Optimal transport for machine learning

Practical sessions

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Data SCience Summer School (DS3) 2018, Paris, France

Course organization

A day in Optimal Transport

09:00 - 10:30 Introduction to OT

11:00 - 12:30 Practical session 1

1. Intro to OT with POT
2. Regularized OT with Sinkhorn
3. Word Mover's Distance on text

14:00 - 15:30 Advanced OT

16:00 - 17:30 Practical session 2

- Domain Adaptation on digits
- Color grading
- Wasserstein GAN

Files and solution

Get the files

Github repository:

https://github.com/rflamary/OTML_DS3_2018

All files:

https://github.com/rflamary/OTML_DS3_2018/archive/master.zip

Solution for all practical sessions

https://remi.flamary.com/cours/otml/solution_[NUMBER].zip

Where [NUMBER] is replaced by the integer part of the value of the Wasserstein distance obtained in Practical Session 1 Part 1 using the Manhattan/Cityblock ground metric.

Required Python libraries

Install POT (Python Optimal Transport)

- On Anaconda (in terminal) :

  ```
  conda install -c conda-forge pot
  ```

- With pip (requires C compiler) :

  ```
  pip install pot
  ```

- Test install by executing:

  ```
  import ot
  ```

Install Keras (optional, only for WGAN session)

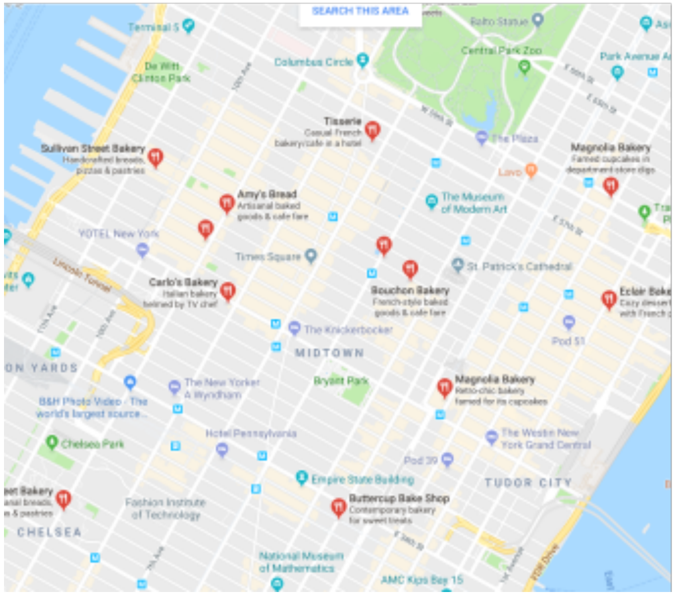
- On anaconda (in terminal) :

  ```
  conda install -c conda-forge keras
  ```

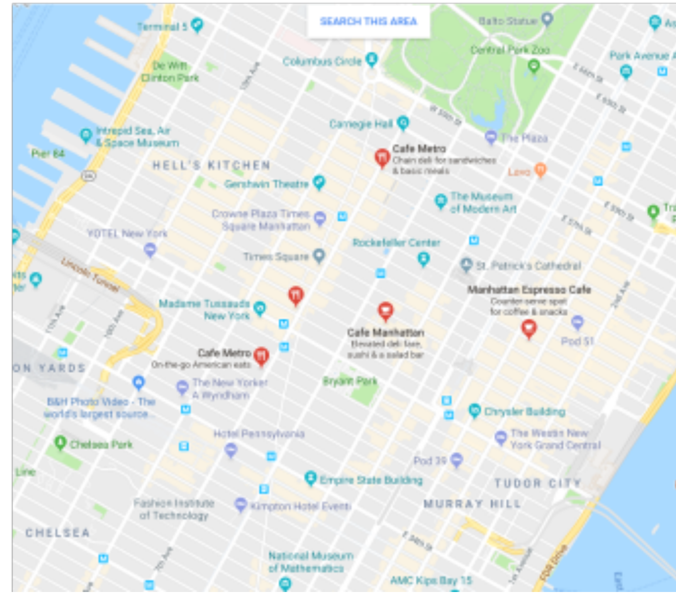
- With pip (requires C compiler) :

  ```
  pip install keras
  ```

