of the Archaeological Map of the Czech Republic)





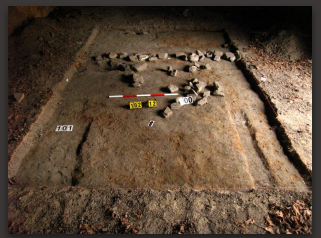












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Automatic Image Annotation Workflow

Copy to clipboard

Steps to fine-tune pre-trained image recognition model for domain-specific applications

This workflow outlines a process for fine-tuning a pre-trained image recognition model to enhance its ability to recognize specific object categories that are underrepresented or entirely absent in its original training dataset. The primary goal is to create a lightweight machine learning (ML) model capable of annotating images using terms from domain-specific controlled vocabularies. This facilitates more accurate and consistent image annotation in specialized contexts.

The workflow serves the dual purpose of improving the model's performance on domain-specific data and streamlining the image annotation process. By iteratively combining manual annotation, automated annotation using the fine-tuned model, and model re-training, the workflow supports efficient creation of

Details

ACCESS

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CATEGORISATION

Activity Annotating Segmenting Tagging Editing Machine Learning Pattern Recognition Storing

https://marketplace.sshopencloud.eu/workflow/G6ck4w

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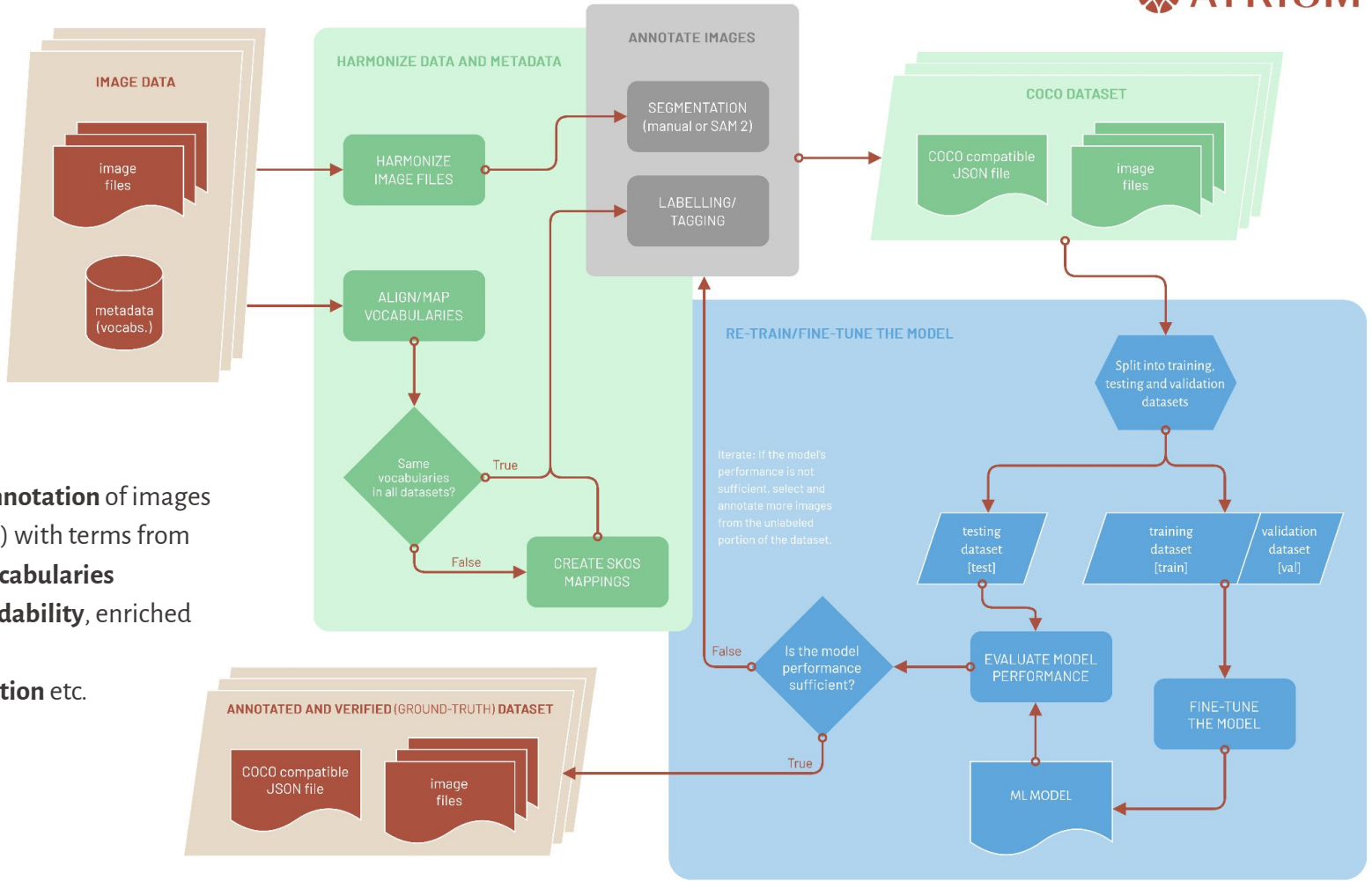
Training workflow



