http://www-sop.inria.fr/geometrica/collaborations/TGDA/index.html

TGDA

Topological and Geometric Data Analysis

Geometric Computing group
Stanford University

Geometrica group
INRIA Saclay / Sophia

Official colaboration between research groups

- **Geometric Computing group**

(L. J. Guibas, 15 people)

- **Geometrica group**

(J-D Boissonnat, 25 people)

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- **Geometric Computing group**

(L. J. Guibas, 15 people)

- Applied Topology group

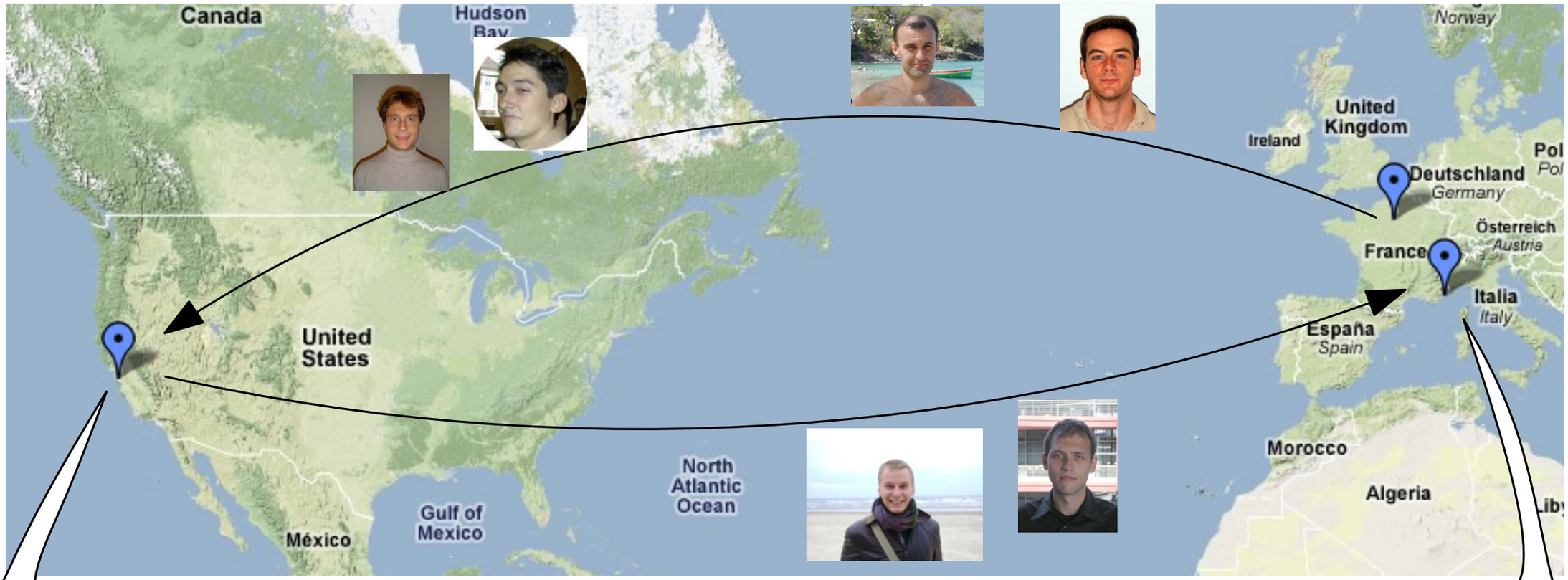
- ML, Robotics, Bio-computation...

- **Geometrica group**

(J-D Boissonnat, 25 people)

- ABS, Select, Asap...

