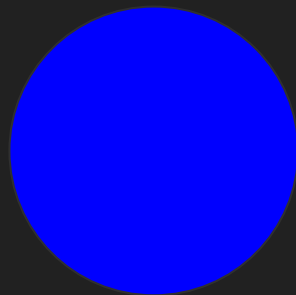


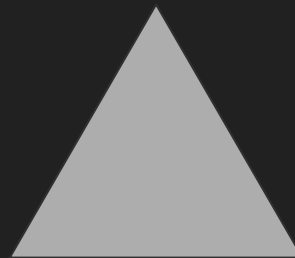
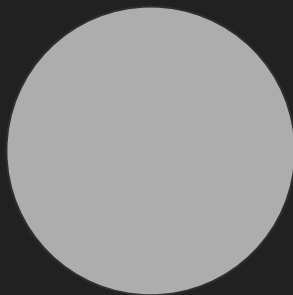
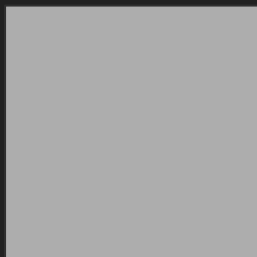
Introduction to Topological Data Analysis

Aleksei Prokopev, SeoulAI, 2018

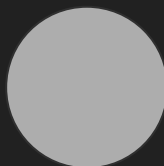
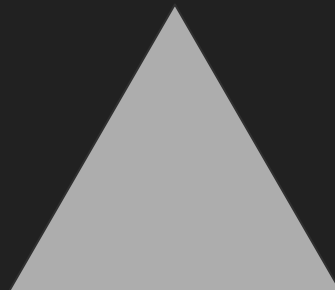
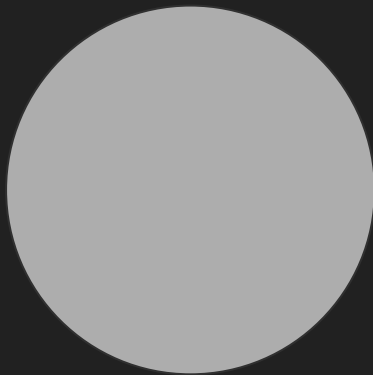
Shape



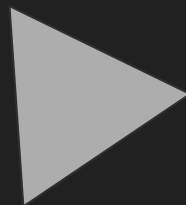
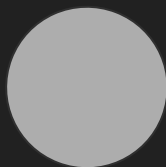
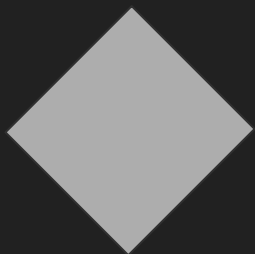
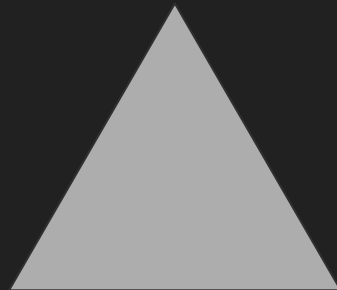
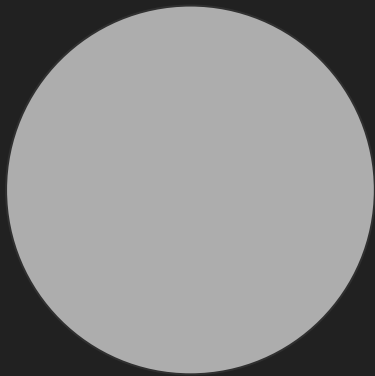
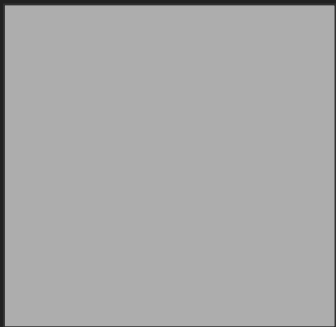
Invariance



