Exploring Riemannian Manifolds for Medical Image Classification

Keywords: Riemannian manifolds, classification, medical imaging

In computer vision, covariance descriptors have been used successfully to fuse image features for classification, object tracking, and shape matching [1, 2]. Since covariance matrices are symmetric and positive-definite (SPD) and the set of SPD matrices form a Riemannian manifold ("curved surface"), Euclidean methods are not suitable. Instead, Riemannian methods should be applied since they respect the non-Euclidean nature of the data. The development and application of such algorithms, including the extension of deep learning algorithms to manifold-valued data as in [3], is an exciting and growing research field of today.
Despite their success in the computer vision field, covariance descriptors have barely been applied to medical images. Even though they have been extended to 3D video data [4], they remain to be explored for 3D and temporal medical imaging data.
This Master's project aims to explore the use of covariance descriptors for disease classification with medical images. First, the MedMNIST toy dataset will be explored. Then, the student will work with an open-source medical dataset, e.g. of 2D chest x-ray or 3D cardiac MR images. The key steps of the project are: (1) Getting familiar with Riemannian manifolds and covariance descriptors, (2) Literature research on the application of covariance descriptors to medical data, (3) Development of a novel covariance descriptor-based classification framework for medical data, (4) Comparison of the novel method to state-of-the-art classification methods. The project can be adapted to the student's interests and ideas.

Requirements

- Prior practical experience with and good understanding of machine learning/deep learning,
- Strong mathematical background (Prior knowledge of manifolds is beneficial but not necessary),
- Very good programming skills in Python (including TensorFlow or PyTorch),
- Independent work style and good communication skills,
- Interest in medical imaging and the development of novel algorithmic methods.

What we offer

- Access to computing resources at the chair,
- If desired, support to submit the results of the thesis to a conference.

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(December 2023)

References

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