Sliced-Wasserstein in the Siegel space

Master/Ecole d'Ingénieur internship

Institutions:	Université Bretagne Sud, IRISA CNRS 6074.
Place:	IRISA, Campus de Tohannic, Vannes, France.
Duration:	4 to 6 months.
Supervisors:	Yann Cabanes ; Nicolas Courty & Clément Bonet
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Key-words: Machine learning, Optimal Transport, Sliced-Wasserstein, Riemannian manifold, hyperbolic spaces, Siegel space.

Scientific context

Optimal Transport (OT) is a theory developed to find the "optimal" matching between two distributions, i.e. find a transport from a distribution to the other which minimizes a cost function [7, 8]. The Wasserstein distance between the two distributions corresponds to the cost of the optimal transport. The computation of the Wasserstein distance is computationally very expensive except for the unidimentional case, i.e. when we consider two distributions on the real line. A popular alternative is the Sliced-Wasserstein distance, which leverages

a closed-form solution of the Wasserstein distance in one dimension: the Sliced-Wasserstein distance is the mean Wasserstein distance between the orthogonal projections of the distributions on all straight lines passing through zero.

During the last decades, OT has also been studied for data or distributions lying in Riemannian manifolds [1,9]. However, few works tackle the problem of computing the Sliced-Wasserstein distance in Riemannian manifolds [2]. The main difficulty is to project the data points on geodesics (the Riemannian equivalent of a straight line). Two definitions of the Riemannian projection on geodesics have been proposed to generalize to Riemannian manifolds the Euclidean orthogonal projection on a straight line: the geodesic projection and the horospherical projection each of them preserving a different property of the Euclidean orthogonal projection [2]. However, there exists no closed-form solution for these two Riemannian projections in general.

Many datasets are naturally represented in Cartan-Hadamard manifolds which are Riemannian manifolds with non-positive curvature including among others Euclidean spaces, Hyperbolic spaces or the space of Symmetric Positive Definite matrices endowed with appropriate metrics [2]. These manifolds have recently received much attention in the machine learning community. In particular, the Siegel space seems to have powerful representation properties [3–6]. However, the closed-form expressions of the Riemannian projections in the Siegel space are not known, making the computation of the Sliced-Wasserstein distance between distributions in the Siegel space very expensive.

Objective

The theoretical part of the internship will focus on searching for closed-form expressions of the geodesic and horospherical projections in the Siegel space which will enable an efficient computation the Sliced-Wasserstein distance on the Siegel space.

The applied part of the internship will lead to implementations in Python of the distances, with the goal to develop domain adaptation algorithms working efficiently in the Siegel space. The Sliced-Wasserstein distances will be used as loss functions, and will be minimized by approximating their gradient flows, using the PyTorch package to compute gradients.

Research environment and location

The research will take place within the OBELIX research group (`www.irisa.fr/obelix`) from IRISA located in the UBS (Université Bretagne Sud) campus in Vannes, France.

Supervisors

The student will be jointly supervised by:

- Yann Cabanes : yann.cabanes@univ-ubs.fr
- Nicolas Courty : nicolas.courty@univ-ubs.fr
- Clément Bonet : clement.bonet.mapp@polytechnique.edu

Candidate profile

Applicants are expected to be graduated in computer science, machine learning or applied mathematics and show an excellent academic profile. Beyond, good programming skills are expected.

Application procedure

To apply for this position, the candidate is requested to first send a CV and a cover letter to Yann Cabanes, Nicolas Courty and Clément Bonet. Candidates matching the desired profile will be contacted for an interview. Feel free to contact us with any questions. Applications remain open until January 31, 2026 as long as the internship is not filled.

Salary

The salary will be around 500 euros per month (about 4.35 euros per hour).

References

[1] Clément Bonet. *Leveraging Optimal Transport via Projections on Subspaces for Machine Learning Applications*. PhD thesis, Université de Bretagne Sud, 2023.

[2] Clément Bonet, Lucas Drumetz, and Nicolas Courty. Sliced-Wasserstein Distances and Flows on Cartan-Hadamard Manifolds. *Journal of Machine Learning Research 26*, pages 1–76, 2025.

[3] Yann Cabanes. *Multidimensional Complex Stationary Centered Gaussian Autoregressive Time Series Machine Learning in Poincaré and Siegel Disks: Application for Audio and Radar Clutter Classification*. PhD thesis, Université de Bordeaux, 2022.

[4] Yann Cabanes and Frank Nielsen. Classification in the Siegel Space for Vectorial Autoregressive Data. *Geometric Science of Information*, 2021.

[5] Federico Lopez, Beatrice Pozzetti, Steve Trettel, and Anna Wienhard. Hermitian Symmetric Spaces for Graph Embeddings. *arXiv preprint arXiv:2105.05275*, 2021.

[6] Xuan Son Nguyen, Aymeric Histace, and Nistor Grozavu. Siegel Neural Networks. *NeurIPS*, 2025.

[7] Gabriel Peyré, Marco Cuturi, et al. Computational optimal transport: With applications to data science. *Foundations and Trends® in Machine Learning*, 11(5-6):355–607, 2019.

[8] Filippo Santambrogio. *Optimal Transport for Applied Mathematicians*. Birkhaüser, 2015.

[9] Cédric Villani. *Optimal Transport*. Springer, 2009.