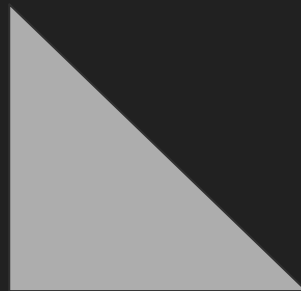
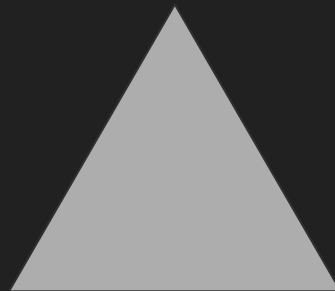
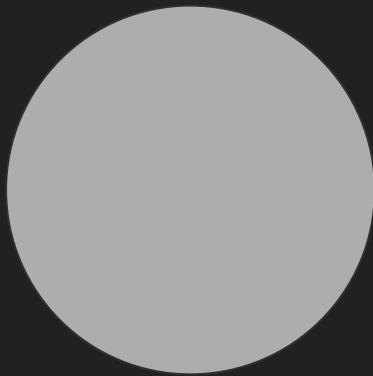
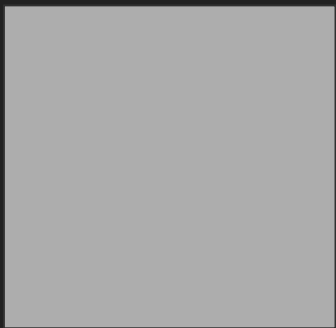
Scale



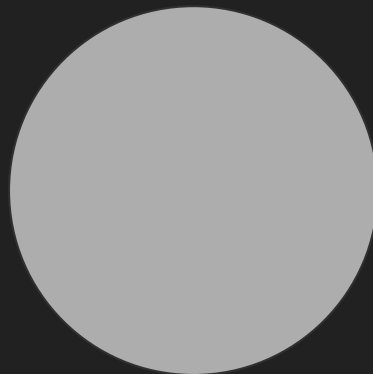
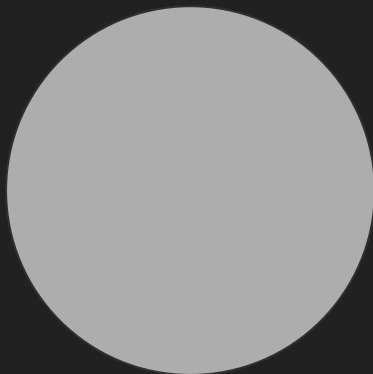
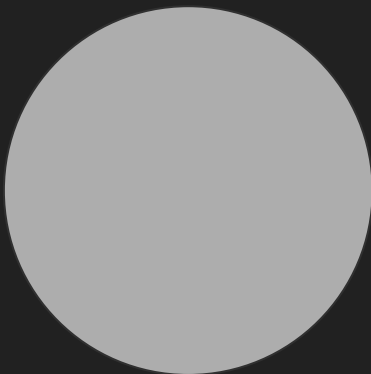
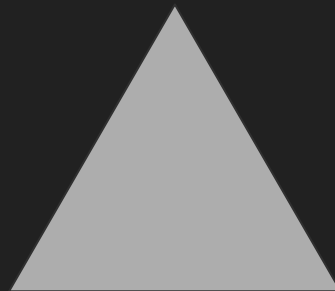
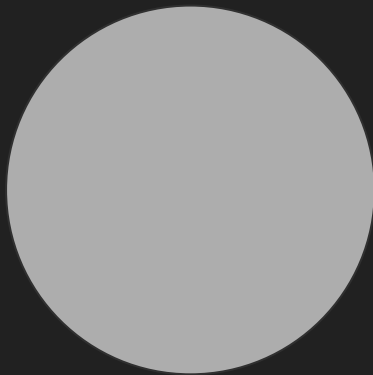
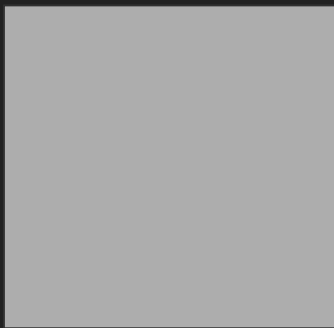
Rotation



Deformation



Homeomorphism



???