Goals:

- **Automatic annotation** of images (photographs) with terms from **controlled vocabularies**
- Enhanced **findability**, enriched **metadata**
- Object **extraction** etc.

Image data

Image data *come in all shapes and sizes…*

- Transform to a common bitmap format (JPEG)
  - TIFFs might be challenging (transparency, multi-page files etc.)
- 3-channel input expected (RGB)
- Further optimization depends on the model selection…

```python
def process_tiff_image(img: Image.Image) -> Image.Image:
    """Process TIFF images, handling multiple frames and bit depths."""
    # Count frames
    try:
        n_frames = 0
        while True:
            img.seek(n_frames)
            n_frames += 1
    except EOFError:
        pass

    # Return single-frame TIFF as is
    if n_frames <= 1:
        img.seek(0)
        return img

    # Find best frame (with most content)
    best_frame, max_std = 0, 0
    for i in range(n_frames):
        img.seek(i)
        std_dev = sum(abs(px - 128) for px in img.convert('RGB').convert('L').getdata()) / (img.width *
        if std_dev > max_std:
            max_std, best_frame = std_dev, i

    img.seek(best_frame)
    return img
```

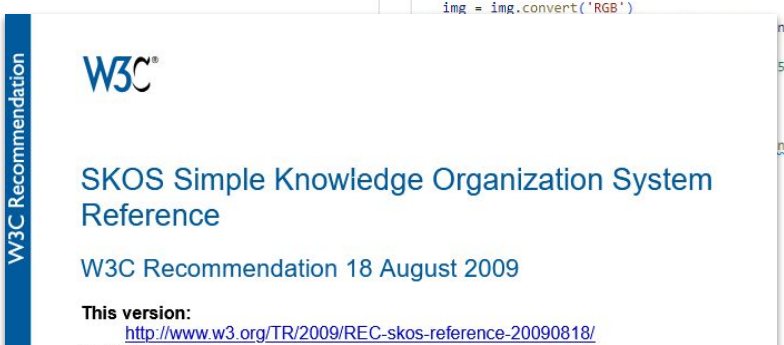
```python
def convert_image_mode(img: Image.Image) -> Image.Image:
    """Convert image to appropriate mode for JPEG saving."""
    original_mode = img.mode

    # Convert based on mode
    if original_mode in ('I;16', 'I'):
        img = img.point(lambda i: i * (255.0 / 65535.0)).convert('L')
    elif original_mode == 'F':
        img = img.convert('RGB')
```

```
nal_mode == 'P' and 'transparency' in img.info):

55, 255, 255))

nel('A'))
```

Alignment of controlled vocabulary terms

- skos:mappingRelation
  - skos:closeMatch
  - skos:**exactMatch**
  - skos:broadMatch
  - skos:narrowMatch
  - skos:relatedMatch

https://marketplace.sshopencloud.eu/workflow/yLX6Bd



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Annotation & segmentation

- CVAT (*Computer Vision Annotation Tool*) https://www.cvat.ai/
- Make Sense AI (https://www.makesense.ai/)

- Segment Anything Model (**SAM2**) Semantic segmentation https://ai.meta.com/sam2/