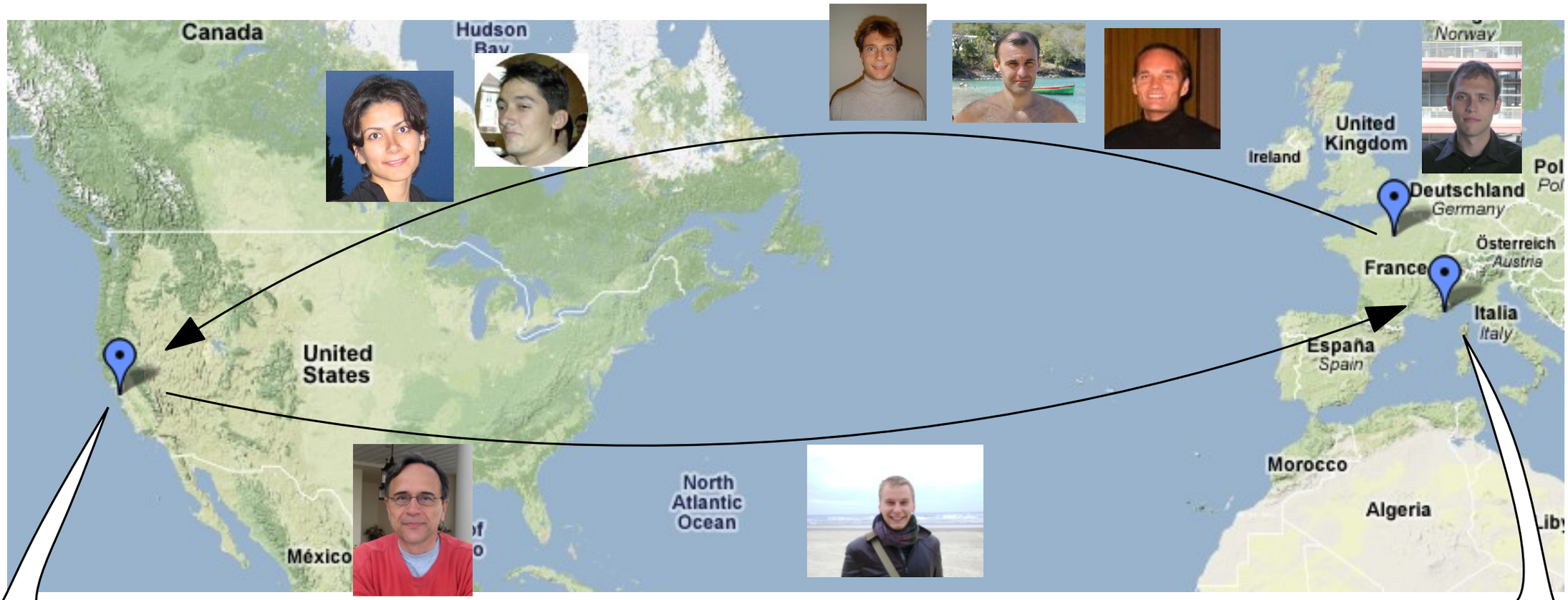
Exchanges (2008)



- **Geometric Computing group**
  - long-term: M. Ovsjanikovs, P. Skraba

- **Geometrica group**
  - long-term: Q. Mérigot, S. Oudot
  - short-term: F. Chazal, D. Cohen-Steiner

Exchanges (2009)



- **Geometric Computing group**
  - long-term: M. Ovsjanikovs
  - short-term: L. Guibas
  - 2-year post-doc: P. Skraba

- **Geometrica group**
  - long-term: Q. Mérigot, P. Memari
  - short-term: F. Chazal, J-D Boissonnat, S. Oudot

Funding

- **Geometric Computing group**

  18 kE in 2008 (NSF)

  25 kE in 2009 (NSF + FFS)

  ...

- **Geometrica group**

  20 kE in 2008 (EA)

