

Deep Learning & Applied AI

Geometric deep learning

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SAPIENZA
UNIVERSITÀ DI ROMA



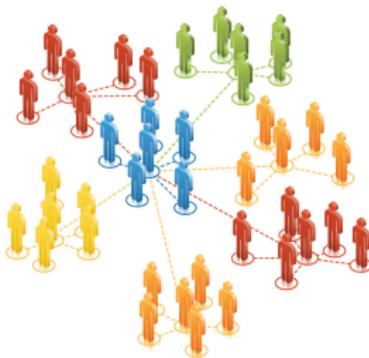
Audio signals



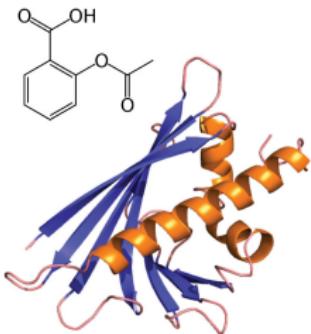
Images



Audio signals



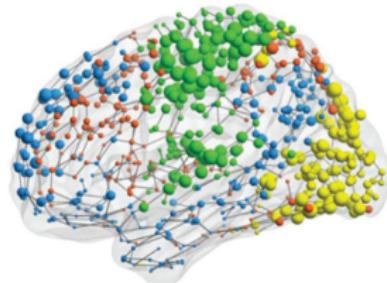
Social networks



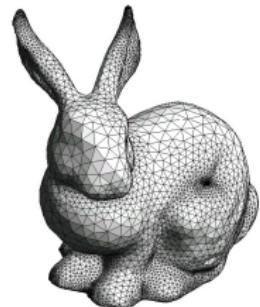
Molecules



Images

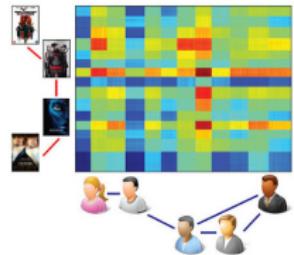


Functional networks

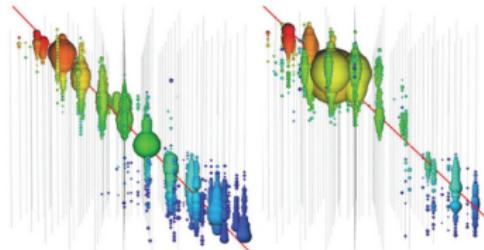


3D shapes

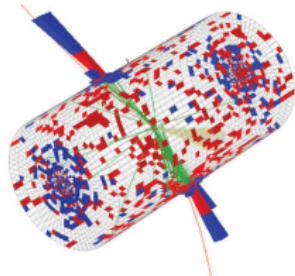
Applications of geometric deep learning



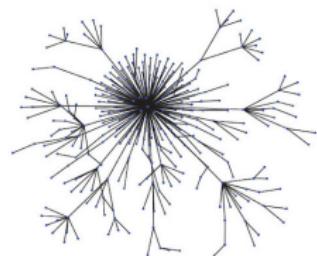
Recommender system