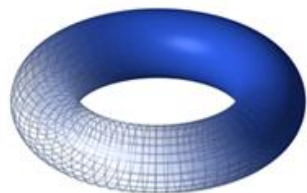
Spot the difference







Torus



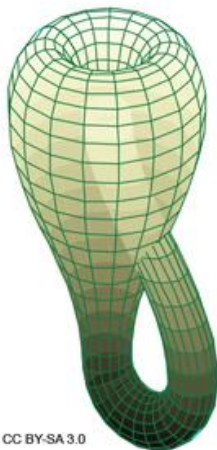
Double torus



Triple torus

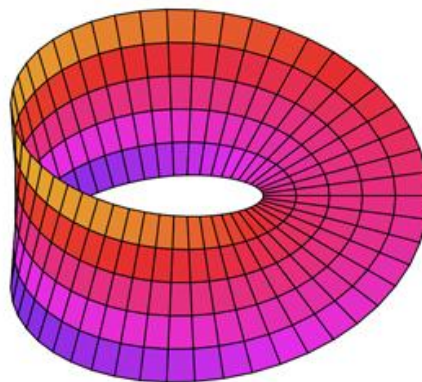


Klein bottle



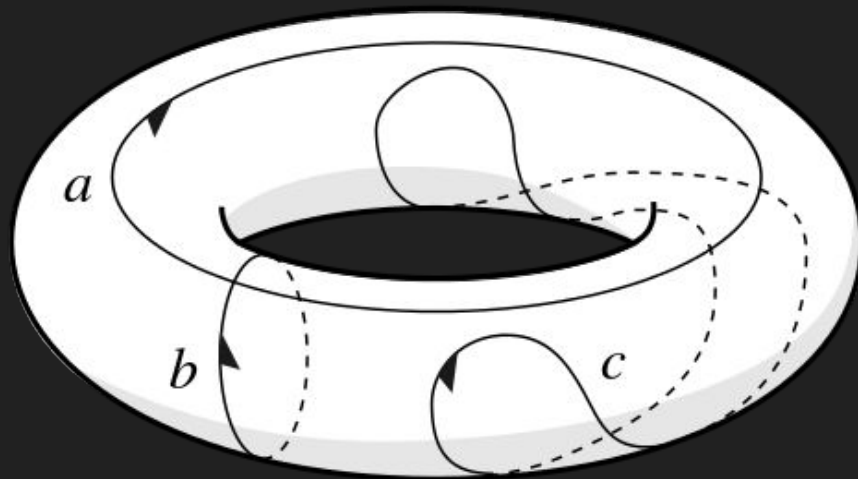
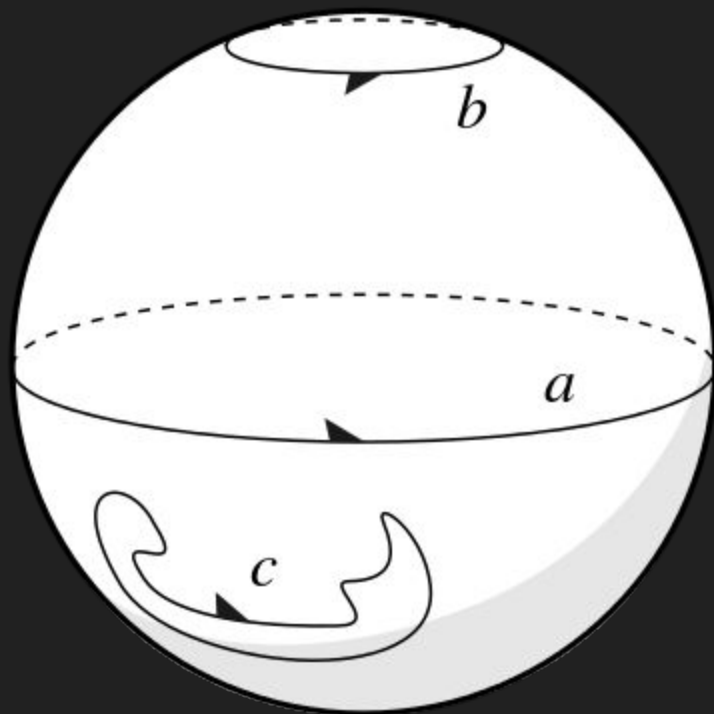
CC BY-SA 3.0

