Featured Code Competition

$1,000,000 Prize Money

Vesuvius Challenge - Ink Detection

Resurrect an ancient library from the ashes of a volcano

Vesuvius Challenge · 1,289 teams · 17 hours ago

kaggle

Winning Solutions Competition Recap

Saturday, June 17, 2023
12:00 pm PDT (UTC-7)

SDML Virtual Meetup

Zoom link in Meetup info


Resurrect an ancient library from the ashes of a volcano.
Win $1,000,000.
The Vesuvius Challenge is a machine learning and computer vision competition to read the Herculaneum Papyri.

79 AD

Mount Vesuvius erupts.

In Herculaneum, twenty meters of hot mud and ash bury an enormous villa once owned by the father-in-law of Julius Caesar. Inside, there is a vast library of papyrus scrolls.

The scrolls are carbonized by the heat of the volcanic debris. But they are also preserved. For centuries, as virtually every ancient text exposed to the air decays and disappears, the library of the Villa of the Papyri waits underground, intact.

1750 AD

A farmer discovers the buried villa.

While digging a well, an Italian farmworker encounters a marble pavement. Excavations unearth beautiful statues and frescoes – and hundreds of scrolls. Carbonized and ashen, they are extremely fragile. But the temptation to open them is great; if read, they would more than double the corpus of literature we have from antiquity.

Early attempts to open the scrolls unfortunately destroy many of them. A few are painstakingly unrolled by an Italian monk over several decades, and they are found to contain philosophical texts written in Greek. More than six hundred remain unopened and unreadable.

2015 AD

Dr. Brent Seales pioneers virtual unwrapping.

This achievement shows that a carbonized scroll can be digitally unrolled and read without physically opening it. Virtual unwrapping has since emerged as a growing field with multiple successes.

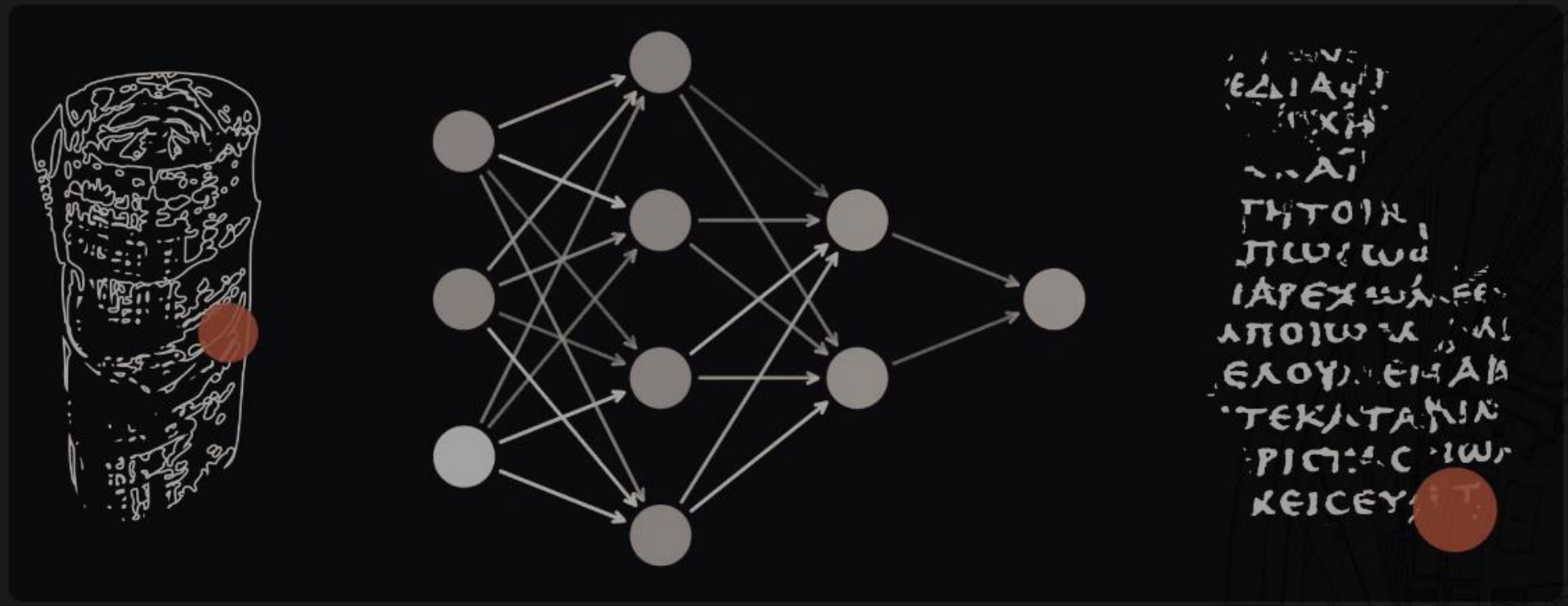
But the Herculaneum Papyri prove more challenging: unlike the denser inks used in the En-Gedi scroll, the Herculaneum ink is carbon-based, affording no X-ray contrast against the underlying carbon-based papyrus.

