

Chair Data Science and Artificial Intelligence for Digitalized Industry and Services

Internship project

Subject

Contrastive Representation Learning in Medical Imaging

Possibility to continue as a PhD candidate

YES (Funding to be confirmed)

About the chair

The Chair Data Science and Artificial Intelligence for Digitalized Industry and Services (DSADIS), lead by Florence d'Alché-Buc, a Professor in the department Image, Data, Signal of Telecom Paris, unites five industrial partners: Airbus Defence & Space, Engie, Idemia, Safran et Valeo. It's general objective is to develop, in collaboration with the partners, teaching and research of the international level.

Its four principal research directions are:

1. Building predictive analytics on time series and data streams.
2. Exploiting large scale, heterogeneous, partially labeled data.
3. Machine Learning for trusted and robust decision.
4. Learning through interactions with environment.

Description of the internship

Supervision

Pietro GORI (<https://perso.telecom-paristech.fr/pgori/>)

Location and dates of the internship

Address : Télécom Paris, 19 Place Marguerite Perey, 91120 Palaiseau

Date of the beginning of the internship

As soon as possible

Team where the thesis will be written

Department IDS, Team IMAGES

Keywords

Deep learning, Contrastive Analysis, Self-Supervised Learning, Medical Imaging, Generative models

Detailed subject

Introduction

Representation Learning has become a hot research topic in recent years. It deals with the automatic estimate of efficient data representations using deep learning architecture. Data are mapped to a latent space which should capture the important semantic information valuable for downstream tasks (classification, segmentation, etc). In our team, we mainly work on two related topics:

1. *Self-Supervised Learning for Medical Imaging*: the goal is to leverage non-annotated or weakly-annotated data to learn a meaningful representation for diagnostic (cancer, disease, etc). Recently, using a highly interpretable and versatile geometric approach [1], we have proposed new losses and regularization terms for a) including both continuous and discrete metadata into contrastive learning [3,5], b) removing known data biases [1] and 3) integrating generative model representations into contrastive learning [2].
2. *Contrastive Analysis for Medical Imaging*: given two datasets comprising healthy subjects and patients with a certain disease, the goal is the unsupervised identification and separation of the healthy latent patterns from the pathological ones using generative models (VAE and GAN) [4].

Objectives

Depending on the background and interest of the student, several research directions are possible within each topic. Here, we list some of them:

1. *Self-Supervised Learning*: extend the proposed geometric approach to multi-modal data and to non-contrastive self-supervised methods (BYOL, Barlow Twins, etc.).
2. *Contrastive Analysis*: integrate new information-theoretic regularizations to better separate and estimate common and salient generative factors; study the identifiability of this kind of models; propose a way to spatially disentangle both spaces (common and salient) so that individual factors should only account for variations in a specific part of the input images.

Candidate profile

M2 in applied mathematics, statistics, computer science, engineering with a good knowledge of Python and deep learning.

Application

Candidates are invited to send their CV to pietro.gori@telecom-paris.fr detailing their academic background and if they are willing to continue with a PhD.

References

- [1] Barbano, C. A., Dufumier, B., Tartaglione, E., Grangetto, M., and Gori, P. Unbiased Supervised Contrastive Learning. In International Conference on Learning Representations (ICLR) (2023).
- [2] Dufumier, B., Barbano, C. A., Louiset, R., Duchesnay, E., and Gori, P. Integrating Prior Knowledge in Contrastive Learning with Kernel. In International Conference on Machine Learning (ICML). (2023).
- [3] Dufumier, B., Gori, P., Victor, J., Grigis, A., and Duchesnay, E. Contrastive Learning with Continuous Proxy Meta-data for 3D MRI Classification. In MICCAI (2021).
- [4] Louiset, R., Duchesnay, E., Grigis, A., Dufumier, B., and Gori, P. SepVAE: a contrastive VAE to separate pathological patterns from healthy ones. In IMLH workshop (ICML). (2023).
- [5] E. Sarfati, A. Bône, M.-M. Rohé, P. Gori, I. Bloch. Weakly-supervised positional contrastive learning: application to cirrhosis classification. In MICCAI, 2023