Bakeries



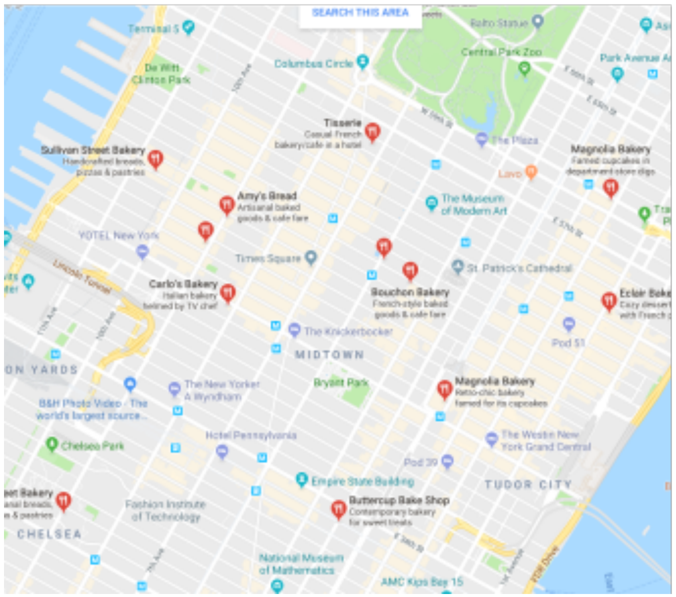
Cafés



Part 1: Intro to OT with POT

- File: `0_Intro_OT.ipynb`
- Problem of Cafés and Bakeries (in Manhattan).
- Visualize the problem (on the map and in matrix form).
- Solve OT with different ground metrics.
- Interpret the OT matrix.

Bakeries



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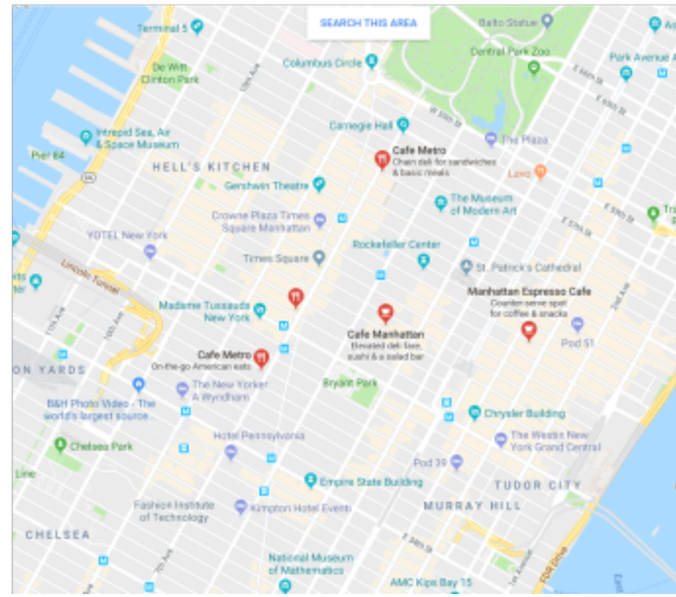

Part 2: Implement Sinkhorn [Cuturi, 2013]

- File: `0_Intro_OT.ipynb`
- Implement the Sinkhorn-Knopp loop.
- Interpret the OT matrix.

Part 3: Word Mover's Distance [Kusner et al., 2015]

- File: `4_WMD.ipynb`
- Reproduce figure above.
- Interpret the OT matrix on words.
- Perform regression for sentence similarity.

