THE HERCULANEUM PAPYRI

Ink Detection in Volumetric X-ray Scans

REVIEW OF STATE-OF-THE-ART AND RESEARCH DIRECTION

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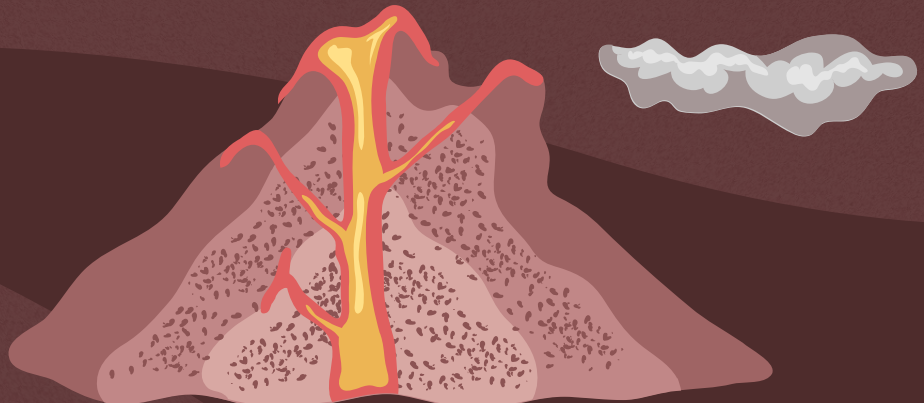


CONTEXT

Herculaneum papyri were carbonized in 79 CE

- Rolled and fragile
- X-ray micro-CT can image interior layers non-destructively
- Carbon-based ink = same density as papyrus, invisible to classical CT

Goal: detect ink from structural cues

CURRENT TECHNIQUES AND LIMITATIONS

Architectures:
- 3-D U-Net / ResNet encoders
- vFFC = 3-D convs + 3-D FFT for local + global frequency reasoning.
- Loss: weighted BCE + Dice

Dataset:
- EduceLab-Scrolls fragments(CT + IR ink maps)

Shortcomings:
- Depth misalignment
- Over-mixing in spectral bottleneck
- Few geometry cues(sheetness, normal)
- Heavy reliance on ensembles

Benchmarks:
- $F_{0.5}$ score, pFM, PSNR

2016

First virtual unwrapping - En Gedi scroll

2019

Showed carbon ink alters papyrus micro-structure

2023

Released open CT dataset + benchmarks

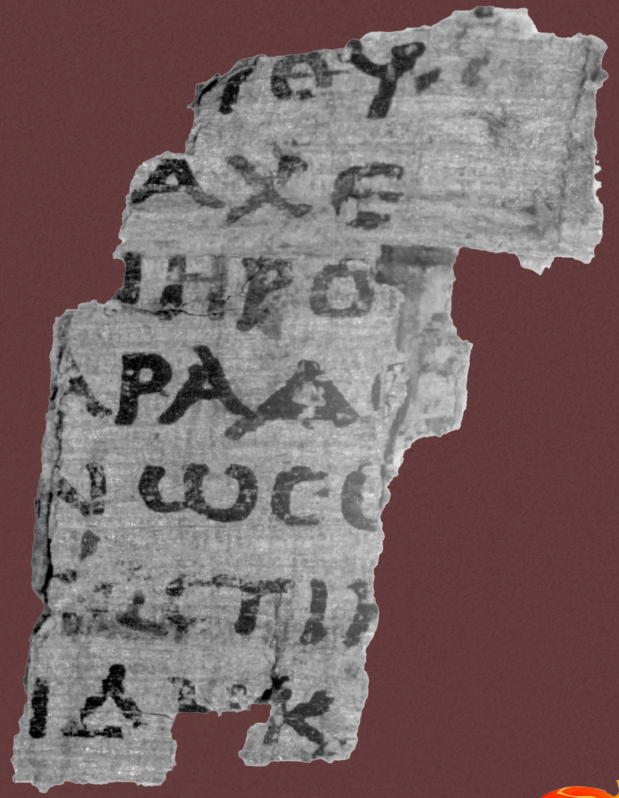
2023

vFFC – Volumetric Fast Fourier Convolution baseline

RESEARCH GAP

Existing models ignore geometric structure and positional drift of the papyrus sheet

- Can geometry-aware channels (sheetness, normals, thickness) improve $F_{0.5}$ on fragment 1 versus the vFFC baseline?
- Does simple depth-roll augmentation make the detector more robust to misaligned layers?



EXPECTED OUTCOME

- Train and reproduce the baseline vFFC ink-detection model on EduceLab-Scrolls data
- Quantify which cues boost carbon-ink detectability
- Quantitatively compare results using $F_{0.5}$ and pFM metrics