Explainable artificial intelligence for image registration

Project proposal (Master student)

Introduction

Medical image registration is the task of aligning anatomical structures and is crucial for image-guided interventions. In recent years, deep learning-based image registration has become popular because it allows for fast registration [1]. In deep learning-based registration, a convolutional neural network (CNN) is used to perform the registration. It is generally challenging to interpret or explain how CNNs perform this complex task. And, the free-form and multi-dimensional nature of the predictions of a CNN can be difficult to validate.

Explainable artificial intelligence (XAI) and visual analytics (VA) alleviate the challenges of interpreting black-box CNNs [2] by, for example, identifying when a model breaks or investigating the model's sensitivity to input perturbations. An example of a VA system for interpreting neural network classification results is ActiVis [3] (fig. 1).
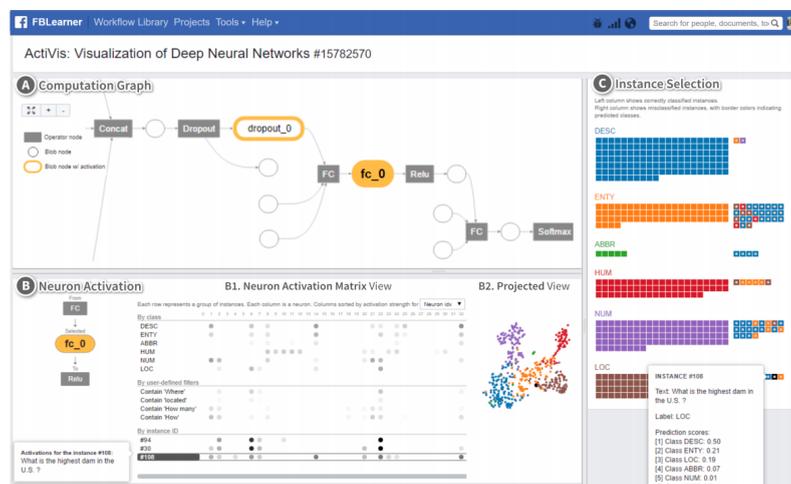

Figure 1. In ActiVis several views are integrated to support the exploration of complex neural network models.

Goal

To implement XAI and VA methods for the task of deep learning-based image registration.

1. You will perform deformable image registration using commonly used CNN(s).
2. You will implement a method for identifying the responses of the trained CNN model to perturbations (e.g. by adding noise to the input images or by spatially deforming the input images).

It is recommended to have experience with Python and experience with deep learning (for example obtained during a group project or externship).

Contact

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References

[1] Fu, Y., et al. (2020). Deep learning in medical image registration: a review. Physics in Medicine & Biology, 65(20), 20TR01;

[2] Hohman, F., Kahng, M., Pienta, R., & Chau, D. H. (n.d.). *Visual Analytics in Deep Learning: An Interrogative Survey for the Next Frontiers*. Retrieved April 21, 2021, from https://arxiv.org/

[3] Kahng, Minsuk, et al. "Activis: Visual exploration of industry-scale deep neural network models." IEEE transactions on visualization and computer graphics 24.1 (2017): 88-97.