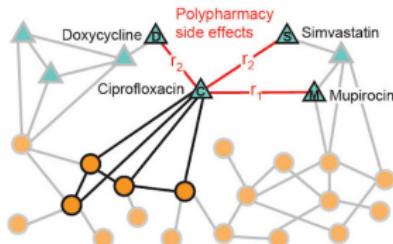
Neutrino detection



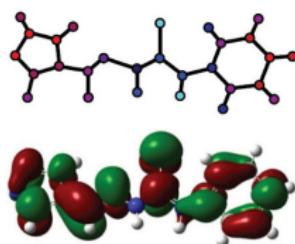
LHC



Fake news detection



Drug repurposing



Chemistry

Prototypical non-Euclidean objects



Manifolds

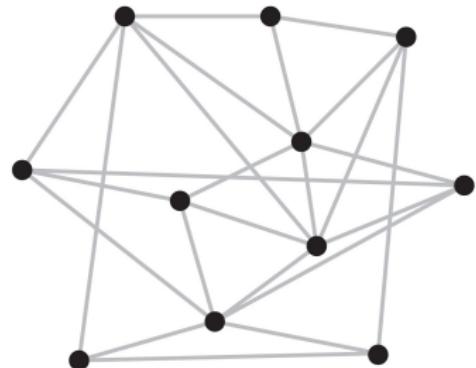


Graphs

Domain structure vs Data on a domain



Domain structure vs Data on a domain

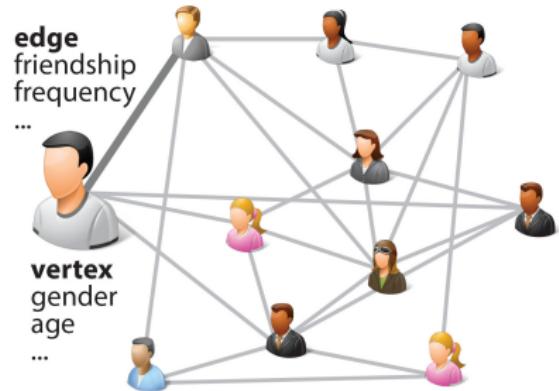


Domain structure

Domain structure vs Data on a domain

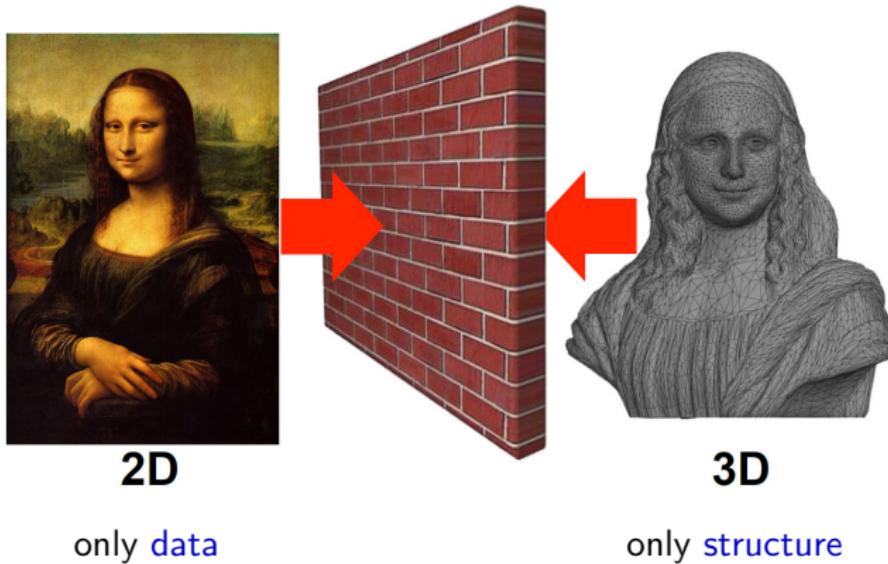


Domain structure



Data on a domain

Domain structure vs Data on a domain



Fixed vs different domain

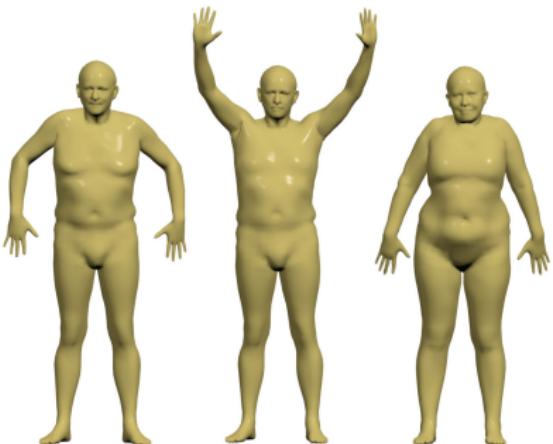


Social network
(fixed graph)