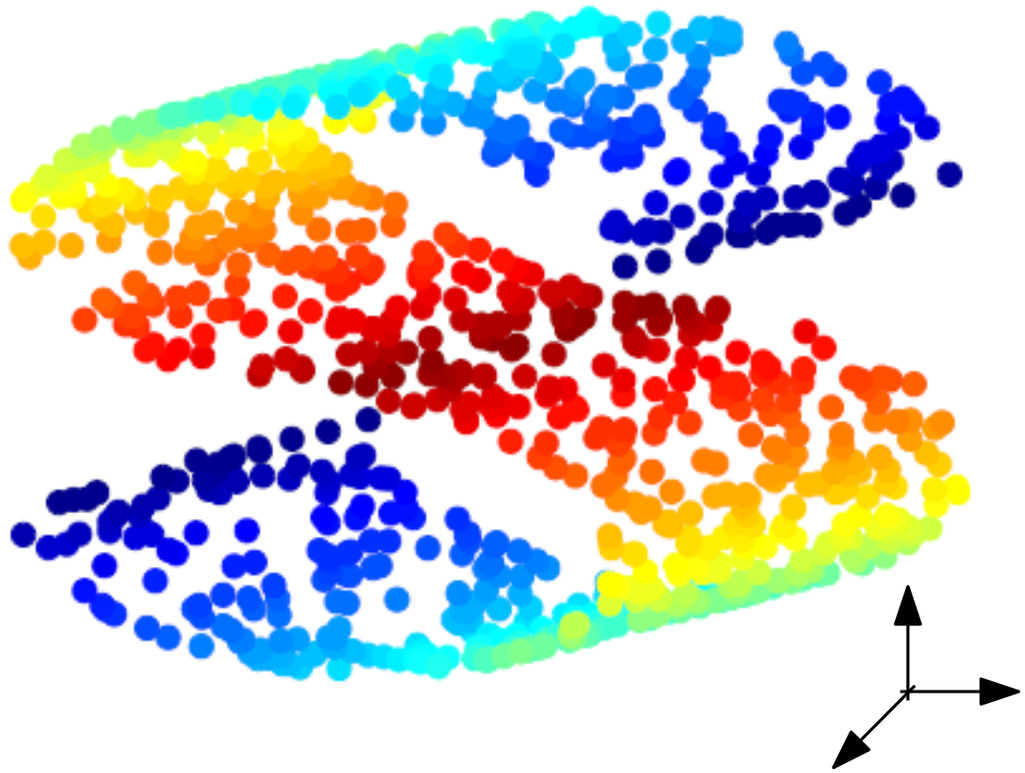
  20 kE in 2009 (EA)

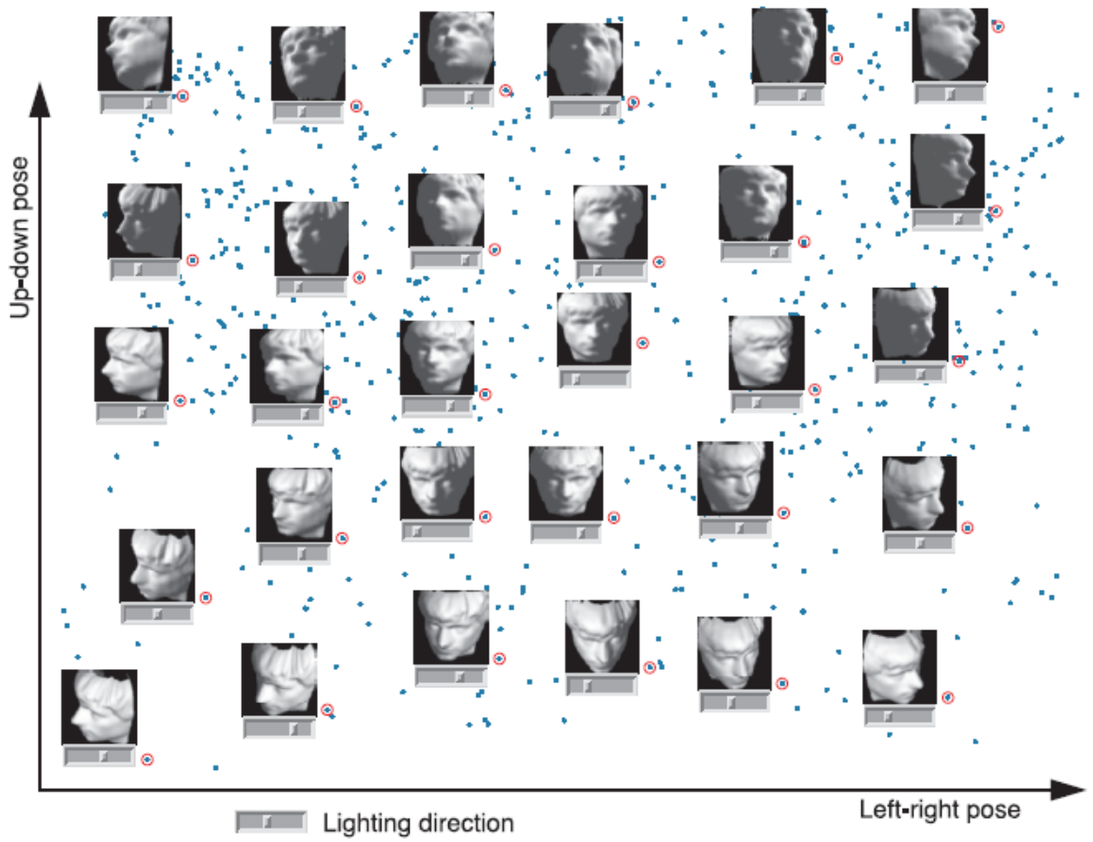
  ...

