Visibility Enhancement of Heritage Materials Through Deep Learning

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Tomography has become common as a way to see and analyse the internal structure of heritage materials. The brilliance of a synchrotron source gives precise control over incident energies and reduces the time scale for the collection of tomographic images at high spatial resolution, making it a very desirable technique for analysis of heritage samples.

Some of the subtlest features, however, require more than mere data collection in order to be teased out and examined. When the raw materials in a heritage object are similarly radiodense, it can be challenging to simply identify features-of-interest. Carbon inks and pigmentations on damaged writing substrates, such as the papyrus sheets used in the construction of ancient bookrolls, are examples.

We have proposed the use of deep learning techniques, in conjunction with large-scale tomographic "reference libraries," in order to enhance synchrotron-based data acquisition and improve the visibility of difficult-to-see features [1]. This approach fits into our broader software pipeline for "virtual unwrapping" as a useful tool for reading texts from tomographic data without physical restoration [2]. In this talk we will discuss not only our initial results from the application of a deep-learning framework for experimentation in this context, but also our intentional collection and management of important metadata and a custom software setup that we designed to allow the training of our deep learning algorithms within "containers" using cloud-based computational resources.

To provide an expanded scope to the promise and challenge of deep learning methods applied to cultural heritage artifacts, we will present the details of our computational approach and the tradeoffs involved with its practical deployment. Specifically, we will address the challenge of building a supervised reference library and training large scale networks with tomographic data at a massive scale. The computational and representational requirements lead to protocols at scan time that emphasize massive data collection in favor of over-collection, as opposed to tuning and pruning "by sight" without the guidance of a fully trained supervised system. We will present results from recent sessions scanning Herculaneum material at Diamond Light Source, the United Kingdom's national synchrotron light source facility, as well as results obtained on other heritage materials using several different tomographic environments.

References

[1] – Parker CS, Parsons S, Bandy J, Chapman C, Coppens F, Seales WB (2019) From invisibility to readability: Recovering the ink of Herculaneum. PLoS ONE 14(5): e0215775. https://doi.org/10.1371/journal.pone.0215775

[2] – Seales WB, Parker CS, Segal M, Tov E, Shor P, Porath Y (2016) From damage to discovery via virtual unwrapping: Reading the scroll from En-Gedi. Science Advances 2(9): e1601247.