Fixed vs different domain



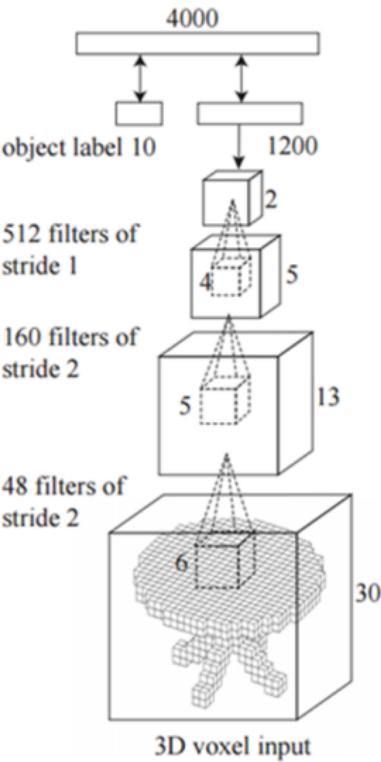
Social network
(fixed graph)



3D shapes
(different manifolds)

3D ShapeNets

- Volumetric representation (shape = binary voxels on 3D grid)

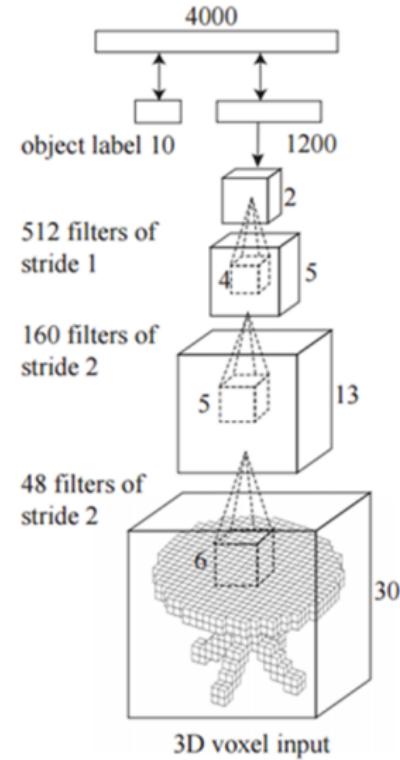
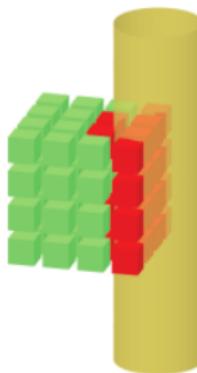


Convolutional deep belief network

Wu et al, "3D ShapeNets: A Deep Representation for Volumetric Shapes" 2015

3D ShapeNets

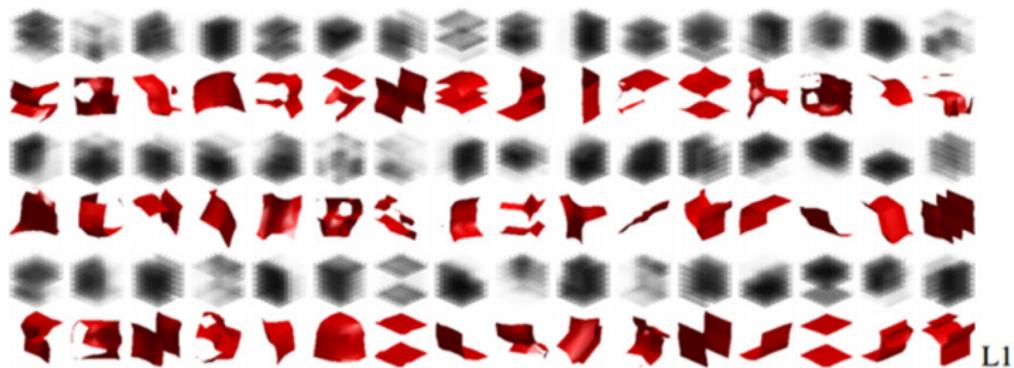
- Volumetric representation (shape = binary voxels on 3D grid)
- 3D convolutional network