2019 AD

Enter the particle accelerator.

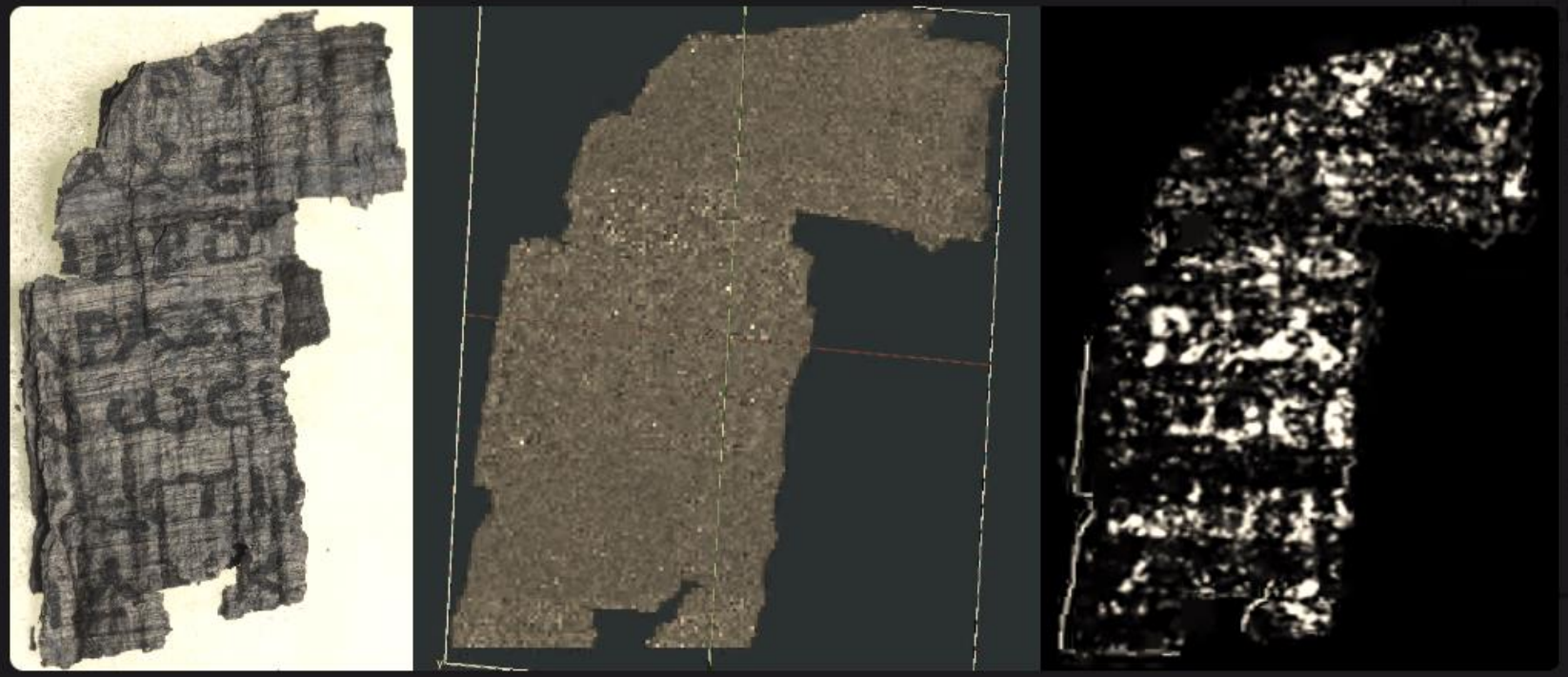
Determined to apply virtual unwrapping to the Herculaneum Papyri, Dr. Seales and his team set out to test a new idea. Under infrared light, some detached fragments of the papyri are readable, and it seems possible that these can be used as ground truth data for a machine learning model that could detect otherwise invisible ink from X-rays.