- Result: **COCO** compatible **JSON**

- Annotation of **AMCR-PAS dataset**
  - **9 762** images, **9 469** annotated (**~97 %**)
  - **10 749** objects (annotations)
  - speed: **~50** objects per hour


```
"annotations": [
    {
        "id": 1,
        "image_id": 1,
        "category_id": 1,
        "segmentation": [
            [
                555.0,
                682.0,
                548.0,
                683.0,
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                518.0,
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                492.0,
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                382.0,
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```


(Image DOIs 10.60585/M-FT-110736000 and 10.71928/M-202300087-N00394)

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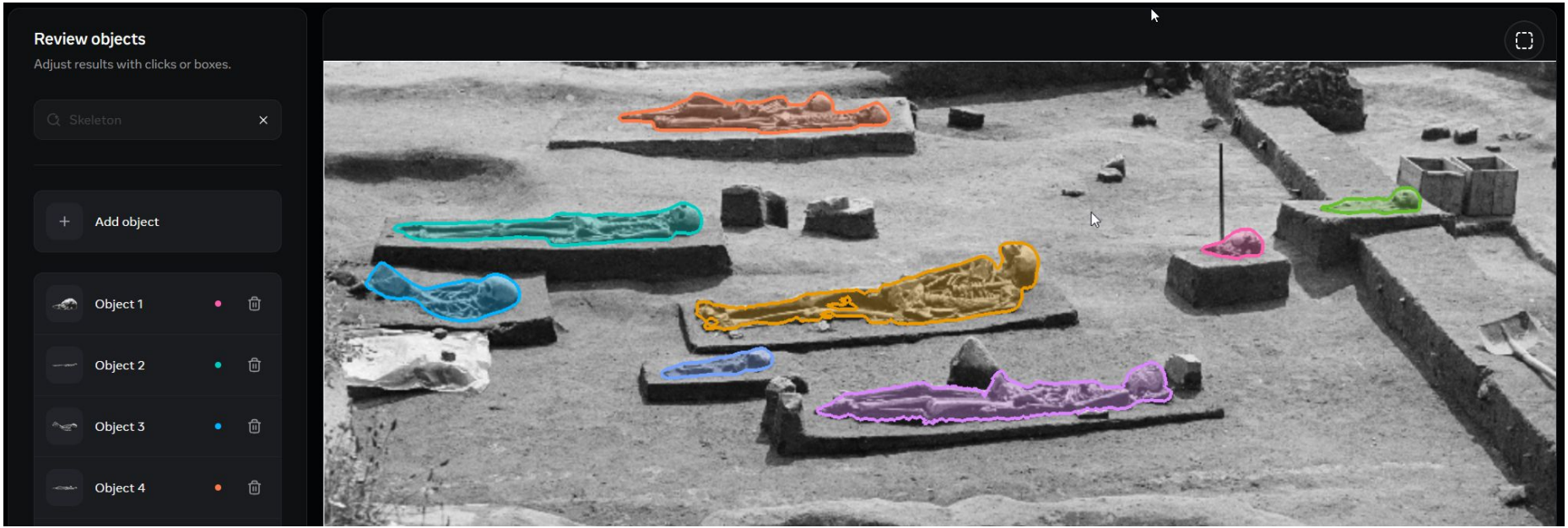
Sidenote

SAM3 (*Segment Anything Model*) by Meta (November 2025, https://ai.meta.com/sam3/) → text prompt



https://aidemos.meta.com/segment-anything

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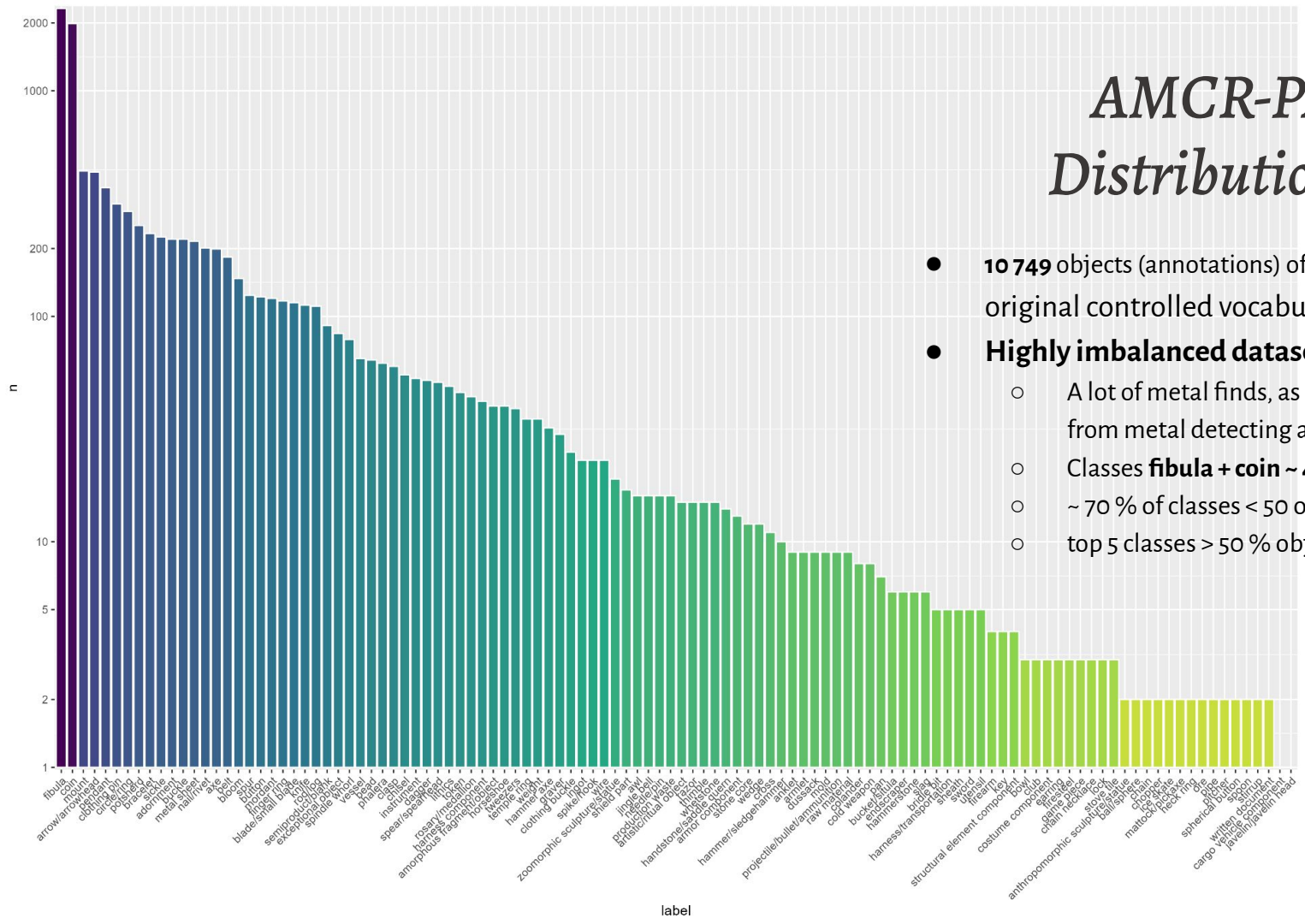
AMCR-PAS dataset: Distribution of classes



- **10 749** objects (annotations) of **112 classes**, original controlled vocabulary has *207 classes*...
- **Highly imbalanced dataset**
  - A lot of metal finds, as the dataset records finds from metal detecting activities.
  - Classes **fibula + coin ~ 40 % of the dataset**
  - ~ 70 % of classes < 50 objects
  - top 5 classes > 50 % objects

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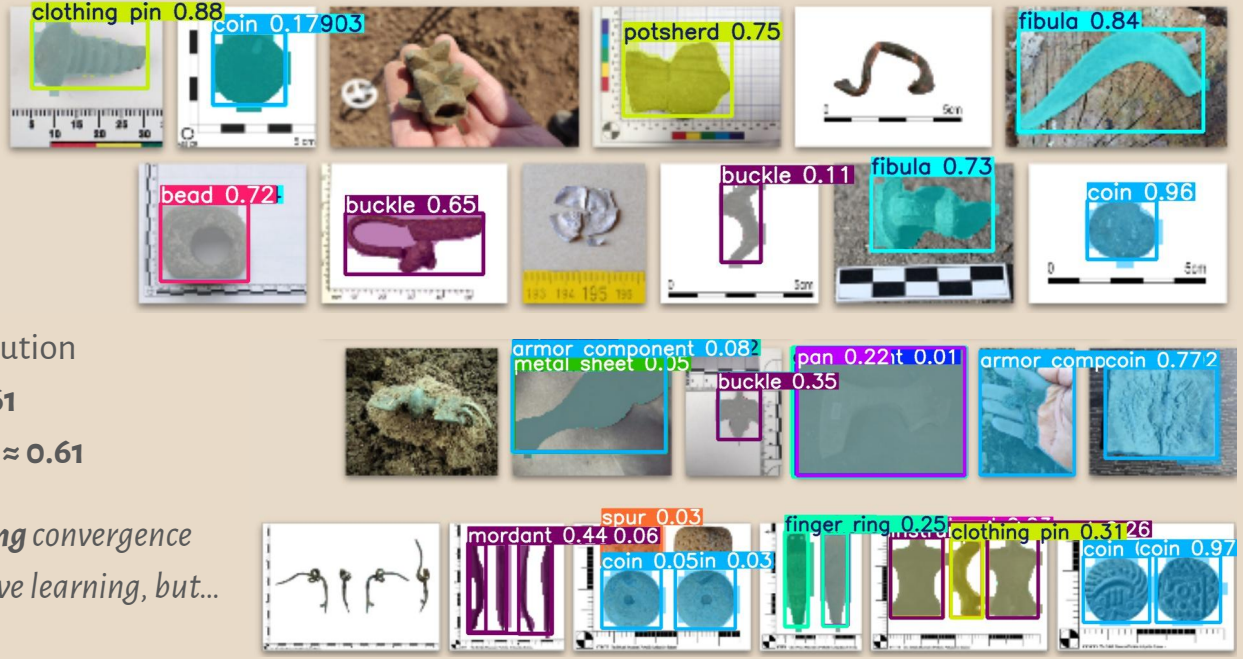