Main Scientific Goals

Input: a point cloud in a metric space.

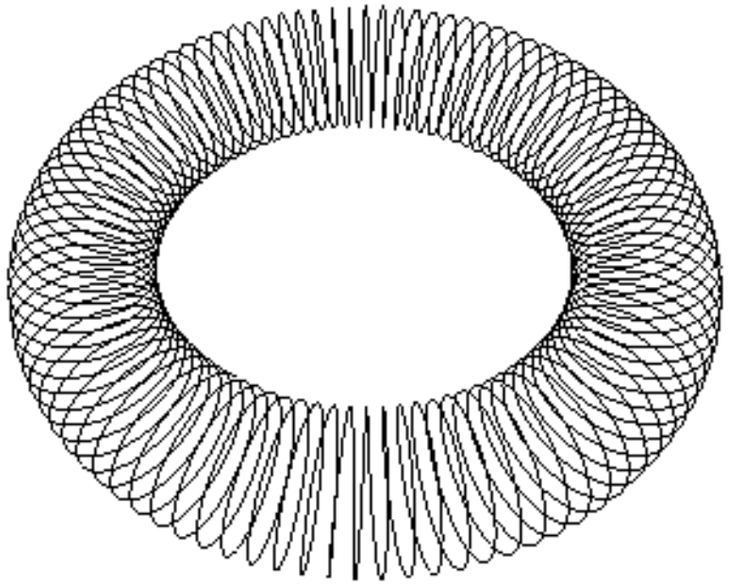
Is there structure in the data?
Can we infer topological invariants?
Can we approximate differential quantities?