To get X-rays at the highest possible resolution, the team uses a particle accelerator to scan two full scrolls and several fragments. At 4-8µm resolution, with 16 bits of density data per voxel, they believe machine learning models can pick up subtle surface patterns in the papyrus that indicate the presence of carbon-based ink.



Today
You can solve this ancient puzzle.

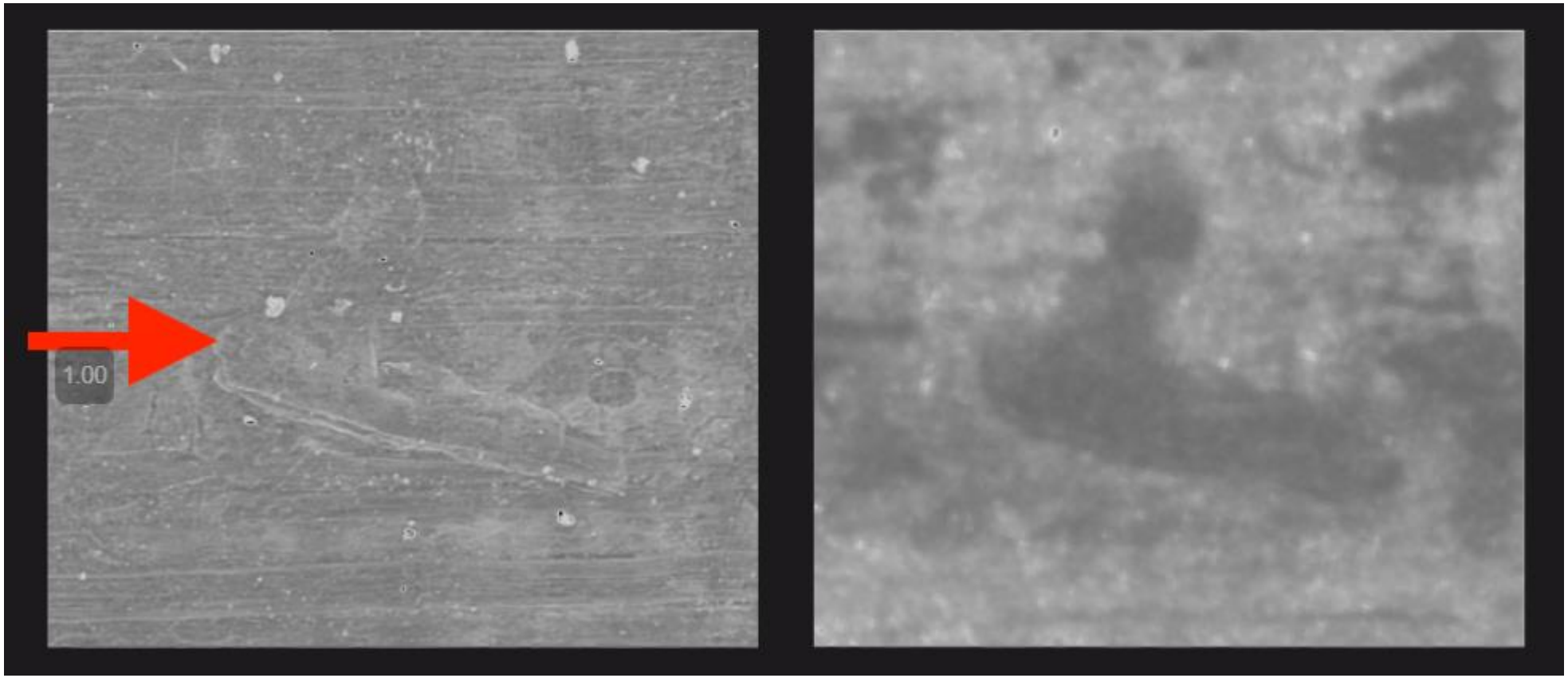
In early 2023 Dr. Seales's lab achieves a breakthrough: their machine learning model successfully recognizes ink from the X-ray scans, demonstrating that it is possible to apply virtual unwrapping to the Herculaneum scrolls using the scans obtained in 2019, and even uncovering some characters in hidden layers of papyrus.



