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DETECTION OF GOLD NANO-PARTICLES IN ATHEROSCLEROTIC PLAQUE USING HYPERSPECTRAL X-RAY IMAGING

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Summary: Due to varying concentration and partial volume effects, gold nanoparticles (AuNP) as contrast agent can not always be localized unambiguously with traditional (micro-)CT. In this presentation, we demonstrate the identification of AuNP in atherosclerotic plaque using hyperspectral X-ray imaging. The results are compared with SR-based L-edge imaging.

1. INTRODUCTION

Gold nanoparticles (AuNP) are an increasingly popular contrast agent in (bio-)medical X-ray imaging due to their ability to be encapsulated in functional materials such as proteins, which can allow imaging of specific targets [1]. However, their concentrations are often relatively low, and due to the partial volume effect they cannot be identified unambiguously, particularly when in proximity of highly-attenuating materials with complex shapes such as in atherosclerotic plaque (Fig. 1).

To tackle this issue and to localize specific chemical elements in the sample, spectral X-ray imaging can be performed using photon-counting detectors or varying the incident spectrum. However, the analysis of these types of datasets is not straightforward due to the complex spectral behaviour in these methodologies.

Recent advances in detector technology have made hyperspectral imaging possible, in which a full spectrum is measured for each pixel of the 2D detector [2,3]. This allows for the simultaneous acquisition of a high number of monochromatic images. Although this is clearly advantageous in the analysis of the data, many technical challenges still remain to be solved for this methodology [4,5]. For this reason, high-resolution synchrotron-based L-edge imaging was performed to obtain a reference image for the development of analysis methods.

2. EXPERIMENTAL METHOD

The murine aortic arches were acquired from apolipoprotein-E deficient mice kept on a high fat and high cholesterol diet for 10 weeks. This allows for the establishment of atherosclerotic plaques in the aorta. These mice were intravenously injected with AuNP labeled monocytes that migrate into the developed plaques. Five days post-injection, aortic arches were excised from the mice and preserved for scanning.

The hyperspectral datasets were acquired at the high-resolution setup of the Ghent University Centre for X-ray Tomography (UGCT; http://www.ugct.ugent.be) using the SLcam or Color X-ray Camera, a full-field spectroscopic detector with an energy resolution of 160 eV (at Mn Kα). The sensor is a 450µm thick Si pnCCD, and it is has

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maximum efficiency around the Au L-edge.

Synchrotron-based L-edge tomographic datasets were acquired at the I13-2 beamline of the Diamond Light Source. Tomographic datasets are acquired closely below and closely above the Au L_3-edge at 11.92 keV. After reconstruction, the two datasets are aligned and subtracted to obtain the attenuation signal of the AuNP.

3. RESULTS

The results show that hotspots of AuNP can be visualized using laboratory-based hyperspectral imaging, albeit with a high amount of image noise due to the very low count-rate allowed by the hyperspectral camera. The same regions can be identified on SR-based images, where edge enhancement effects make the analysis more difficult.

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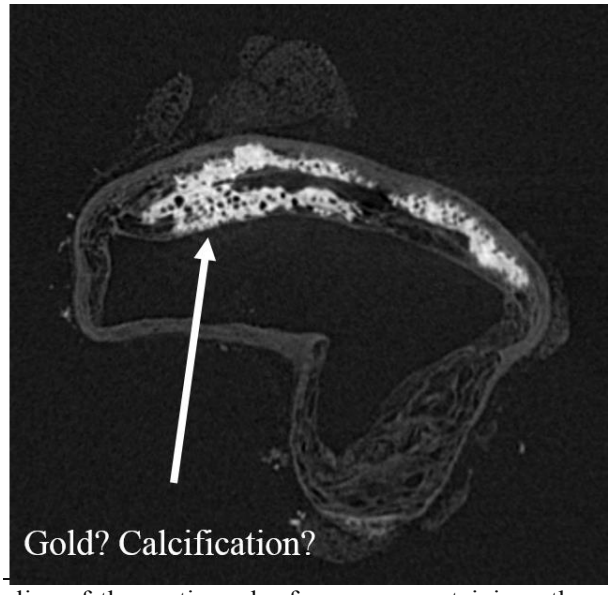

Figure 1: A reconstructed slice of the aortic arch of a mouse containing atherosclerotic plaque and AuNP contrast agent.