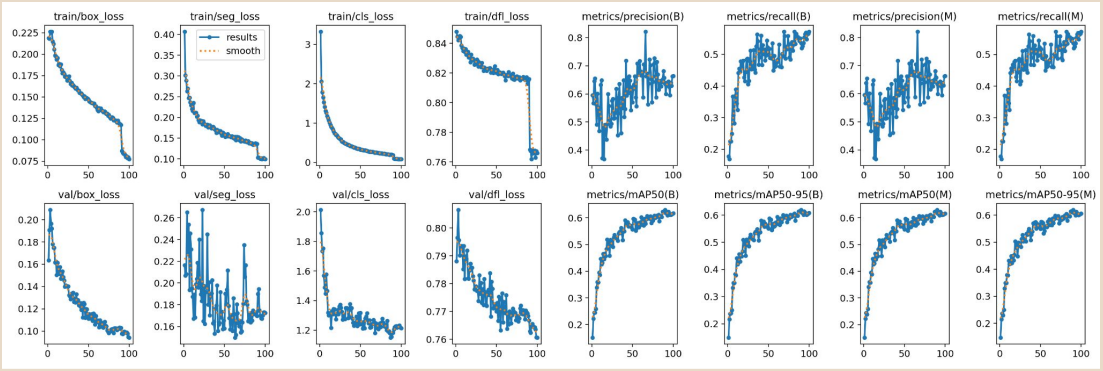
Training

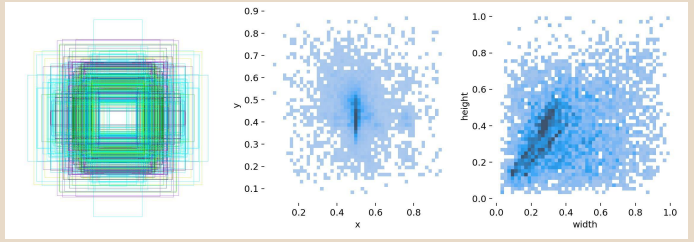
YOLO v11 seg., 100 epochs, PyTorch

- Best results with **340x340px** resolution
- Detection (BBox) **mAP50–95 ≈ 0.61**
- Segmentation (mask) **mAP50–95 ≈ 0.61**

*Pilot training sessions demonstrate **promising** convergence with steady loss reduction, indicating effective learning, but... the dataset is highly **imbalanced**!*







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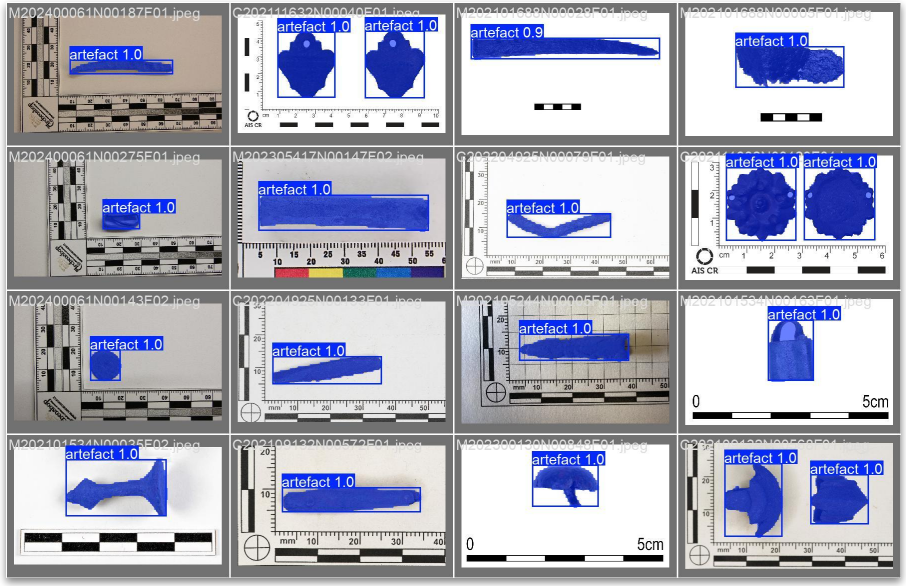
Next steps...

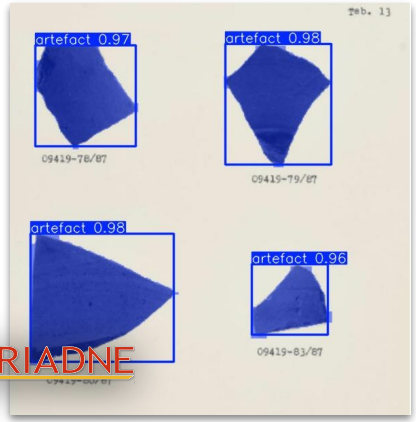
- **Continue annotation** of the datasets
  - ML models help with further annotations
  - *Ground-truth* datasets **grow**
- Deal with **imbalance** in the datasets
  - Data augmentation strategies/synthetic data
