From persistent homology to machine learning

Henry Adams

Colorado State University

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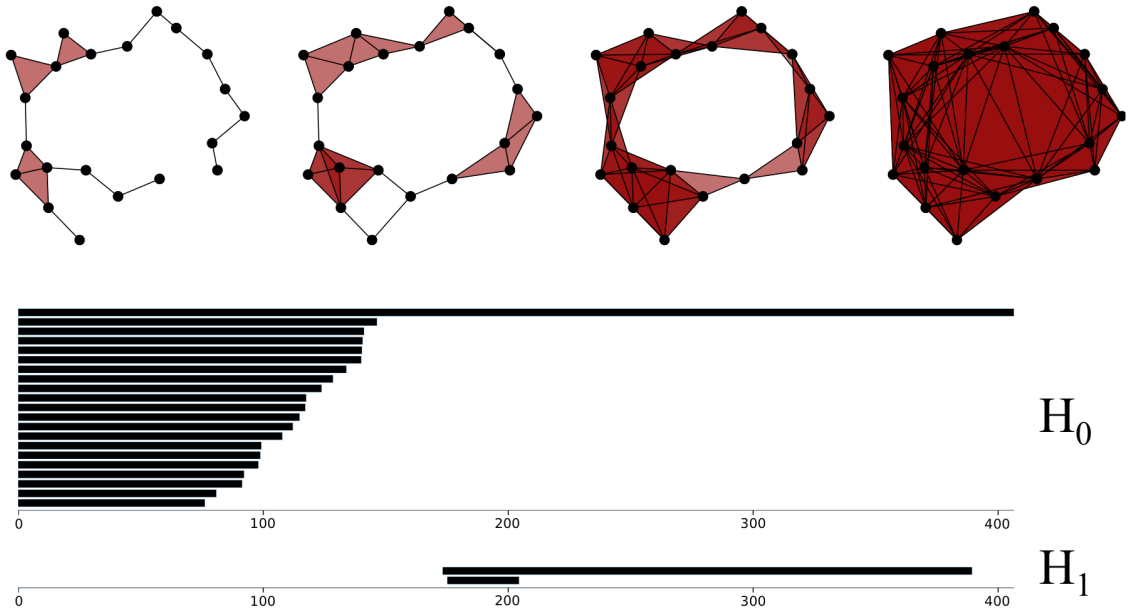
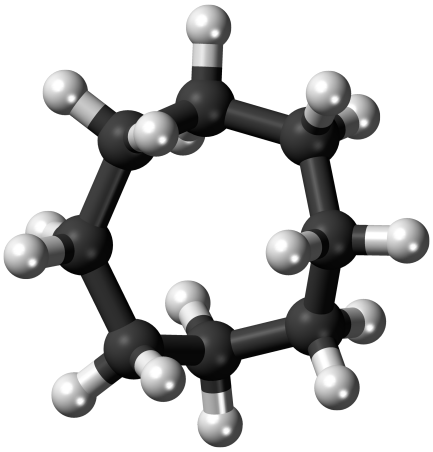
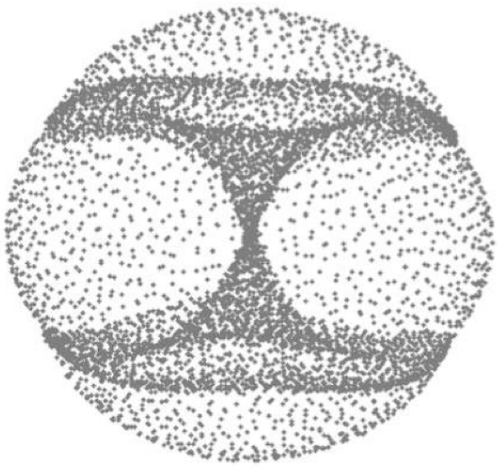
Persistent homology measures both the global topology and the local geometry of a dataset.

