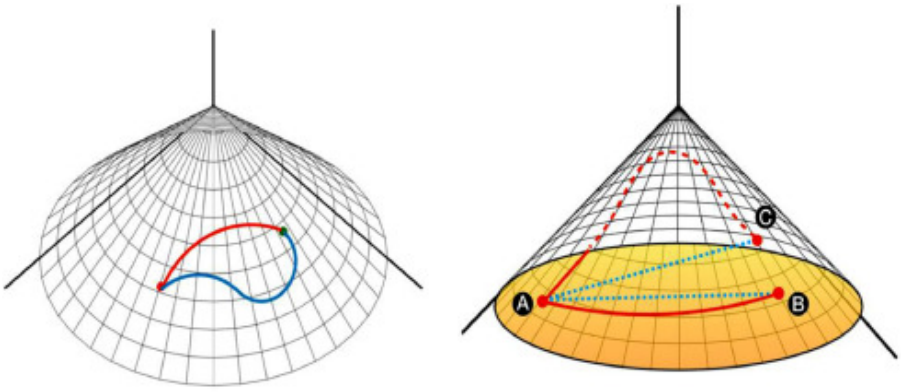
TECHNISCHE UNIVERSITÄT DARMSTADT

Thesis (B.Sc. / M.Sc.)
SPD Matrices Reimagined: A Novel Approach to Computer Vision

Background: Symmetric Positive Definite (SPD) matrix learning has emerged as a significant method in image and video processing tasks. With the ability to provide accurate statistical representations and adhere to the Riemannian geometry of underlying SPD manifolds, this method has led to exciting advancements.

Building on [1], recent research such as [2,3] and have successfully employed SPD matrix learning for various visual classification tasks.



SPD manifold. The geodesic distance between A and B is shorter than that of A and C while it is reverse in the Euclidean distance. From [4].

Objective: Our lab has previously developed a novel SPD layer for causal learning, and now we aim to adapt this innovation to the field of computer vision. The goal of this master thesis is to adapt and explore this layer for applications in computer vision, integrating it within the broader context of SPD networks.

Specifically, the project will focus on:

- **Implementation and Integration:** Integrating the new layer into an existing SPD network framework, adjusting parameters for optimal performance, and adapting the model for causal learning to computer vision.
- **Evaluation and Testing:** Applying the enhanced SPD network on selected computer vision tasks to assess the effectiveness and efficiency of the new layer.
- **Comparison with Existing Models:** Analyzing the performance in comparison with existing methods.
- **Scientific Contribution:** Documenting the findings, presenting the results, and possibly contributing to a published paper in the field.

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Prerequisites:

- Background in mathematics, basic knowledge of linear algebra and differential geometry (e.g., students of electrical engineering, information theory, computer science, medical engineering, physics, mathematics).
- Familiarity with Python.
- Familiarity with neural network architectures and deep learning frameworks.

The Self-Organizing-Systems Lab merges practical applications of machine learning with a pronounced emphasis on strong theoretical foundations. Within our interdisciplinary team, we actively work towards publications, offering students an opportunity to engage with cutting-edge research.

For further information, please contact Philipp Froehlich.

References:

[1] Zhiwu Huang, Luc Van Gool, "A Riemannian Network for SPD Matrix Learning," Proceedings of the AAAI Conference on Artificial Intelligence, 2017.

[2] Xuan Son Nguyen, "GeomNet: A Neural Network Based on Riemannian Geometries of SPD Matrix Space and Cholesky Space for 3D Skeleton-Based Interaction Recognition," Proceedings of the IEEE International Conference on Computer Vision (ICCV), 2021.

[3] Rui Wang, Xiao-Jun Wu, Tianyang Xu, Cong Hu, Josef Kittler, "U-SPDNet: An SPD manifold learning-based neural network for visual classification," Neural Networks, Volume 161, April 2023, Pages 382-396.

[4] Kisung You, Hae-Jeong Park, "Re-visiting Riemannian geometry of symmetric positive definite matrices for the analysis of functional connectivity," NeuroImage, Volume 225, 15 January 2021, Page 117464.