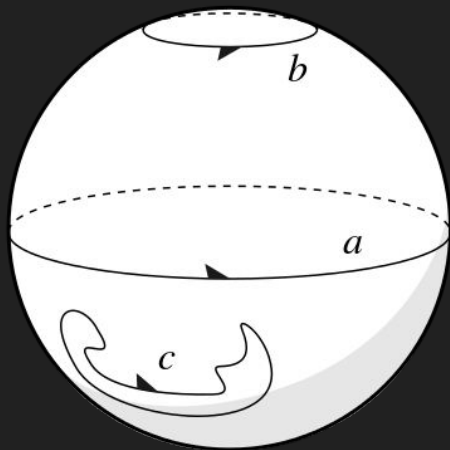
Möbius strip



CC BY-SA 3.0

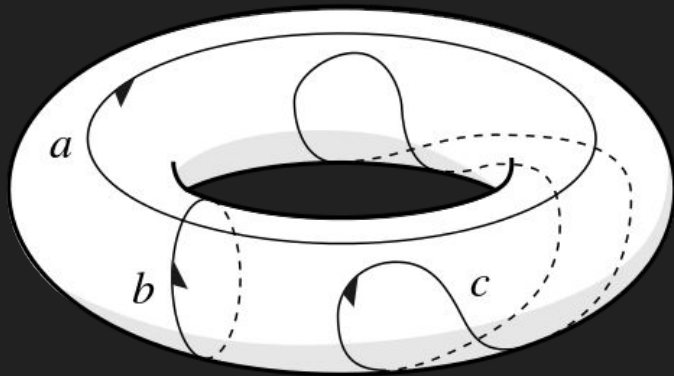
Homology





$=$

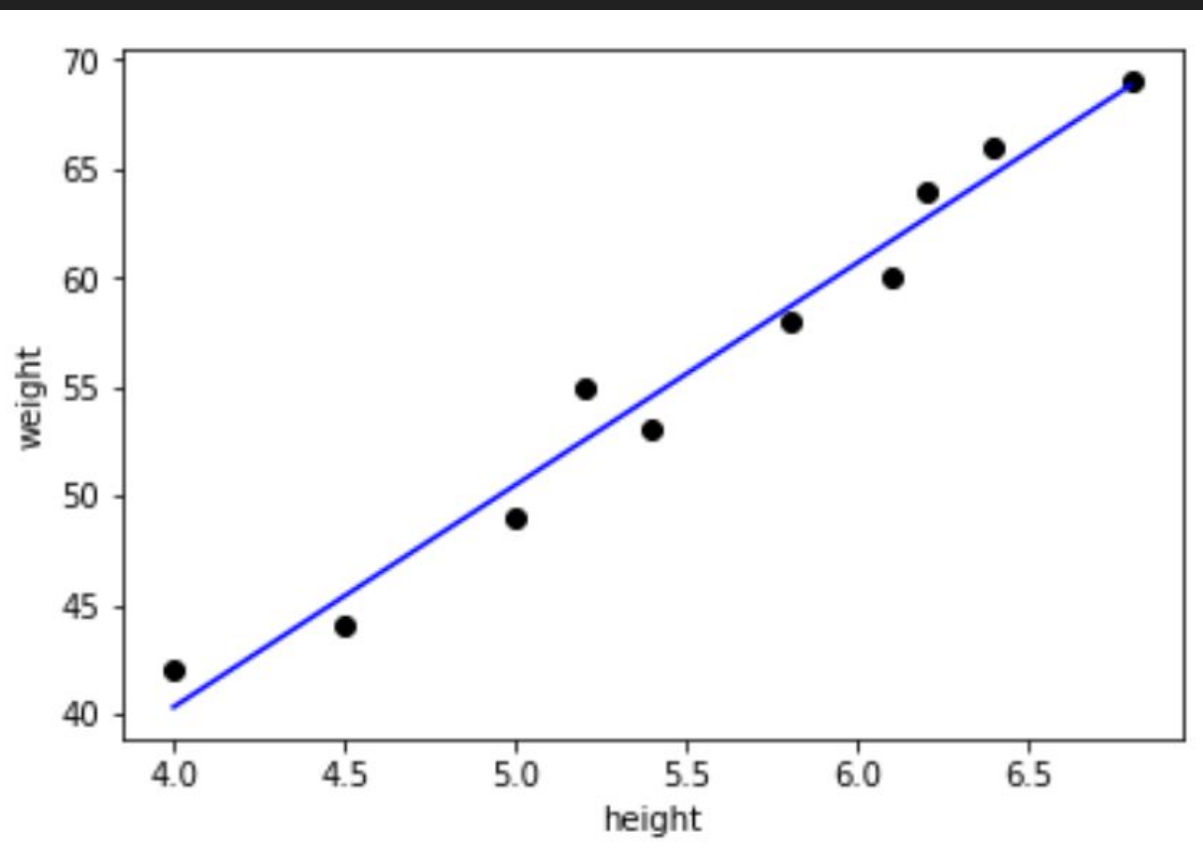
0



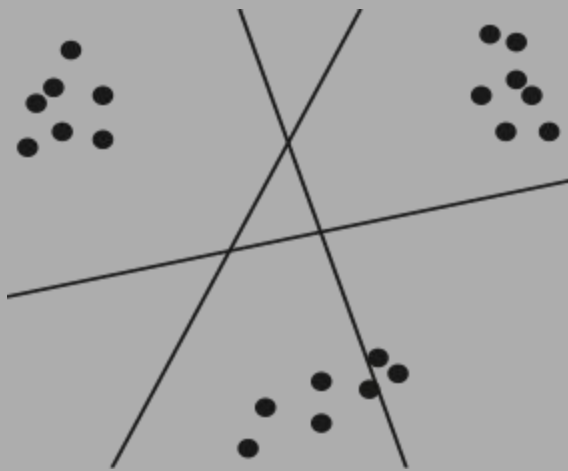
$=$