Global topology



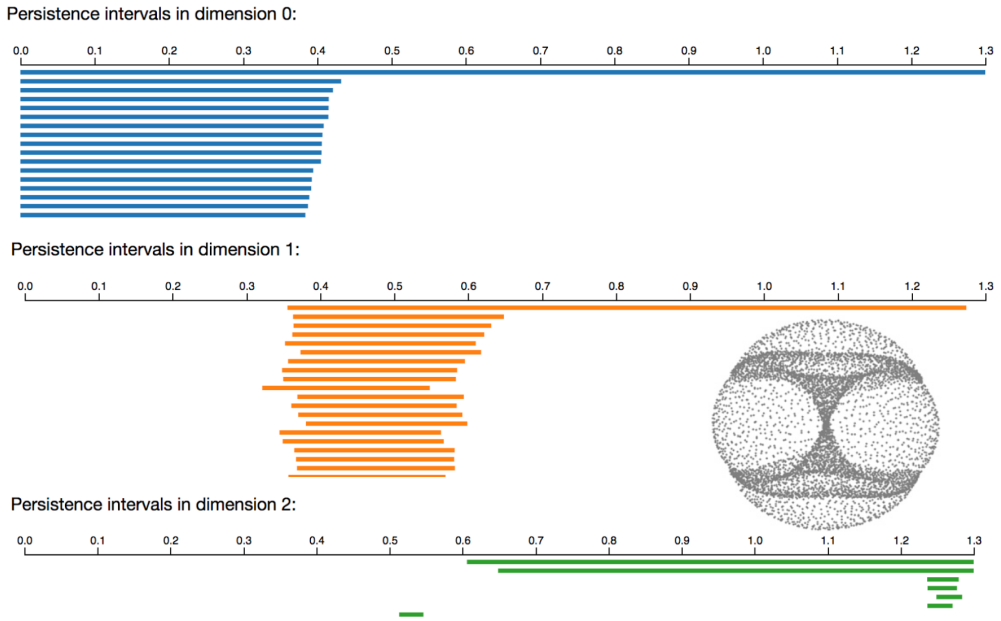
Global topology





Topology of cyclo-octane energy landscape
Martin, Thompson, Coutsias, Watson, 2010

Global topology



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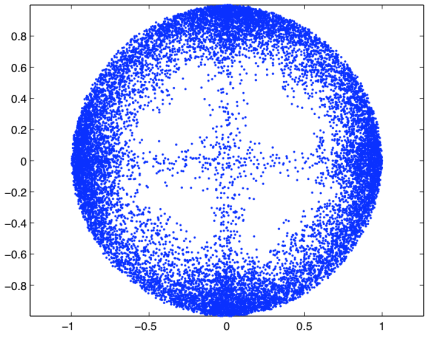
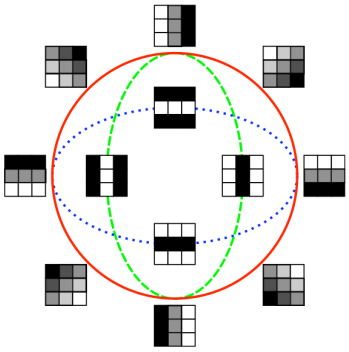
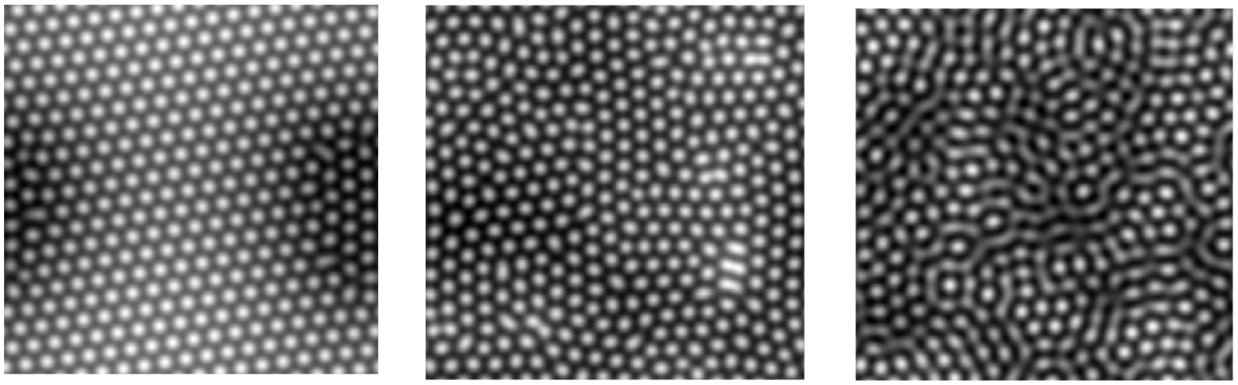




