PhD Thesis Proposal

Age and Sex Estimation from CT Images using Keypoints and Machine Learning Methods

Abdominal CT image

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PhD location:	ICube, Illkirch (Strasbourg University, CNRS)
Thesis Supervisors:	Sylvain Faisan, Associate Professor, ICube
	Fabrice Heitz, Professor, ICube
Thesis Funding[1] :	ANR (Agence Nationale de la Recherche)
PhD starting date:	Fall 2020

[1]Funding for this thesis has already been granted by ANR

This PhD thesis proposal is part of the ANR TOPACS [2] national research project that proposes to investigate full-body computational anatomy, through the analysis of a large set of 3D CT and MRI scans (more than 10000 individuals). This project involves five research laboratories (Creatis Lyon, ICube Strasbourg, Gipsa Lab Grenoble , LIRIS Lyon and Institut Pascal Clermont).

The objective of this thesis is to develop new methods for the computerized analysis of CT scans, based on 3D keypoints (such as SIFT3D or SURF3D [BETV08]) extracted from the images (Fig. 1). More specifically, the goal is to provide the doctor and the scientist with tools for infering from the 3D scans, information such as the age or sex of the individual or any other characteristic of interest. Machine learning methods, adapted for the analysis of large datasets of 3D points, will be devised for this purpose.

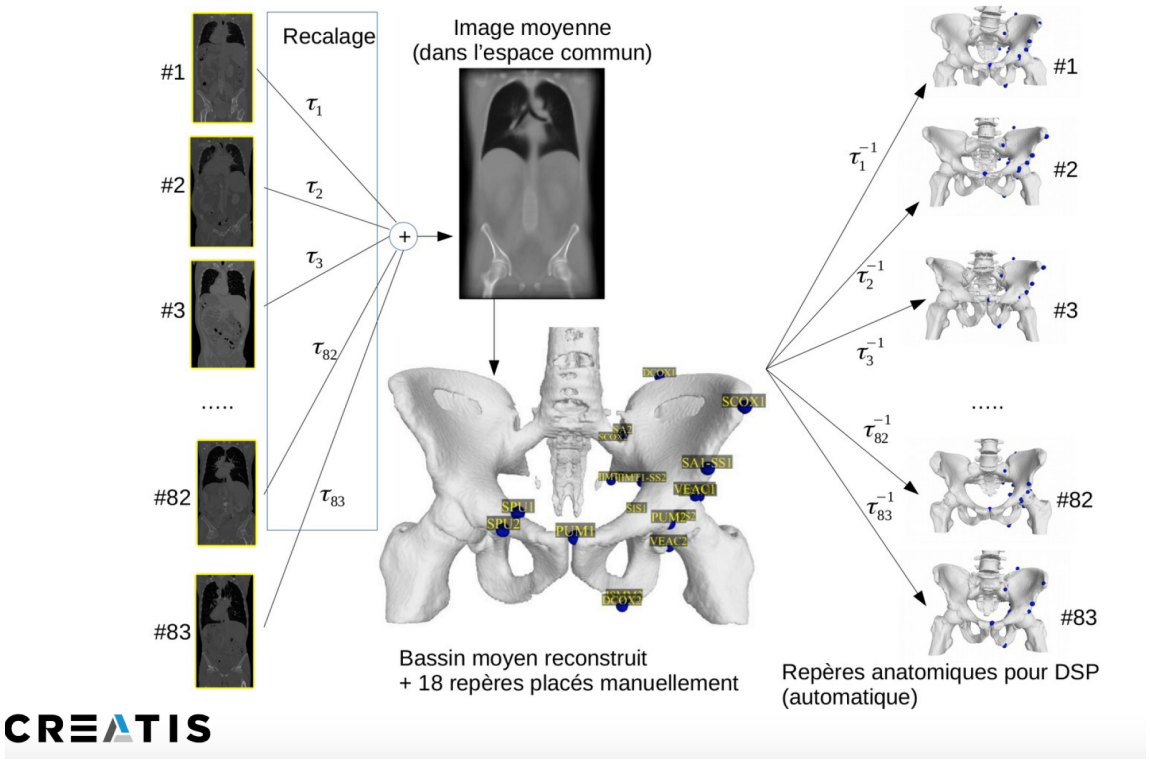

Figure 1: Keypoints extracted on a CT image (courtesy: Creatis, Lyon)

Apart from applications in medicine, applications will focus on Forensic Science, such as the determination of age and sex on body parts. Another application is to predict different anatomic characteristics from a partial 3D body image in anthropology and taphonomy studies. This project could also contribute to the emerging field of virtual autopsy, which consists in analysing a deceased individual in a non-destructive manner via 3D imagery.