After 275 years, the ancient puzzle of the Herculaneum Papyri has been reduced to a software problem – one that you can help solve!

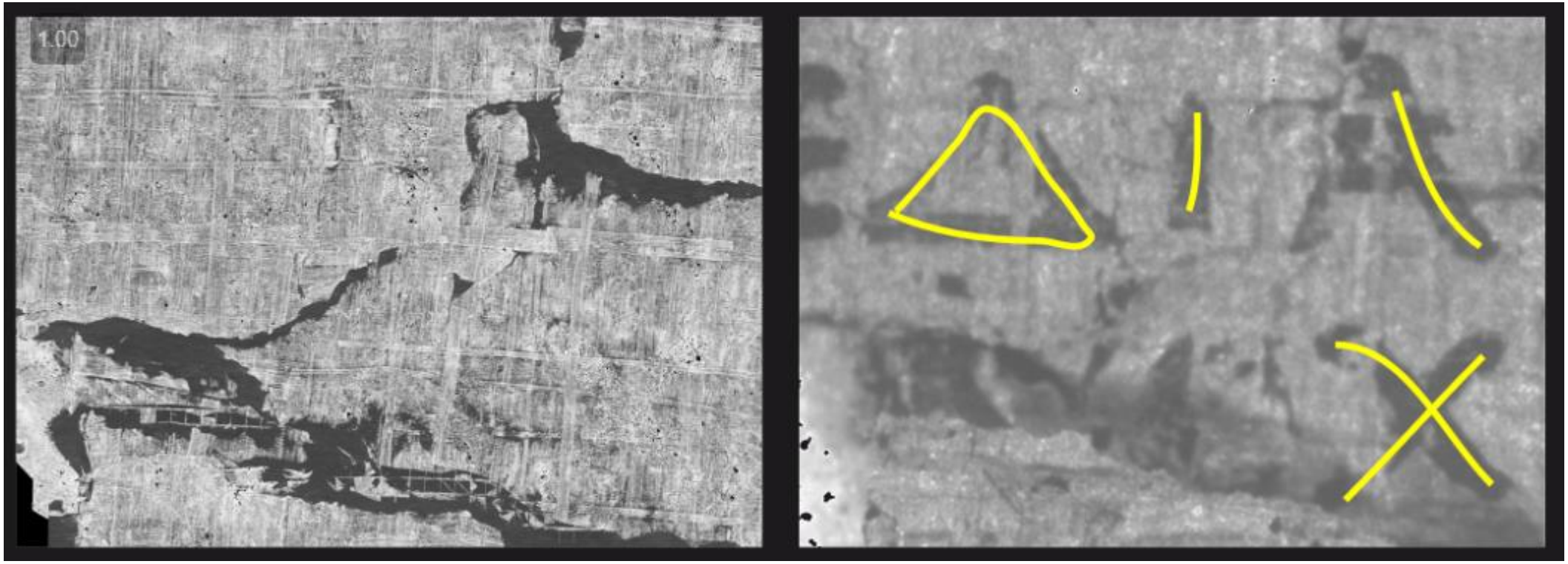
Ink Detection from Scans

- Best case scenario, the ink areas would be clearly visible in the scans:



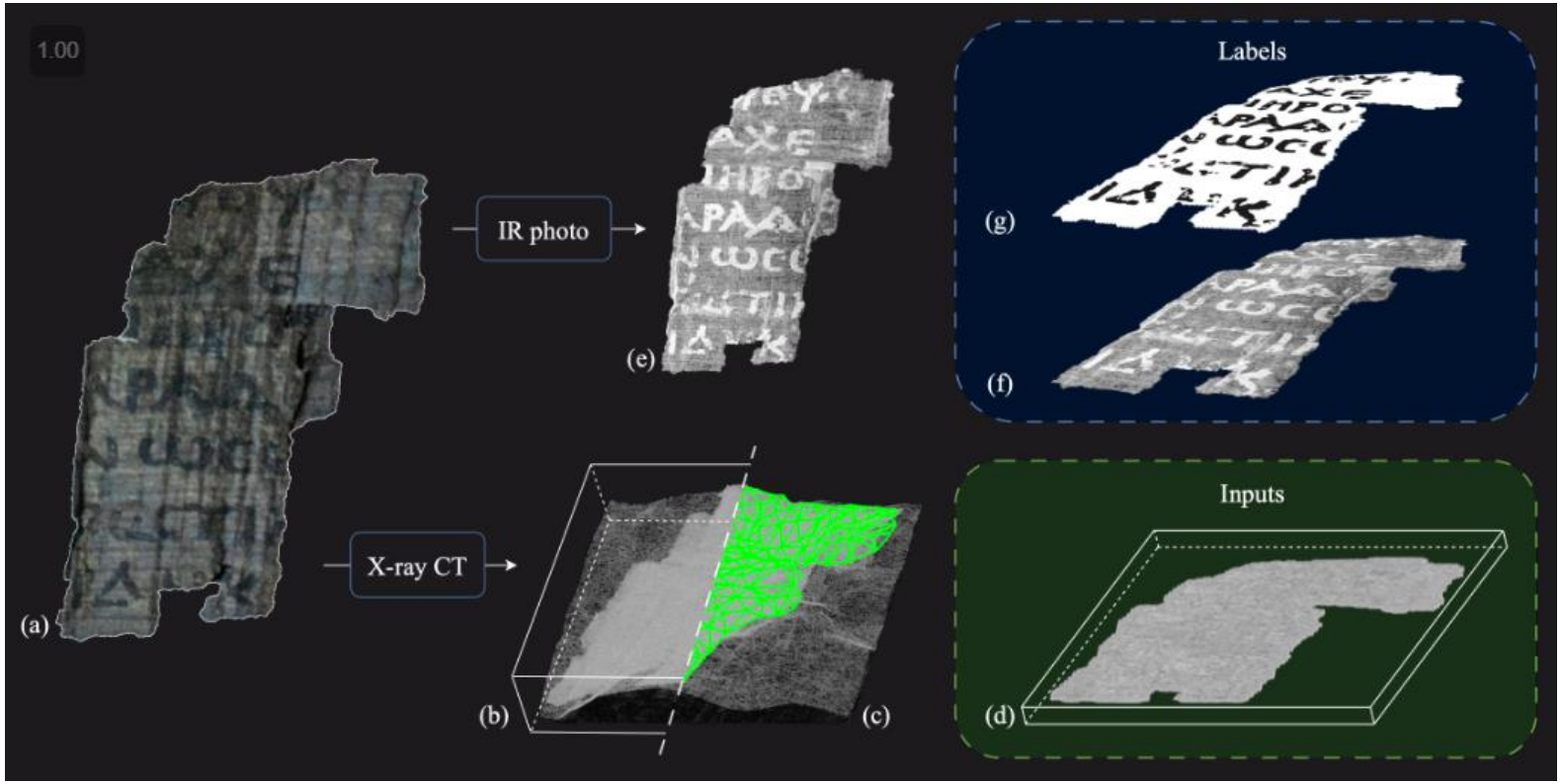
Ink Detection from Scans

- But most scans look like this:



Supervised Learning

- With 3 fragments that have been separated from the scroll cylinder, infrared imaging allowed experts to hand label our ink ground truth