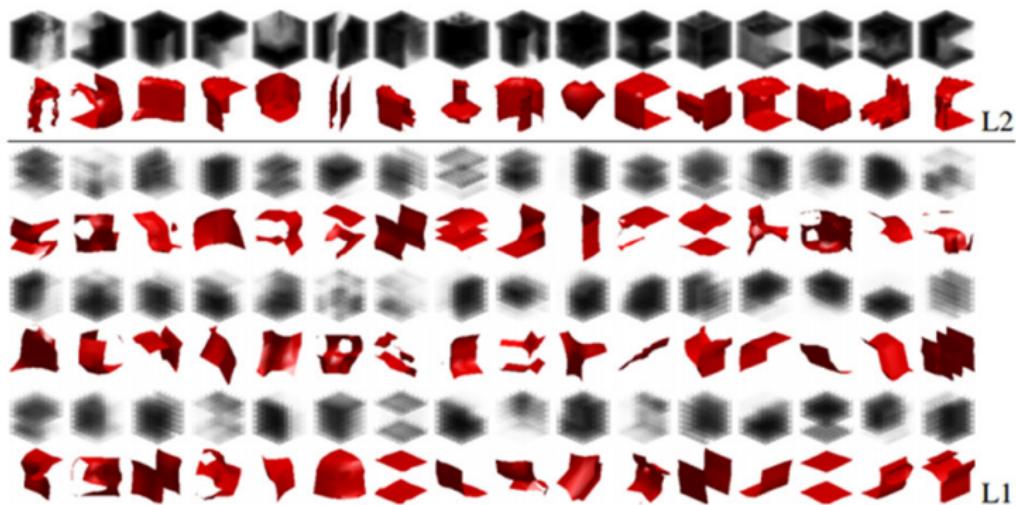
Convolutional deep belief network

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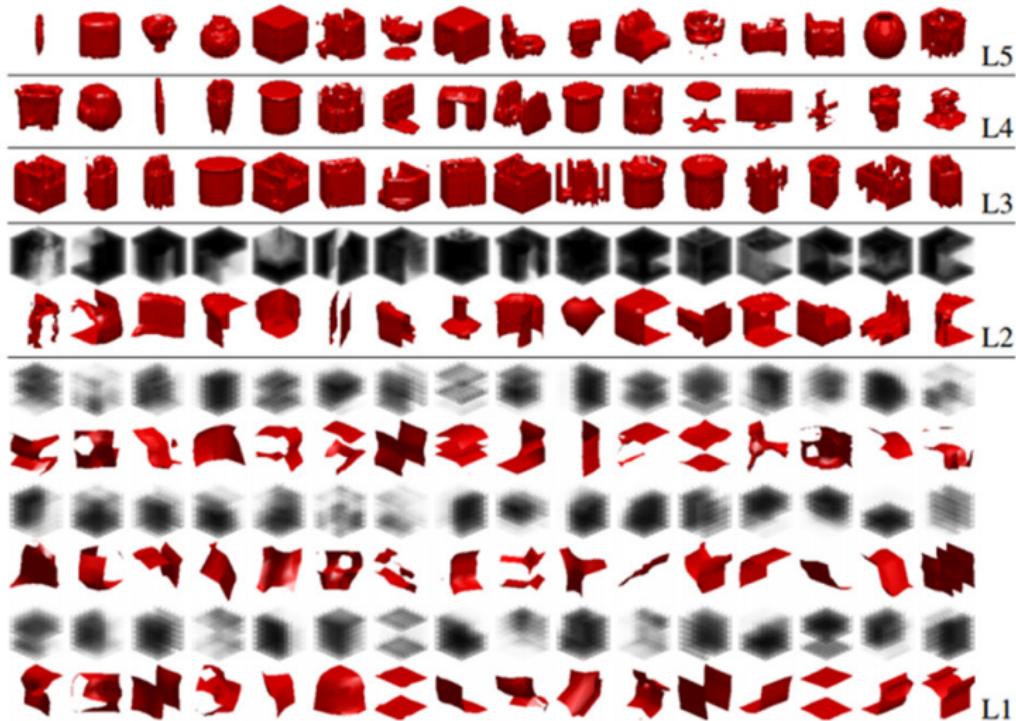
Learned features: 3D primitives