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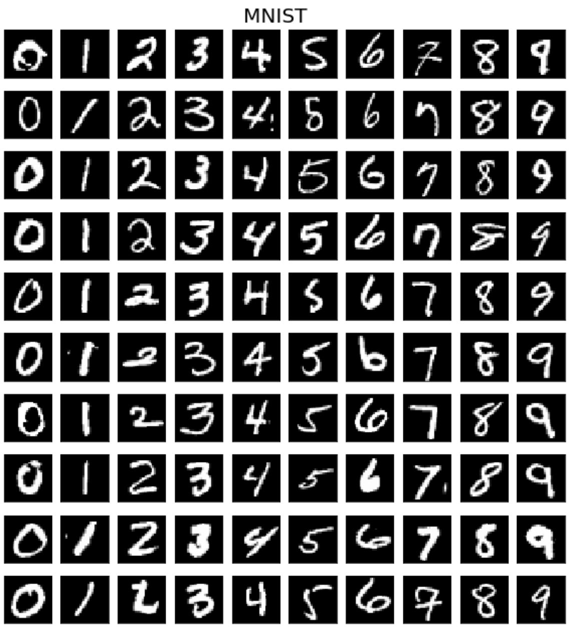
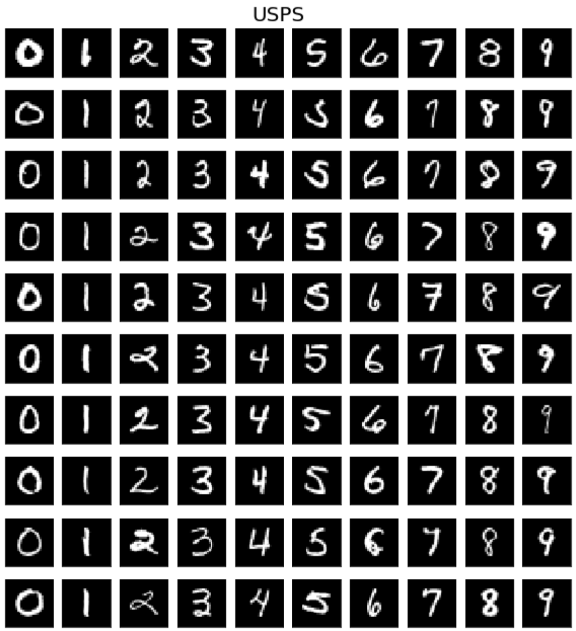
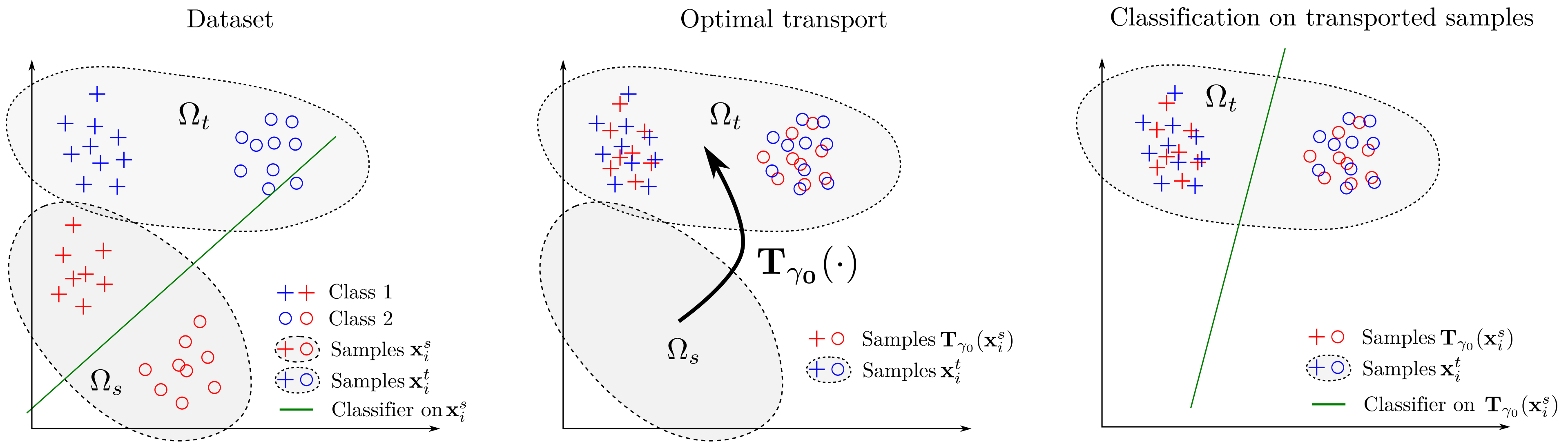
Practical Session 2





Domain adaptation with OT [Courty et al., 2016]

- File: `1_DomainAdaptation.ipynb`
- Adapting between MNIST and USPS digits datasets.
- Solve OT and apply approximate Monge Mapping.
- Look at displaced samples and train classifier.



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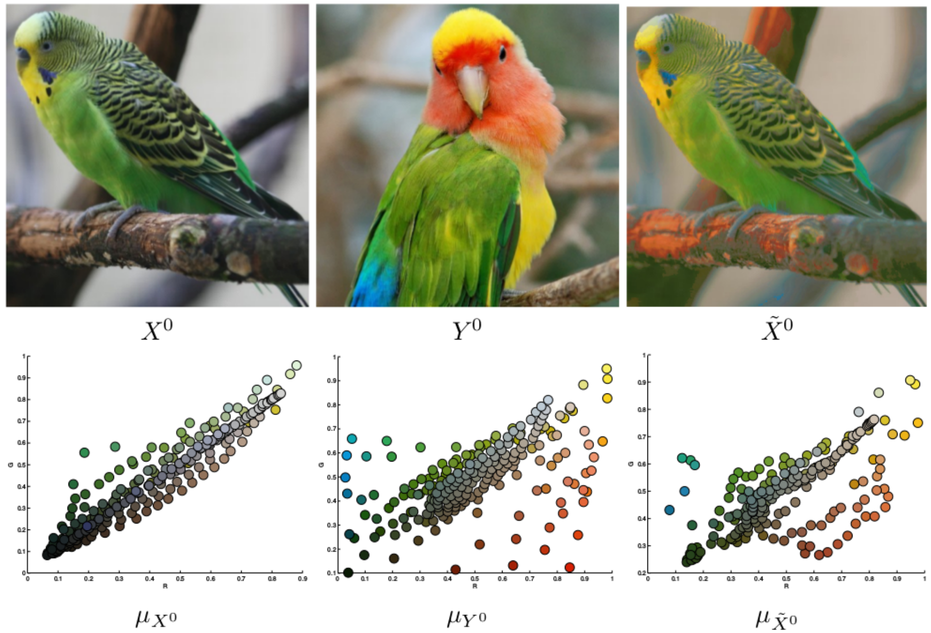
Practical Session 2