Supervised Learning

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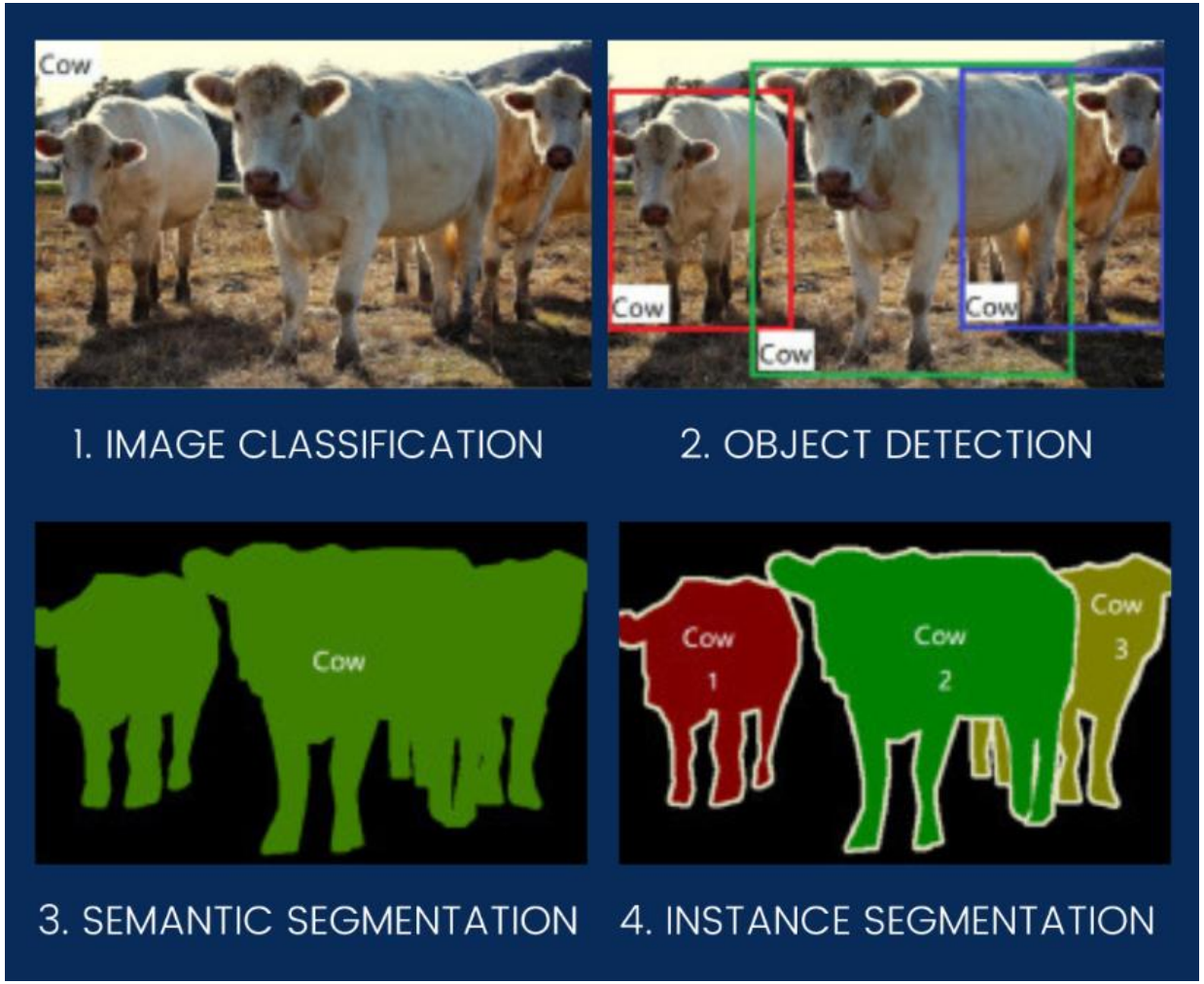
Photo of fragment 1

Aligned infrared photo

Hand-labeled binary mask

Semantic Segmentation

- In computer vision, there are four major tasks
- This competition's task was semantic segmentation of where there was ink on the carbonized papyrus scrolls



https://www.smart-interaction.com/2022/07/14/computer-vision-the-ultimate-guide-on-the-4-main-tasks/-

U-Net Architecture

- A very common neural network architecture used for semantic segmentation is the U-Net
- This design looks like a convolutional neural network (CNN) on the left, but also has upscaling on the right and skip connections