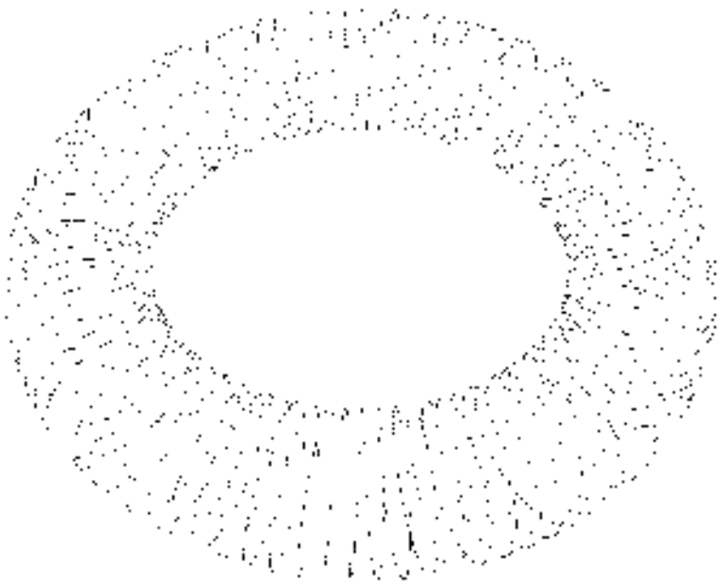




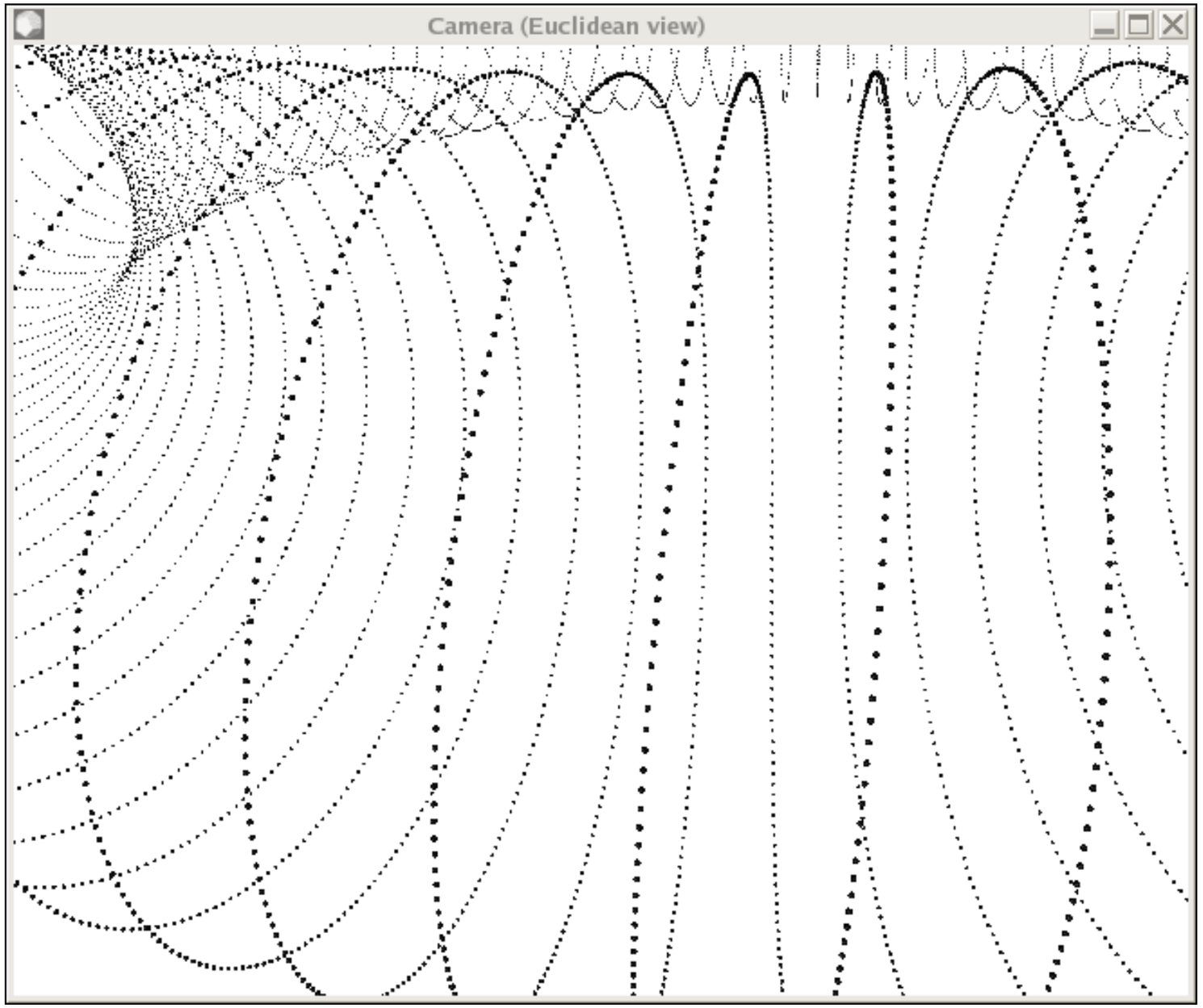
Example: set of 4096-dimensional data points, representing 64x64 pixels images of a same object, seen under various lighting and camera angles. (from Isomap, *Science* 290).

Theoretical Challenges





What is the underlying object?



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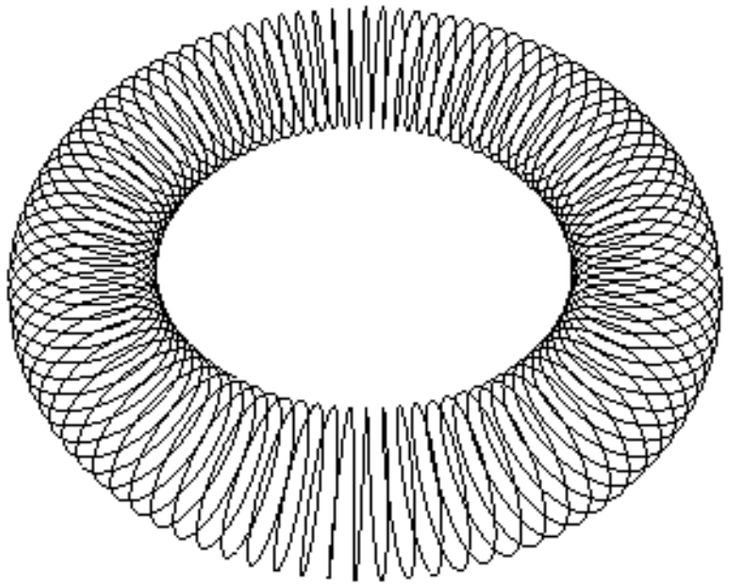