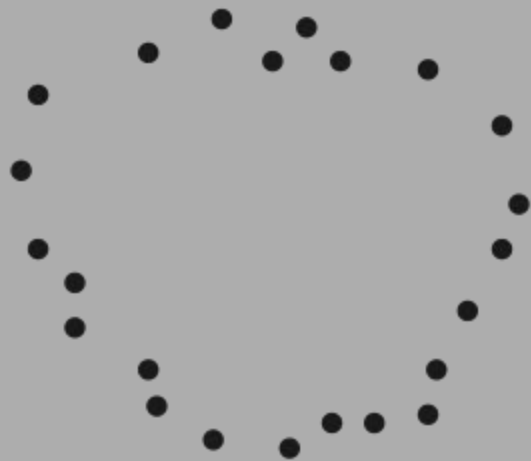
2

Data



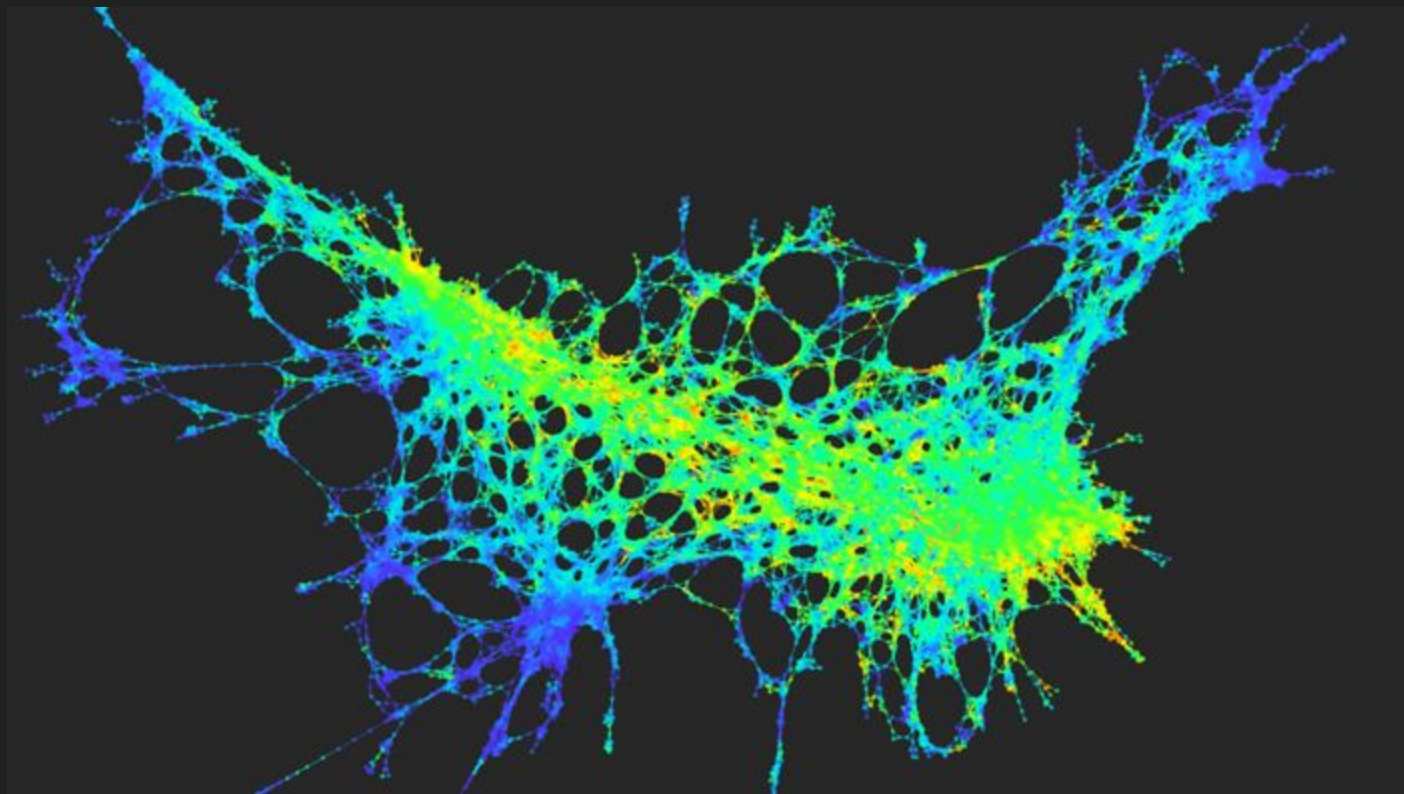








Persistent Homology



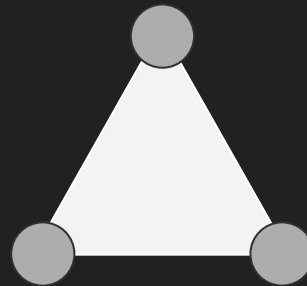
Simplex



0

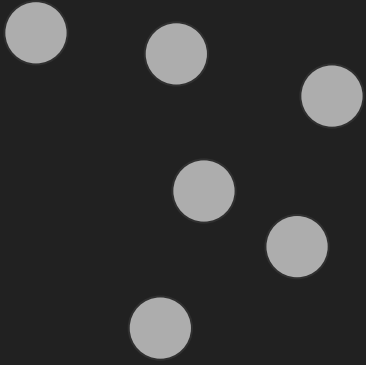


1