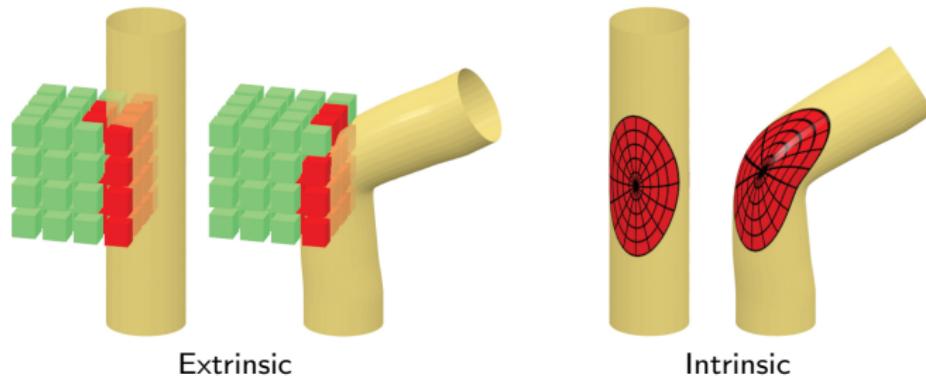
Learned features: 3D primitives



Learned features: 3D primitives



Challenges of geometric deep learning



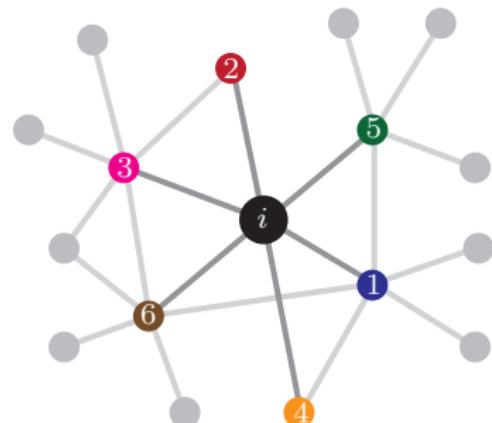
Extrinsic vs Intrinsic

Extrinsic

Intrinsic

Local ambiguity

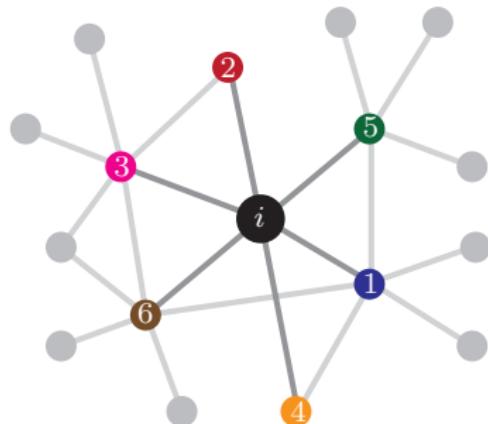
Unlike images, there is **no canonical ordering** of the domain points.



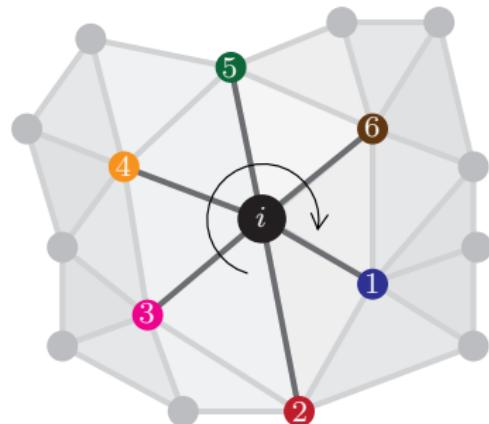
Graph (permutation)

Local ambiguity

Unlike images, there is **no canonical ordering** of the domain points.