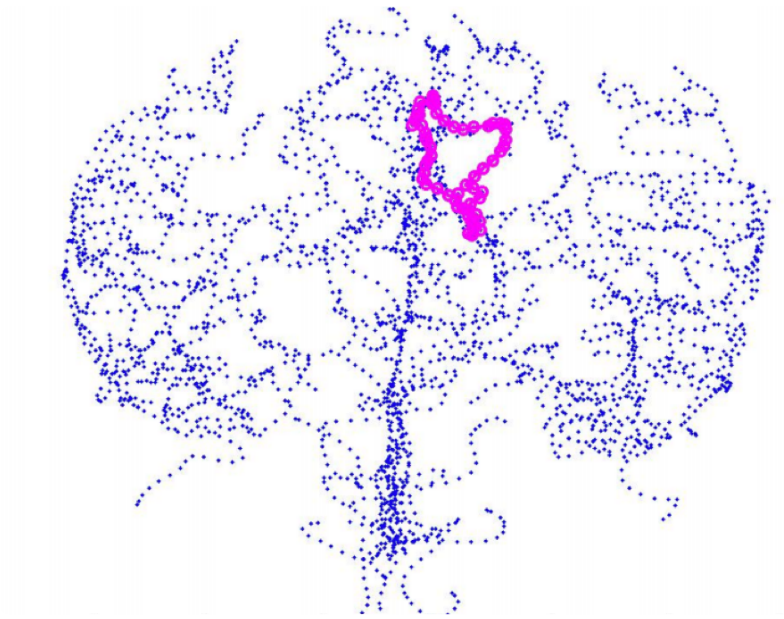
On the local behavior of natural images
Carlsson, Ishkhanov, de Silva, Zomorodian, 2008

Local geometry



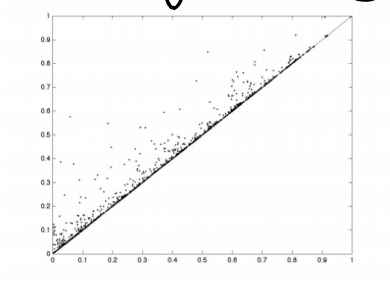
Measures of order for nearly hexagonal lattices
Motta, Neville, Shipman, Pearson, Bradley, 2018

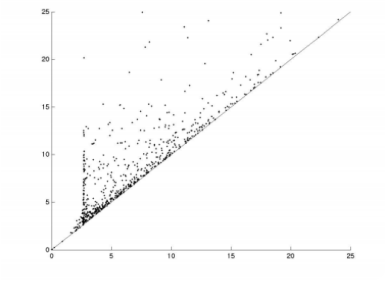
Local geometry

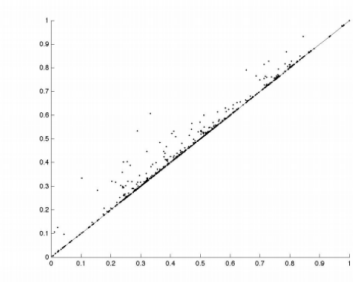


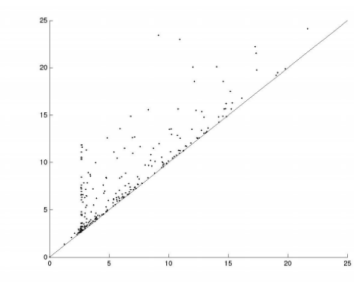
Persistent homology analysis of brain artery trees
Bendich, Marron, Miller, Pieloch, Skwerer, 2014