  - Class-aware sampling
- Cope with **variability** of angles and viewpoints
  - A fibula viewed from a *side* and from *top* looks very differently...
- *proceed, iterate...*

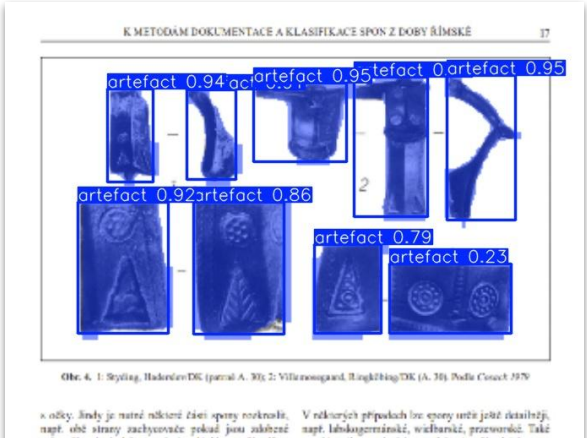


Planned results:

- *Workflow* – already published ✓

  https://marketplace.sshopencloud.eu/workflow/G6ck4w
- *Data processing 'pipeline' in* Archaeological map of the Czech Republic
- *Datasets* – published at the end of the project?
- *Code* – utilities for dataset curation etc., *soon?*
- *Enriched metadata in* Archaeological map of the Czech Republic *and* ARIADNE





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Thank you for listening!

For more information, please visit https://www.atrium-research.eu/

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