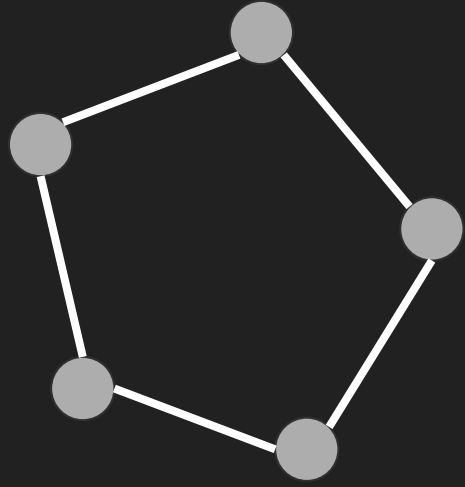


2

Cycle

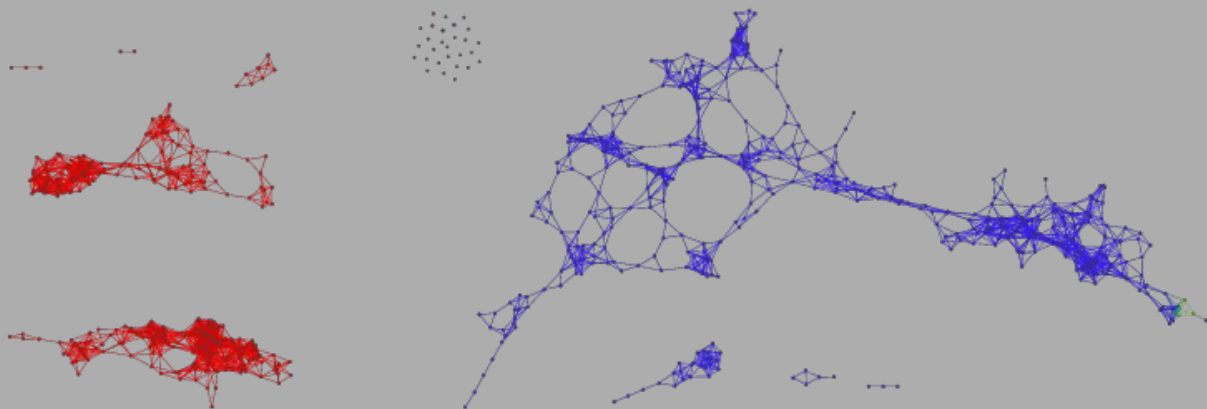


0



1

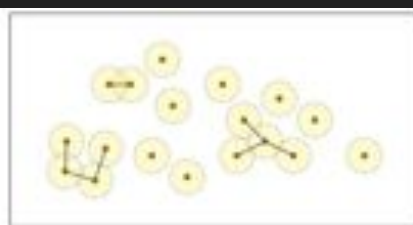
Simplicial Complex



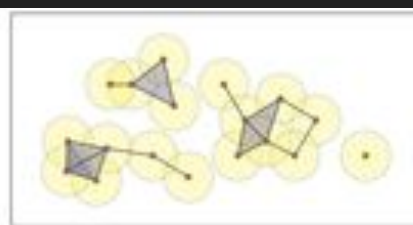
Filtration