From a modeling point of view, we will favor Geometric Deep Learning approaches [BBL+17]. Indeed, deep learning approaches have mainly considered data defined on Euclideans domains and regular grids, such as 2D and 3D images. Geometric Deep Learning aims at extending deep learning techniques to geometric data structures such as point clouds or graphs. [CSKG17] is one of the first attempts to model point clouds.

[2] https://www.creatis.insa-lyon.fr/~valette/public/project/topacs/

However, it captures only global features. To alleviate this limitation, several works [QYSG17, WSL$^+$19, SJS$^+$18, AML18, LBS$^+$18] have been carried out by extending convolution operator to point clouds.

In the TOPACS project, the extraction and non-rigid registration of the point clouds extracted from large databases of different individuals will be carried out by Creatis and Institut Pascal. The first objective of the PhD thesis at ICube is to test existing Geometric Learning and Keypoint-based machine learning methods in the context of our applications. Then, the PhD student will derive a new model adapted to the problem. Supervised regression and classification approaches will be considered.

As an example, a large vector of characteristics can be computed for each detected point. Using these vectors, and not only the positions of the extracted points may be relevant to capture local features. Estimated geometric transformations, related to the registration of the different CT scans may also enrich the modeling since most of the aforementioned methods require a rigid transform block (all data points are not in the same reference space at the beginning).

Working environment The student will be a member of the IMAGeS team (`http://images.icube.unistra.fr/`) in the ICube laboratory in Illkirch. The PhD thesis will start on October 2020. Interactions with the other partners of the TOPACS project will be part of the work.

Supervisors: Fabrice Heitz (`fabrice.heitz@unistra.fr`) and Sylvain Faisan (`faisan@unistra.fr`).

Profile of the candidate

- Last year of Master studies or Engineering School in the following fields: computer science, image processing, applied mathematics and machine learning.
- Good programming skills (the coding language will be Python).
- Interest for image processing and medical applications.

Application

Send a long CV, motivation letter and academic transcripts for the past 2 years to:
Sylvain Faisan (`faisan@unistra.fr`) and Fabrice Heitz: (`fabrice.heitz@unistra.fr`).

References

[AML18] Matan Atzmon, Haggai Maron, and Yaron Lipman. Point convolutional neural networks by extension operators. *ACM Transactions on Graphics*, 37(4):1–12, 2018.

[BBL+17] Michael M. Bronstein, Joan Bruna, Yann LeCun, Arthur Szlam, and Pierre Vandergheynst. Geometric deep learning. going beyond euclidean data. *IEEE Signal Processing Magazine*, pages 18–42, July 2017.

[BETV08] H. Bay, A. Ess, T. Tuytelaars, and L. Van Gool. Speeded-up robust features (SURF). *Comp. Vis. Image Understanding*, 110(3):346–359, June 2008.

[CSKG17] R. Q. Charles, H. Su, M. Kaichun, and L. J. Guibas. Pointnet: Deep learning on point sets for 3d classification and segmentation. In *2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 77–85, 2017.

[LBS+18] Yangyan Li, Rui Bu, Mingchao Sun, Wei Wu, Xinhan Di, and Baoquan Chen. Pointcnn: Convolution on x-transformed points. In S. Bengio, H. Wallach, H. Larochelle, K. Grauman, N. Cesa-Bianchi, and R. Garnett, editors, *Advances in Neural Information Processing Systems 31*, pages 820–830. Curran Associates, Inc., 2018.

[QYSG17] Charles Ruizhongtai Qi, Li Yi, Hao Su, and Leonidas J Guibas. Pointnet++: Deep hierarchical feature learning on point sets in a metric space. In I. Guyon, U. V. Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, and R. Garnett, editors, *Advances in Neural Information Processing Systems 30*, pages 5099–5108. Curran Associates, Inc., 2017.

[SJS+18] Hang Su, Varun Jampani, Deqing Sun, Subhransu Maji, Evangelos Kalogerakis, Ming Hsuan Yang, and Jan Kautz. Splatnet: Sparse lattice networks for point cloud processing. In *Proceedings - 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition, CVPR 2018*, Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pages 2530–2539, United States, dec 2018. IEEE Computer Society.

[WSL+19] Yue Wang, Yongbin Sun, Ziwei Liu, Sanjay E. Sarma, Michael M. Bronstein, and Justin M. Solomon. Dynamic graph CNN for learning on point clouds. *ACM Trans. Graph.*, 38(5), October 2019.