The Natalie Reznikov lab at McGill University in Montreal seeks candidates for a funded position (up to 3 years) at the postdoctoral or PhD level to work on a 3D image analysis project.

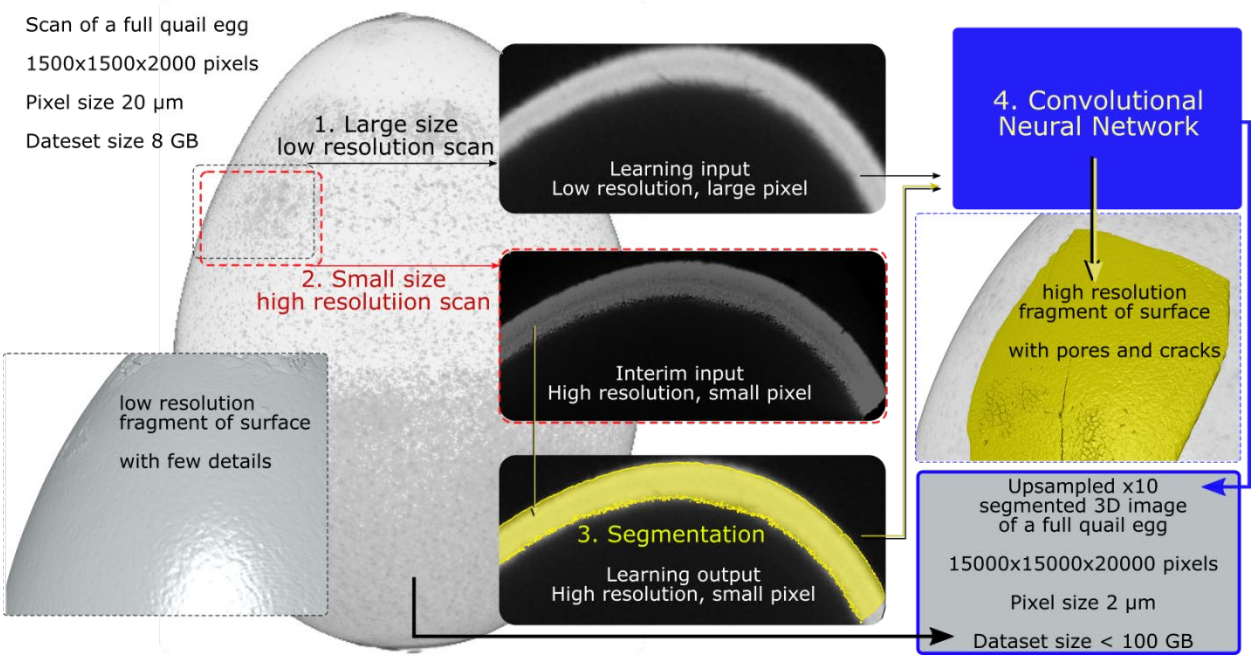
Project title: Upsampling of low-resolution/large-volume 3D tomographic images using generative adversarial neural networks applied to biological anthropology, medical imaging and evolutionary biology.

Project description: Large-volume versus high-resolution information is an inherent conundrum in all domains of research that rely on imaging; you can achieve either one, or the other, but never both. The incentives to increase resolution while keeping large context are many, from comprehensive analysis of basic biological phenomena, to maintaining radiation safety standards in imaging, to preserving the integrity of rare specimens of cultural value. However, extrapolating nonexisting spatial information has always been an ill-posed problem because its solution is not unique – until now with the application of deep learning using neural networks. Although there is ample literature on upscaling single images using super-resolution convolutional neural networks (CNN), recurrent neural networks (RNN) or generative adversarial networks (GAN), most algorithms are designed for (and validated on) synthetically downsampled 2D images.

The aim of this project is to design and validate an open-ended upsampling algorithm using 3D images of historical (ancient mummies), clinical (dental cone-beam X-ray computed tomography) and basic science (bird eggshell) samples. Unique to this project is the availability of original multi-scale 3D image sets that span multiple resolution/volume scales, and which can be accurately superimposed (registered) in 3D, and can be expertly segmented (having meaningful features identified and assigned to the target class on a voxel basis). Images are hierarchical, meaning that the neighborhood of local features is as important as the features themselves; indeed, that is the basis of the CNN operation which identifies and labels features based on their context (and the context of context). GANs include a generator algorithm that constructs artificial features, and a discriminator algorithm that compares artificial and true features: iteration of the two leads to convergence, and to construction of realistic artificial spatial information. By applying GAN-CNN to a low-resolution/large-volume image using a high-resolution/low-volume image as ground truth, we will achieve 3D image upsampling $\times n$. To circumvent the inevitable increase of the data size ($\times n^3$) we will implement a parallel segmentation algorithm that reduces voxel depth, because the ultimate objective is the segmentation of upsampled images. Finally, we will explore the limit of image upsampling in 3D using registered series of 3D images of ancient mummies, bird eggshells and the human craniofacial complex, acquired at multiple magnifications. This open-ended study will raise biological anthropology, zoology and clinical radiology towards a new level in bioimaging and 3D image analysis.

Qualifications:

- Batchelor's or Master's in Computer Science or related disciplines
- Knowledge in computer vision related topics including but not limited to 3D image segmentation
- In-depth knowledge of modern deep learning techniques for image processing
- Familiarity with one of the deep learning frameworks (Tensorflow, Pytorch)
- Understanding of micro-computed tomography
- Strong Python, Matlab, and C++ experience
- Strong presentation, communication and writing skills



How to apply:

Interested applicants should send an email with the subject line "*3D image upsampling*" to Prof Natalie Reznikov natalie.reznikov[at]mcgill.ca with the following attachments: (*i*) CV with contact info for two references, (*ii*) a sample publication where the applicant is an author, and (*iii*) a motivation letter for interest in this position.

Only shortlisted candidates will be contacted by reply email.