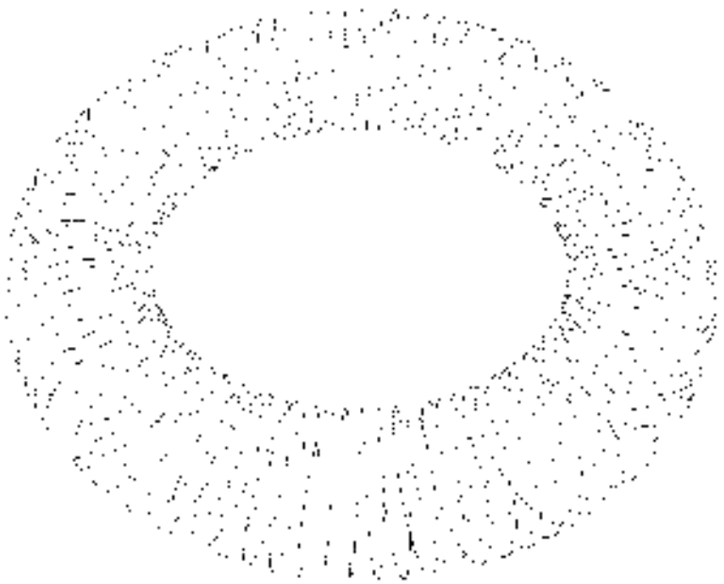

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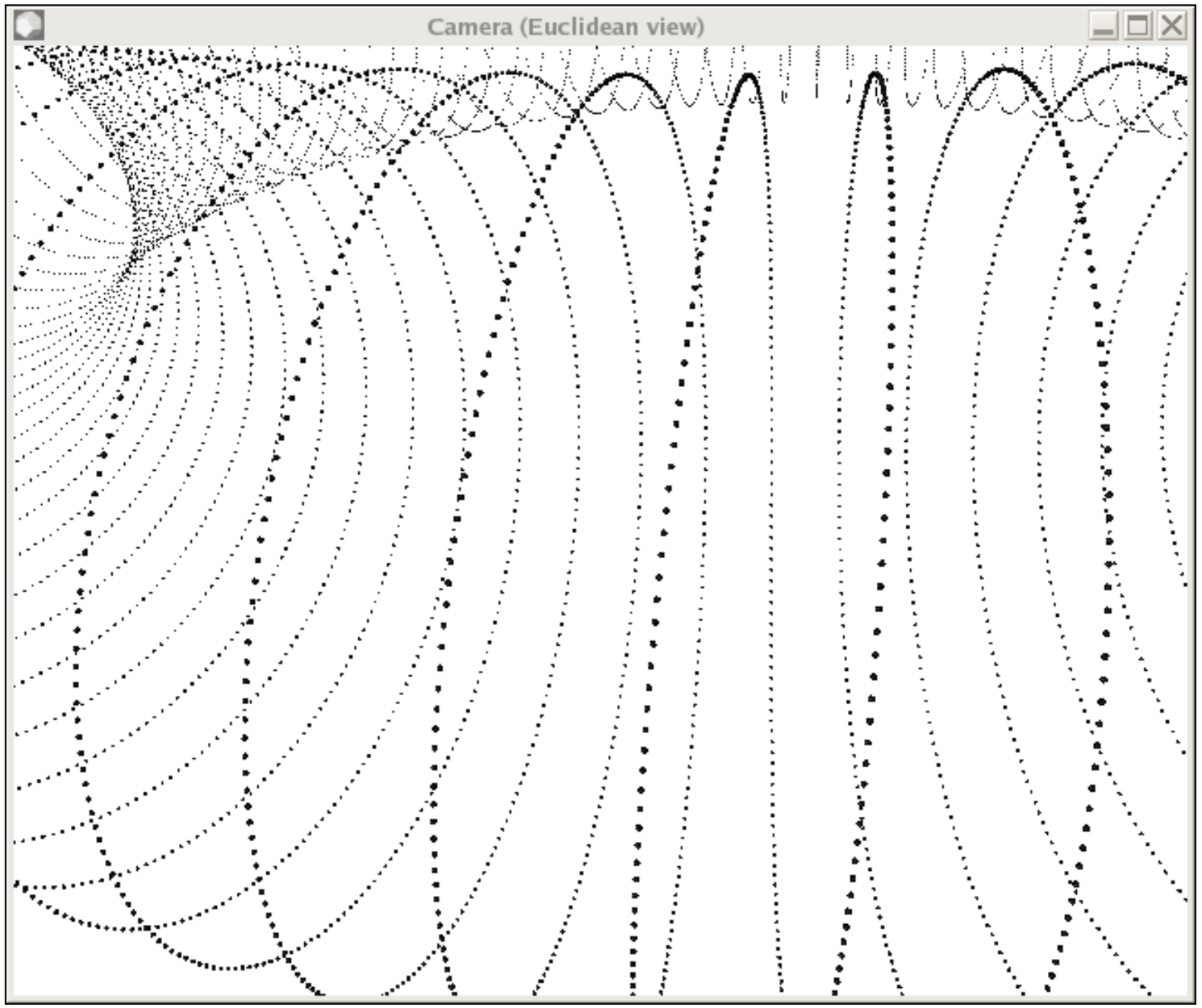