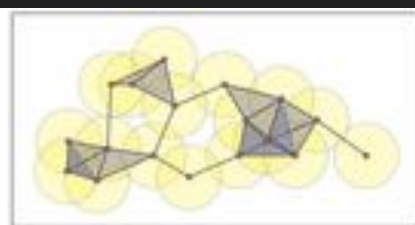
$\varepsilon = 1.5$



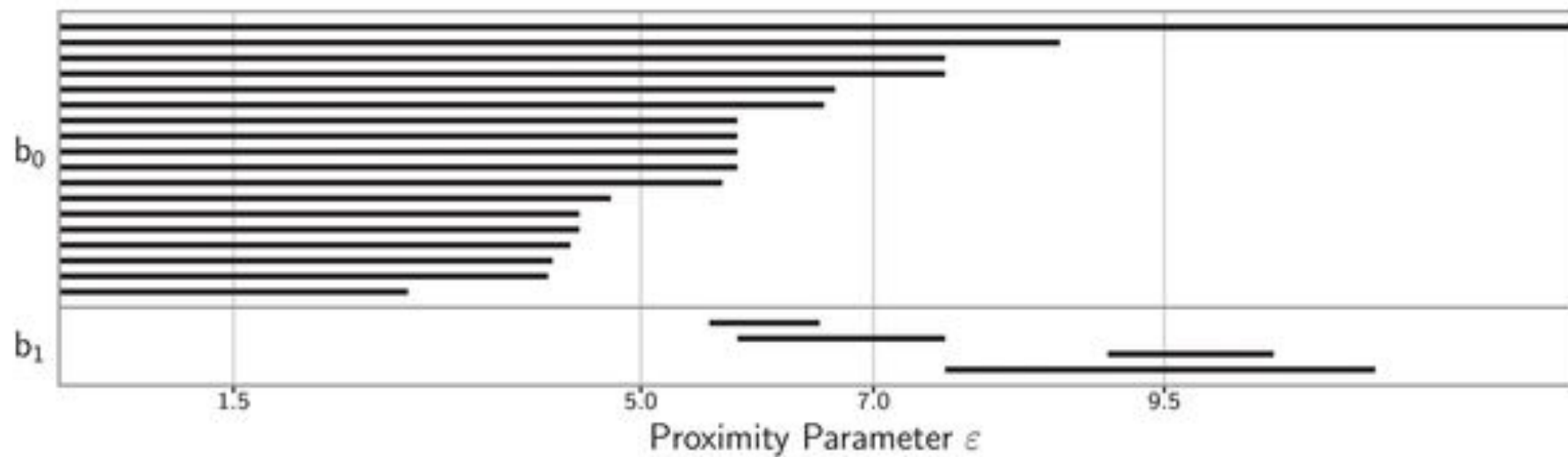
$\varepsilon = 5.0$



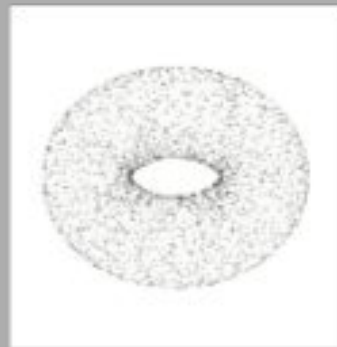
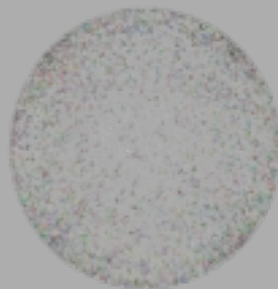
$\varepsilon = 7.0$