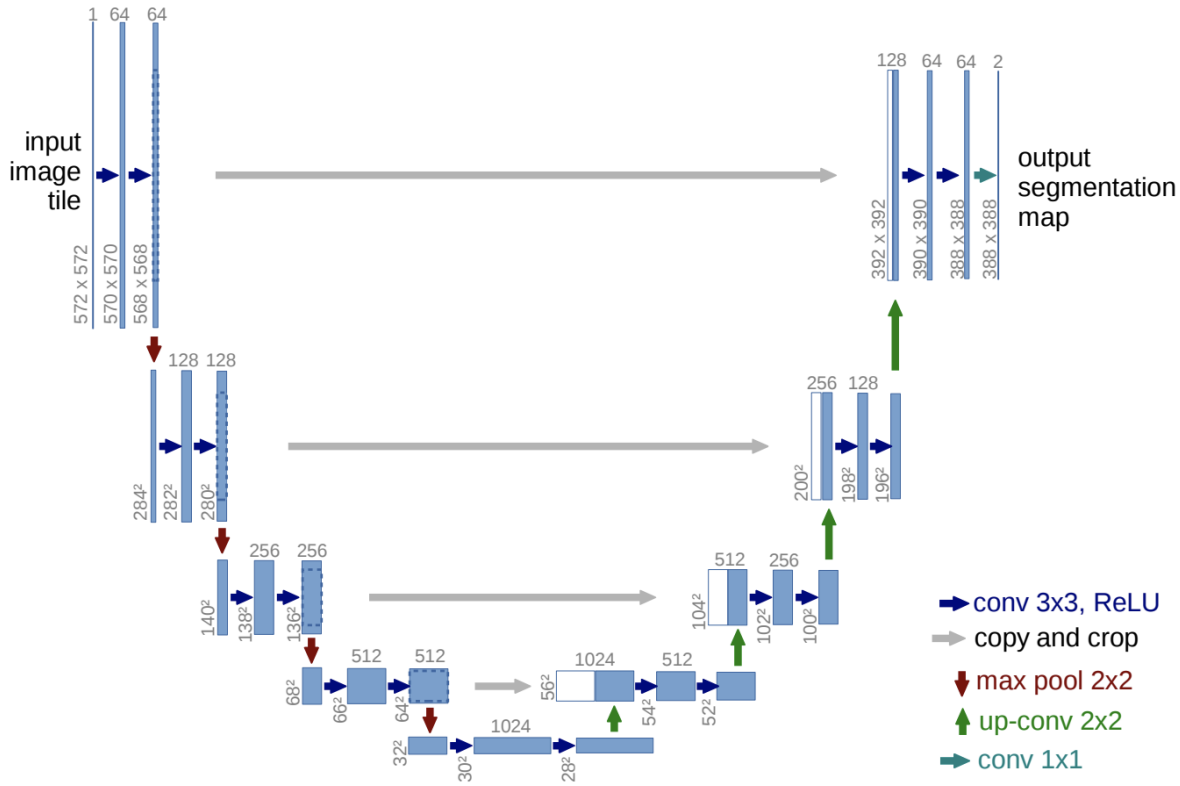


Fig. 1. U-net architecture (example for 32x32 pixels in the lowest resolution). Each blue box corresponds to a multi-channel feature map. The number of channels is denoted on top of the box. The x-y-size is provided at the lower left edge of the box. White boxes represent copied feature maps. The arrows denote the different operations.

https://paperswithcode.com/method/u-net

Competition Details

Timeline

- Started March 15, 2023 and ended June 14, 2023

Metric

- In this semantic segmentation problem, we are doing binary classification on each pixel
- Metrics include IoU and the Sørensen–Dice coefficient. This competition used F0.5, a modified version of the F1 score:

$$\frac{(1+\beta^2)pr}{\beta^2 p + r} \text{ where } p = \frac{tp}{tp+fp}, \quad r = \frac{tp}{tp+fn}, \quad \beta = 0.5$$

Additional Resources

For more information, see these resources:

- Vesuvius Challenge
  https://scrollprize.org/
- Kaggle's Vesuvius Challenge - Ink Detection competition
  https://www.kaggle.com/competitions/vesuvius-challenge-ink-detection
- Discussion thread with Ryan's write up of our solution
  https://www.kaggle.com/competitions/vesuvius-challenge-ink-detection/discussion/417496