- perform multi-scale analysis (landmarking, topological persistence)

Algorithmic Challenges

Curse of dimensionality:

The ε-entropy ($\varepsilon < 1$) of a smooth k-dimensional submanifold M of Euclidean space $\mathbb{R}^d$ is of the order of $-k\log(\varepsilon)$. In other words, for any finite set X s.t. $d_H(M, X) \leq \varepsilon$, $|X| = \Omega((\frac{1}{\varepsilon})^k)$.

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- assume high co-dimension: $1 \lesssim k \ll d$

Double curse:

For a finite set of points on a k-submanifold of $\mathbb{R}^d$, classical data structures from computational geometry and topology (Čech complex, Delaunay triangulation, α-shape) scale up exponentially with d, not k.

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- Build lightweight data structures (Rips complex, witness complex)

Theoretical Tools

Delaunay

- restricted Delaunay
- ε-sampling theory
- α-shape
- Witness complex

Persistent Homology

- filtrations (Čech, Rips, ...)
- persistence algorithm
- stability of diagrams

Distance Functions

- offsets of compact sets
- critical point theory
- λ-medial axis

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Some Achievements and Perspectives

	Wednesday, July 8th
08:30 - 09:00	Registration
09:00 - 09:20	Opening remarks
09:20 - 10:30	**Key Note:** Geometric entropy minimization Alfred Hero
10:30 - 10:50	Coffee break
10:50 - 12:30	**Session 1: Reconstruction in 3D**
	Scale space meshing Julie Digne
	Reconstructing 3D compact sets Frédéric Cazals
12:30 - 14:00	Lunch
14:00 - 15:40	**Session 2: Reconstruction in arbitrary dimensions**
	Manifold Reconstruction from Tangential Complex Arijit Ghosh
	Model selection for simplicial approximation Bertrand Michel
15:40 - 16:00	Coffee break
16:00 - 17:40	**Session 3: Geometric inference in the presence of outliers**
	Geometric Inference for Measures based on Distance Functions Quentin Mérigot
	Efficient Approximation of the Distance to an Empirical Measure Dmitriy Morozov

	Thursday, July 9th
09:00 - 09:20	Registration
09:20 - 10:30	**Key Note:** An introduction to zigzag persistence Vin de Silva
10:30 - 10:50	Coffee break
10:50 - 12:30	**Session 4: Persistence and unsupervised learning**
	Persistence-based clustering Primoz Skraba
	Persistent cohomology and circular coordinates Mikael Vejdemo-Johansson
12:30 - 14:00	Lunch
14:00 - 15:40	**Session 5: Signatures for shape classification**
	Topo-geometric Modeling for 3D objects Hamid Krim
	Gromov-Wasserstein stable signatures for object matching and the role of persistence Facundo Mémoli
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	Deformable shape matching using linear programming Qixing Huang

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09:00 - 10:40	**Session 7: Reconstruction and mesh generation in 3D**
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	Reconstruction from Cross-Sections Pooran Memari
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	A compact data structure to represent the Delaunay Triangulation Clément Maria
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