MSc Project:
Deep Learning for 3D Curve Extraction from the Inner ear Surface

Context: In recent years, unsupervised and semi-supervised learning from populations of surfaces and curves has received a lot of attention. Such data representations are analyzed according to their shapes [1] which open a broad range of applications in machine learning, robotics, statistics and engineering. In particular, studying curves and surfaces have become an important tool in biology and medical imaging. Often, the extraction of appropriate data representations, such as curves, is done manually by an expert, which is time consuming and challenging from low quality image data and surfaces.

Deep learning based methods are of great interest in various fields such as medical imaging, computer vision, applied mathematics and are successfully used in the field of image segmentation. Generally, a specific formulation requires a particular attention to representations, loss functions, probability models, optimization techniques, etc. This choice is very crucial due to the underlying geometry on the space of representations and constraints. In this project, we aim to develop a new set of automatic methods that can segment curves from a boundary 3D surface.

The goal of this project is to understand the-state-of-the-art methods (e.g., [2]) and to propose solutions in the context of extracting a 3D curve from a surface. We are interested in learning from a dataset of surfaces and their corresponding extracted 3D curves to make the extraction automatic and accurate for a previously unseen but similar surface. The application will be the extraction of a 3D curve from the cochlea and inner ear surface, whose shapes can then be analyzed [1] subsequently for population studies [3, 4].

To summarize, the key steps are : (i) Literature review and getting familiar with some state-of-the-art methods in the medical context; (ii) Implementing and testing the code before validation on real data; (iii) Optimizing the code and comparing with baseline methods. If successful, the method would be applied to analyze and classify curves such as in [3, 4].

Related informations

- Supervisors and labs:
Veronika Zimmer (veronika.zimmer@tum.de), CompAI, TUM
Chafik Samir (chafik.samir@uca.fr), CNRS UCA, France.
- Programming : Python, Pytorch, TensorFlow, etc..
- Organization: 6 months with possibility to visit the french lab in Clermond-Ferrand which will cover expenses.
- Skills: The Master student should have good programming skills with a good mathematical background and prior experiences with deep learning.

References

[1] Fradi et al. "Nonparametric Bayesian Regression and Classification on Manifolds With Applications to 3D Cochlear Shapes", IEEE Trans. on Image Processing 31 (2022): 2598-2607.

[2] Wang et al. "PIE-NET : Parametric Inference of Point Cloud Edges", NeurIPS 2020.

[3] Braga, et al. "Cochlear shape reveals that the human organ of hearing is sex-typed from birth." Scientific reports 9.1 (2019): 1-9.

[4] Braga, et al. "Cochlear shape distinguishes southern African early hominin taxa with unique auditory ecologies." Scientific reports 11.1 (2021): 1-10.