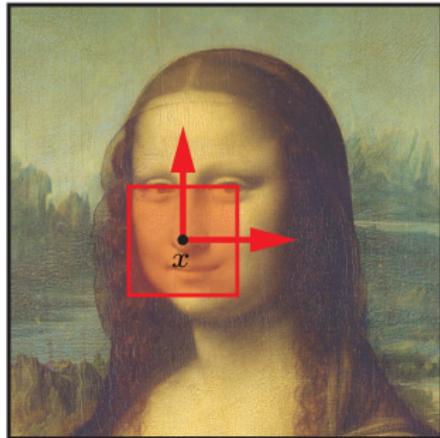


Graph (permutation)

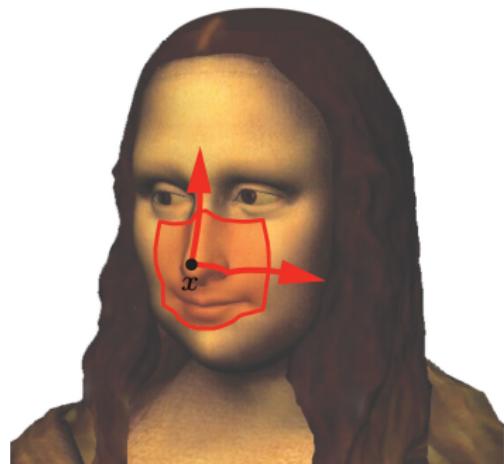


Mesh (rotation)

Non-Euclidean convolution?

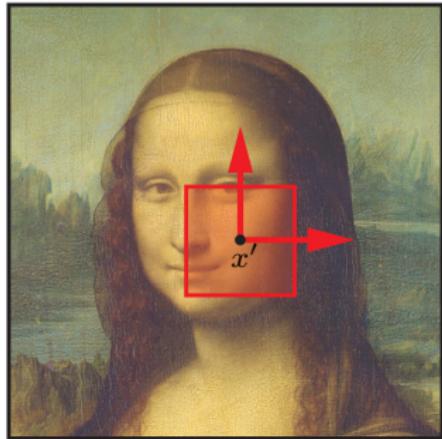


Euclidean

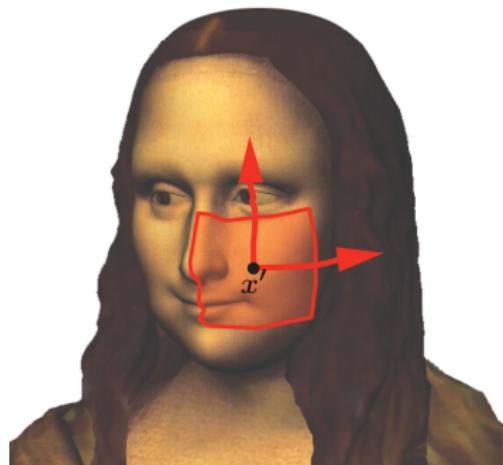


Non-Euclidean

Non-Euclidean convolution?

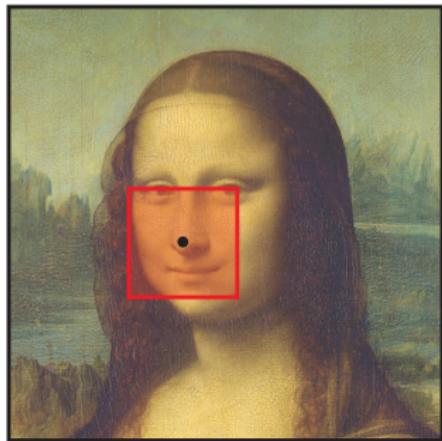


Euclidean

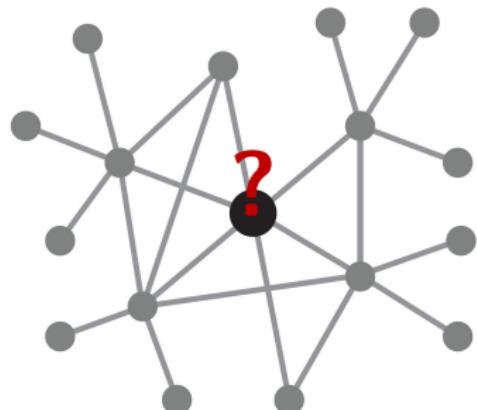


Non-Euclidean

Non-Euclidean convolution?



Image



Graph

Suggested reading

Bronstein et al, 2016

“Geometric deep learning: going beyond Euclidean data”

<https://arxiv.org/abs/1611.08097>