Color Grading [Ferradans et al., 2014]

- File: `2_ColorGrading.ipynb`
- Adapt between paintings from Gustav Klimt and Egon Schiele.
- Represent image as distribution of pixels in 3D.
- Compute OT and apply approximate Monge mapping.
- Reconstruct image.



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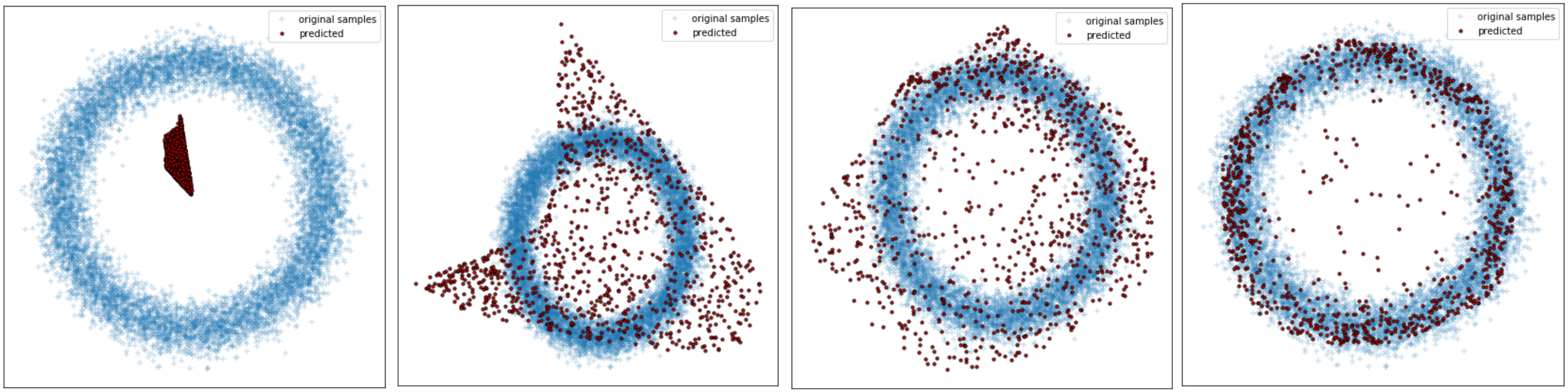

Wasserstein GAN [Arjovsky et al., 2017]

- File: `3_WGAN.ipynb`
- Requires Keras and knowledge of neural networks.
- Design and learn Wasserstein GAN for 2D samples.
- Implement both original WGAN and and improved WGAN (gradient penalty [Gulrajani et al., 2017]).
- Convergence in few minutes on laptops.

References i

Arjovsky, M., Chintala, S., and Bottou, L. (2017).
Wasserstein gan.
arXiv preprint arXiv:1701.07875.

Courty, N., Flamary, R., Tuia, D., and Rakotomamonjy, A. (2016).
Optimal transport for domain adaptation.
Pattern Analysis and Machine Intelligence, IEEE Transactions on.

Cuturi, M. (2013).
Sinkhorn distances: Lightspeed computation of optimal transportation.
In *Neural Information Processing Systems (NIPS)*, pages 2292–2300.

References ii

Ferradans, S., Papadakis, N., Peyré, G., and Aujol, J.-F. (2014).
Regularized discrete optimal transport.
SIAM Journal on Imaging Sciences, 7(3).

Gulrajani, I., Ahmed, F., Arjovsky, M., Dumoulin, V., and Courville, A. C. (2017).
Improved training of wasserstein gans.
In *Advances in Neural Information Processing Systems*, pages 5769–5779.

Kusner, M., Sun, Y., Kolkin, N., and Weinberger, K. (2015).
From word embeddings to document distances.
In *International Conference on Machine Learning*, pages 957–966.