Local geometry









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Local geometry

Collective motion, self-organization

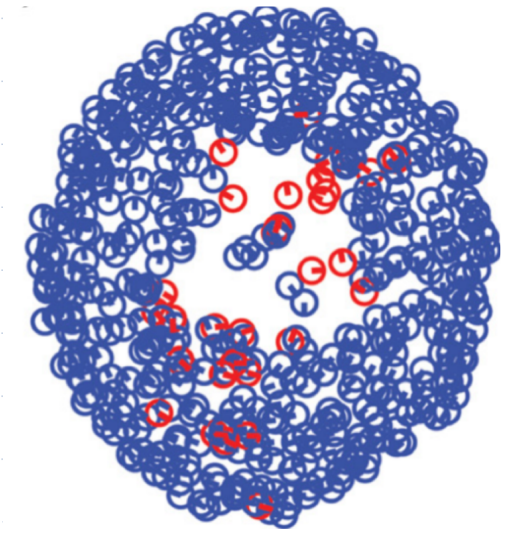
Local geometry



Collective motion, self-organization

Topological data analysis of biological aggregation models
Topaz, Ziegelmeier, Halverson, 2015

Local geometry



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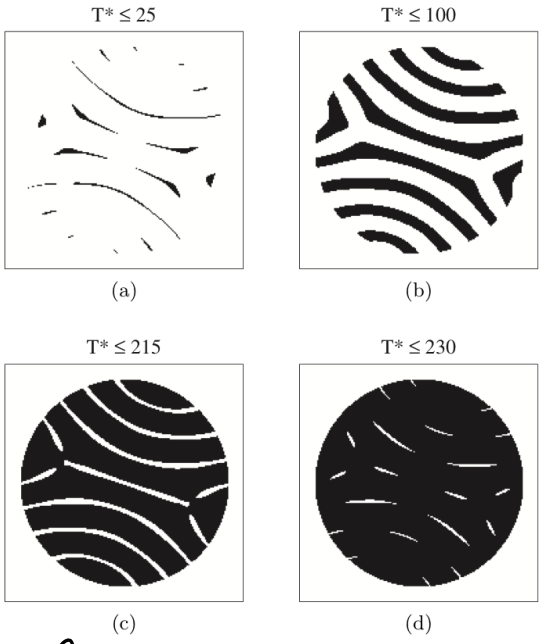
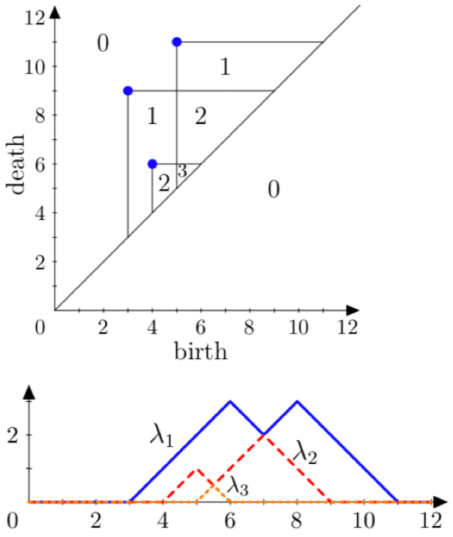
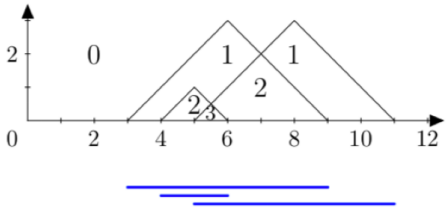


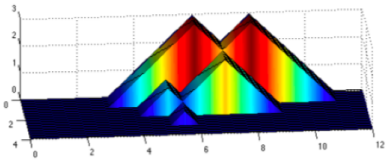
Analysis of Kolmogorov flow and Rayleigh-Bénard convection using persistent homology

