

# HIERARCHICAL PHASE-CONTRAST TOMOGRAPHY FOR SCANNING AN INTACT HUMAN KIDNEY AND ANALYSIS OF THE VASCULATURE ACROSS SCALES

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## Introduction

Hierarchical Phase-Contrast Tomography (HiP-CT) is a recently developed technique to image intact human organs across length scales that combines propagation phase contrast X-ray imaging with hierarchical image acquisition [1&2]. The hierarchical approach allows for the analysis of acquired images at different levels of resolution, making it possible to reveal differences in structure at different scales [3]. This study assesses the application of HiP-CT by analysing structural differences in a whole human kidney across scales and different resolutions. Three image datasets including a whole human kidney scanned at  $25 \mu\text{m}^3$  per voxel, and two local regions scanned at  $6.5$  and  $2.6 \mu\text{m}^3$  per voxel, were analysed. Image registration is conducted across the three image datasets acquired from HiP-CT (Fig. 1). Image analysis and segmentation are then performed in Avizo version 2021 to segment arterial vessels from the HiP-CT images.

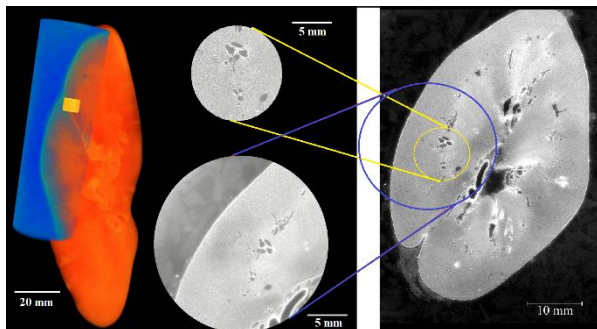


Figure 1: 3D registered whole human kidney scanned at  $25 \mu\text{m}$  in red with two cylindrical regions scanned at  $6.5 \mu\text{m}$  in blue and  $2.6 \mu\text{m}$  in yellow. Regions inside the blue and yellow circles are associated with  $6.5$  and  $2.6 \mu\text{m}$  image datasets.

## Results

Fig. 2 shows the segmented arterial vessels associated with the three datasets scanned at different resolutions.

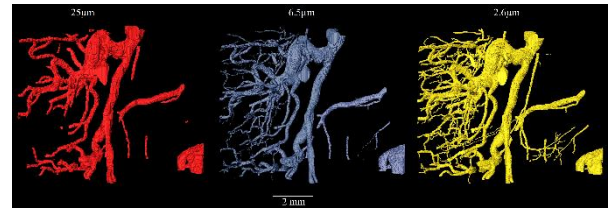


Figure 2: Segmented arterial vessels associated with the three datasets scanned at different resolutions

The analysis of high resolution images revealed the presence of finer vessels and the complexity of the connections between them, which were not visible at the lower resolution setting. A total number of 76, 251, and 356 vessels were found for the three resolutions respectively.

Vessel networks analysis showed that one additional vessel generation was resolved at each step of resolution. The combination of multi-resolution data can be used to accurately calibrate the results obtained on larger organs with lower resolution data. This allows for the use of high resolution finest structures to more accurately pinpoint areas of interest or to provide more detailed analysis of the data. This can lead to more accurate diagnosis, treatment, or understanding of the underlying mechanisms of a given organ. Additionally, this combination of data can provide a more comprehensive view of the organ, allowing researchers to gain a deeper understanding of the anatomy, physiology, or pathology of the organ. Furthermore, this information can be used to better understand the structure and function of the vessels, as well as the associated diseases.

## References

1. Walsh et al. Nature method. 2021; 18: 1532-1541.
2. Xian et al. Scientific Data . 2021, 9.1 (2022): 264.
3. Brunet et al. Nature protocol. 2023; <https://doi.org/10.1101/2022.07.02.498430>

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