Rapid measurement of ice core chemical maps

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The oldest continuous ice core record, containing climate information reaching back at least 1.2 million years, was recently retrieved from Antarctica. Many properties of such an ice core are measured to reconstruct Earth's past climate variability. One of many important properties is the chemical impurities contained within the ice which give insight into past atmospheric circulation patterns and ice sheet extent. 2D maps of the chemical variability and microstructural localisation of impurities can be measured using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Coupling this data with spatially coherent optical data facilitates discussion of the spatial localisation of chemical elements in solid ice samples simultaneously, to build a many-channeled (multi-dimensional) picture of impurity variability at the scale of tens of microns or smaller.

Treating these 2D chemical maps as images allows developments in computer vision to be integrated, and the measurement, analysis, and interpretation of spatial ice core impurity data to be greatly improved. The following areas, illustrated in figure 1, can benefit from input from the imaging community:

- Automatic segmentation of regions of interest, using traditional and machine learning approaches, to cross-reference optical and chemical channels
- Restoration of missing regions in chemical data using image inpainting, previously implemented utilising a simple context encoder neural network
- Dimensionality reduction on multi-dimensional data using techniques including t-SNE and UMAP

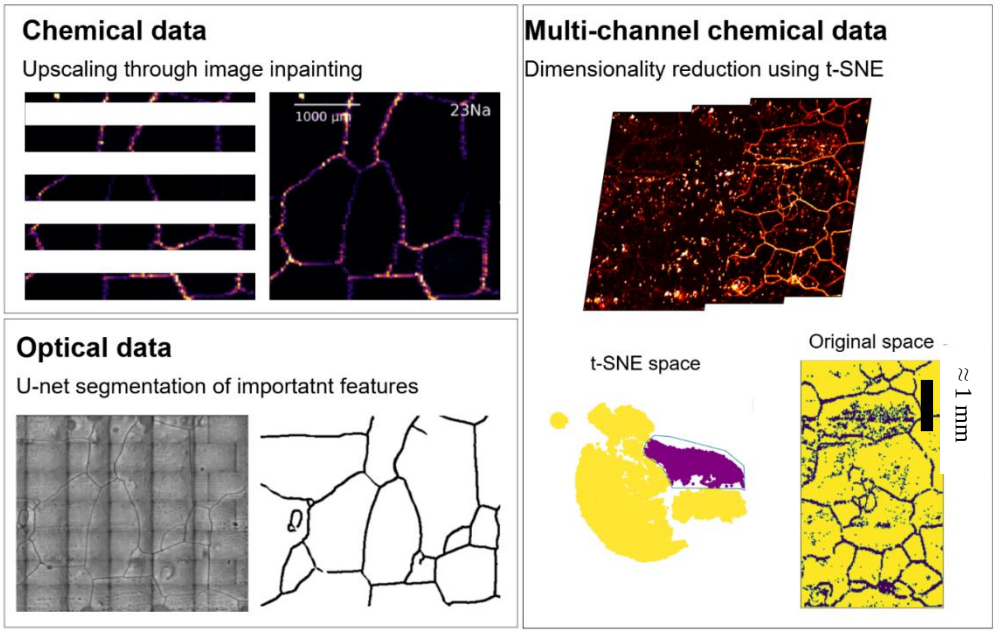

Figure 1; Illustration of four computer vision approaches applied to optical and chemical data collected on ice core samples.

Here, we will 1) illustrate the application of these computer vision approaches to 2D optical and chemical data collected from ice core samples using a LA-ICP-MS system, and 2) outline open research areas, and specific research questions, which are best tackled by inter-disciplinary collaboration between the ice core and imaging communities.