Kramár, Levanger, Tithof, Suri, Xu, Paul, Schatz, Mischaikow

Local geometry

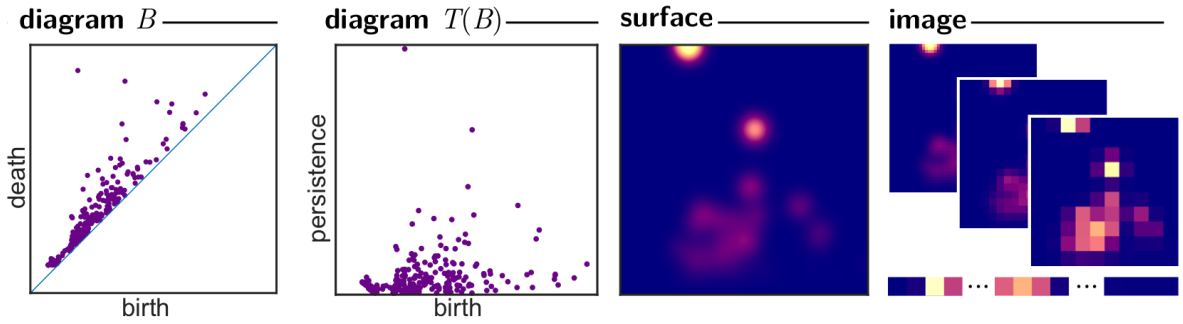






Statistical topological data analysis using persistence landscapes
Bubenik, 2015

Local geometry



Persistence images: A stable vector representation of persistent homology. Adams, Chepushtanova, Emerson, Hanson, Kirby, Motta, Neville, Peterson, Shipman, Ziegelmeier, 2017

Local geometry

Answer: (from left) $r = 1.75, 2, 1.75, 2, 2.$

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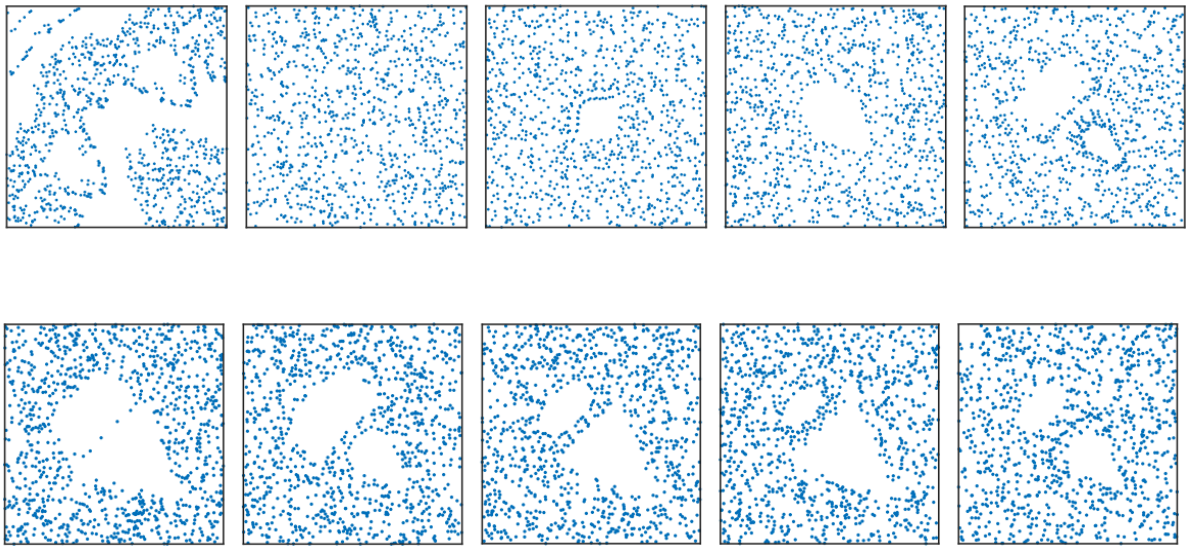
Local geometry



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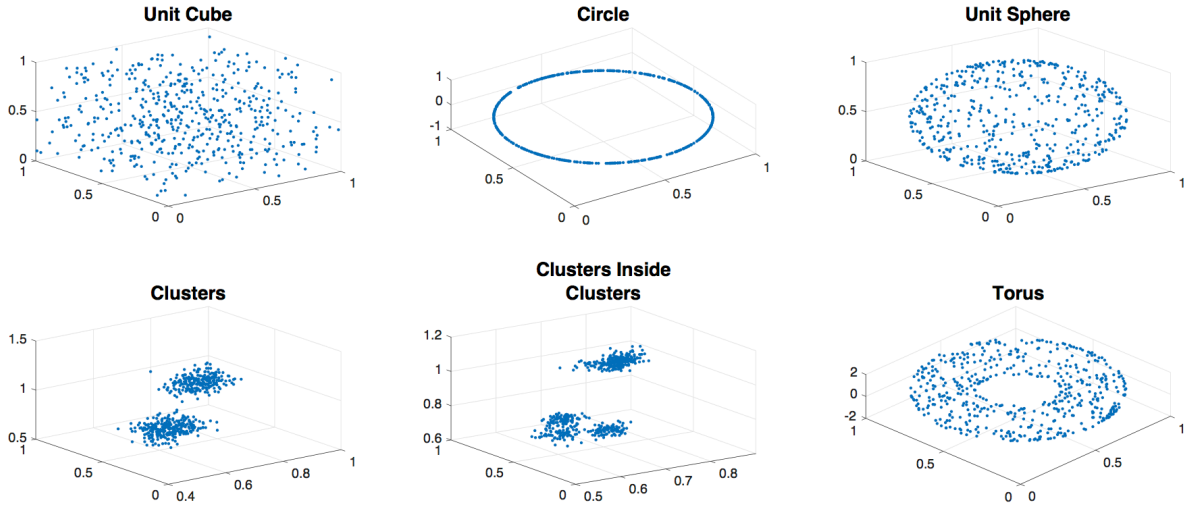

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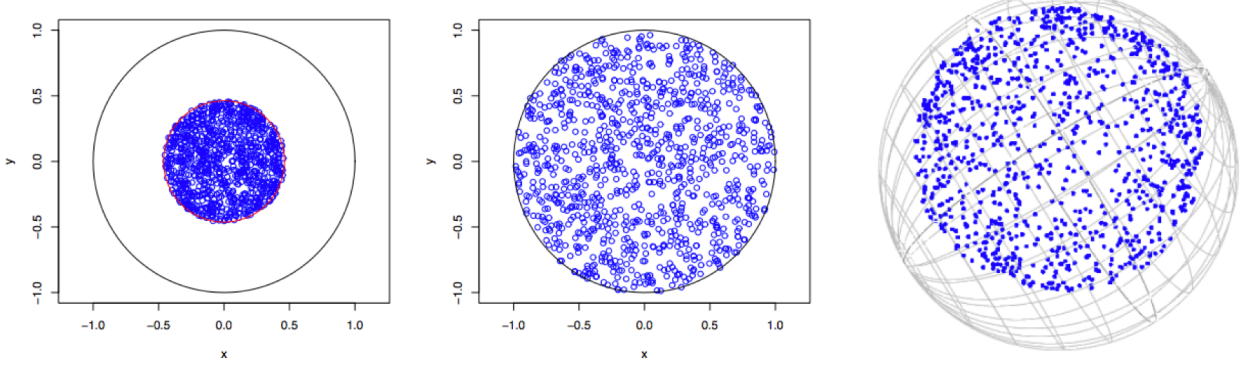
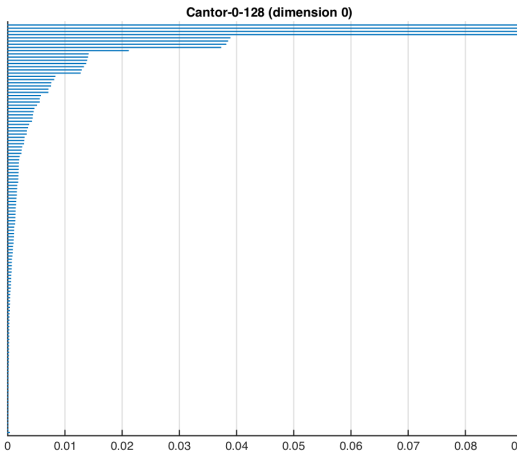
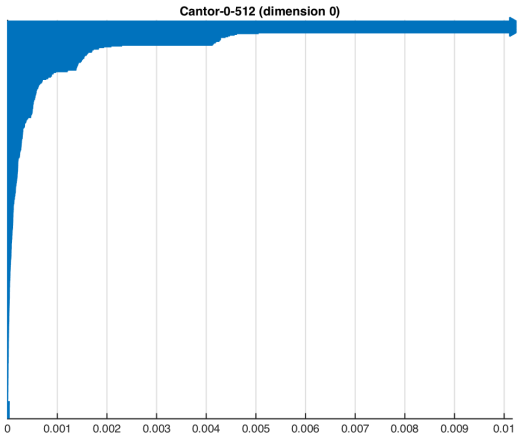


Persistent homology detects curvature
Bubenik, Hull, Patel, Whittle, 2019

Local geometry





A fractal dimension for measures via persistent homology
Adams, Aminian, Farnell, Kirby, Peterson, Mirth, Neville, Shonkwiler, 2020

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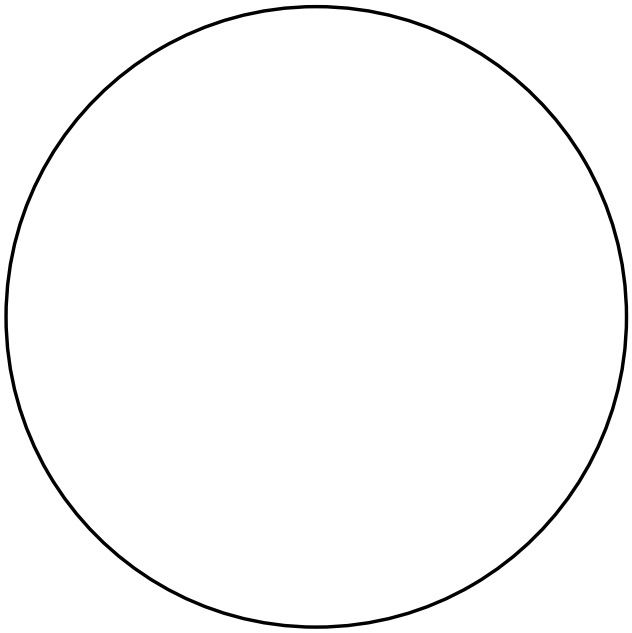

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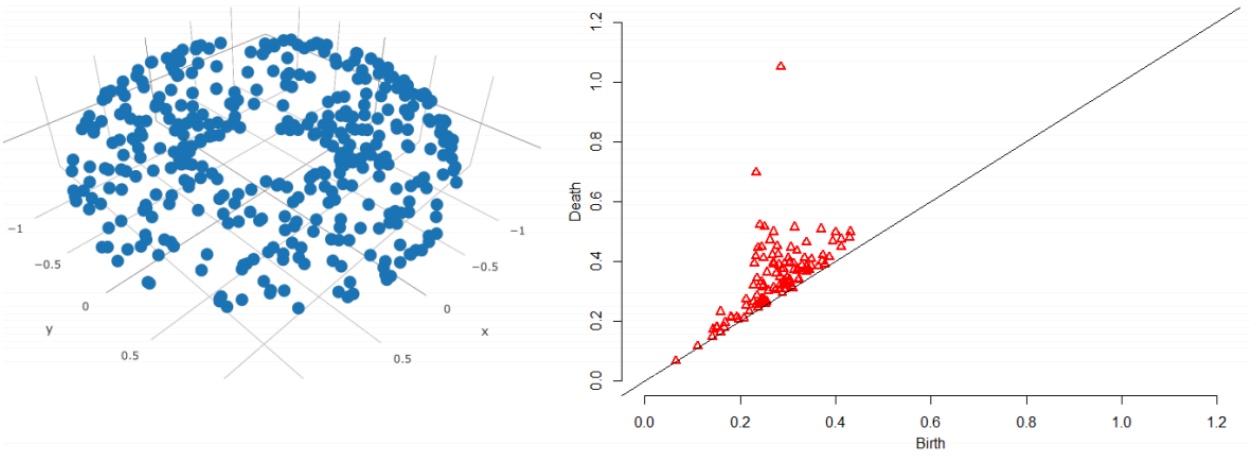

On the choice of weight functions for linear representations of persistence diagrams
Divol and Polonik, 2019

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