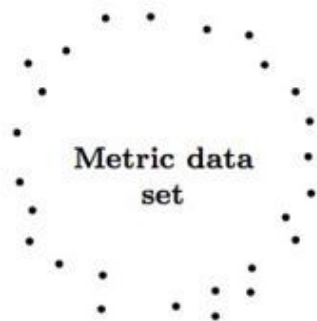
$\varepsilon = 9.5$



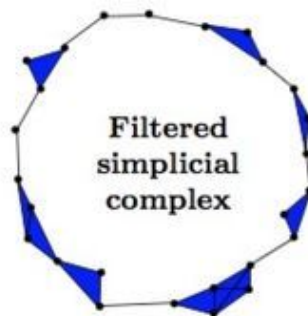
Persistence



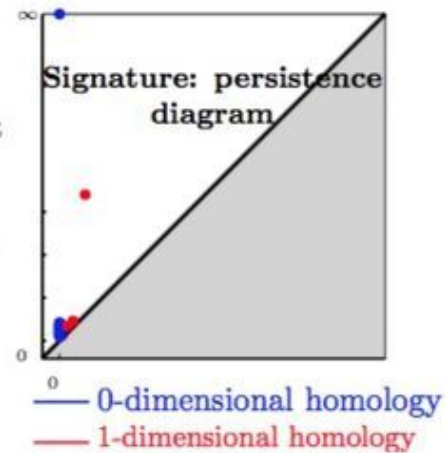
Pipeline



Build geometric
filtered complex on
top of data



Compute persistent
homology of the
complex.



Mapper

A Original Point Cloud



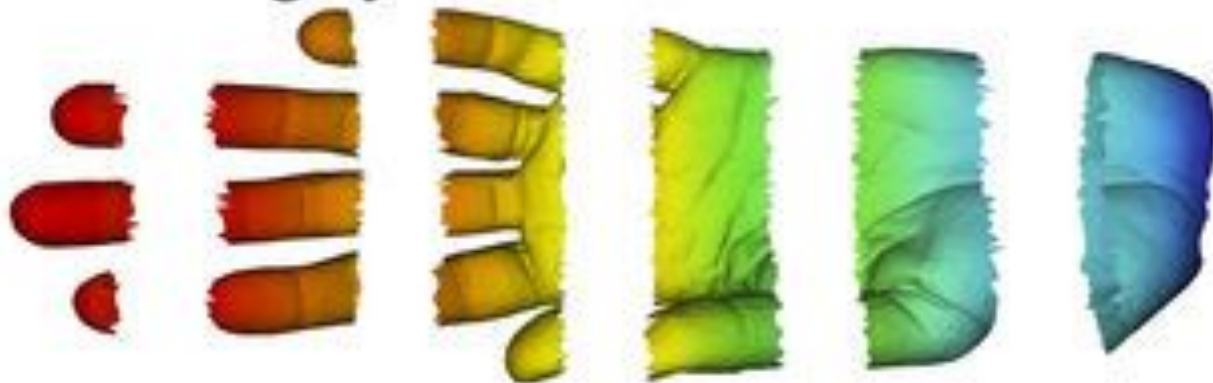
Filtration

B Coloring by filter value



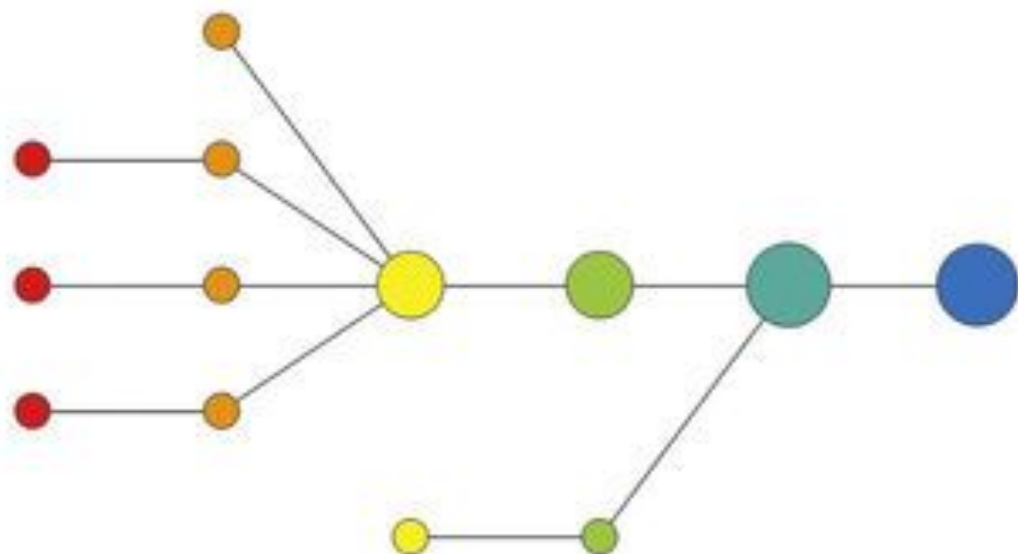
Binning

C Binning by filter value

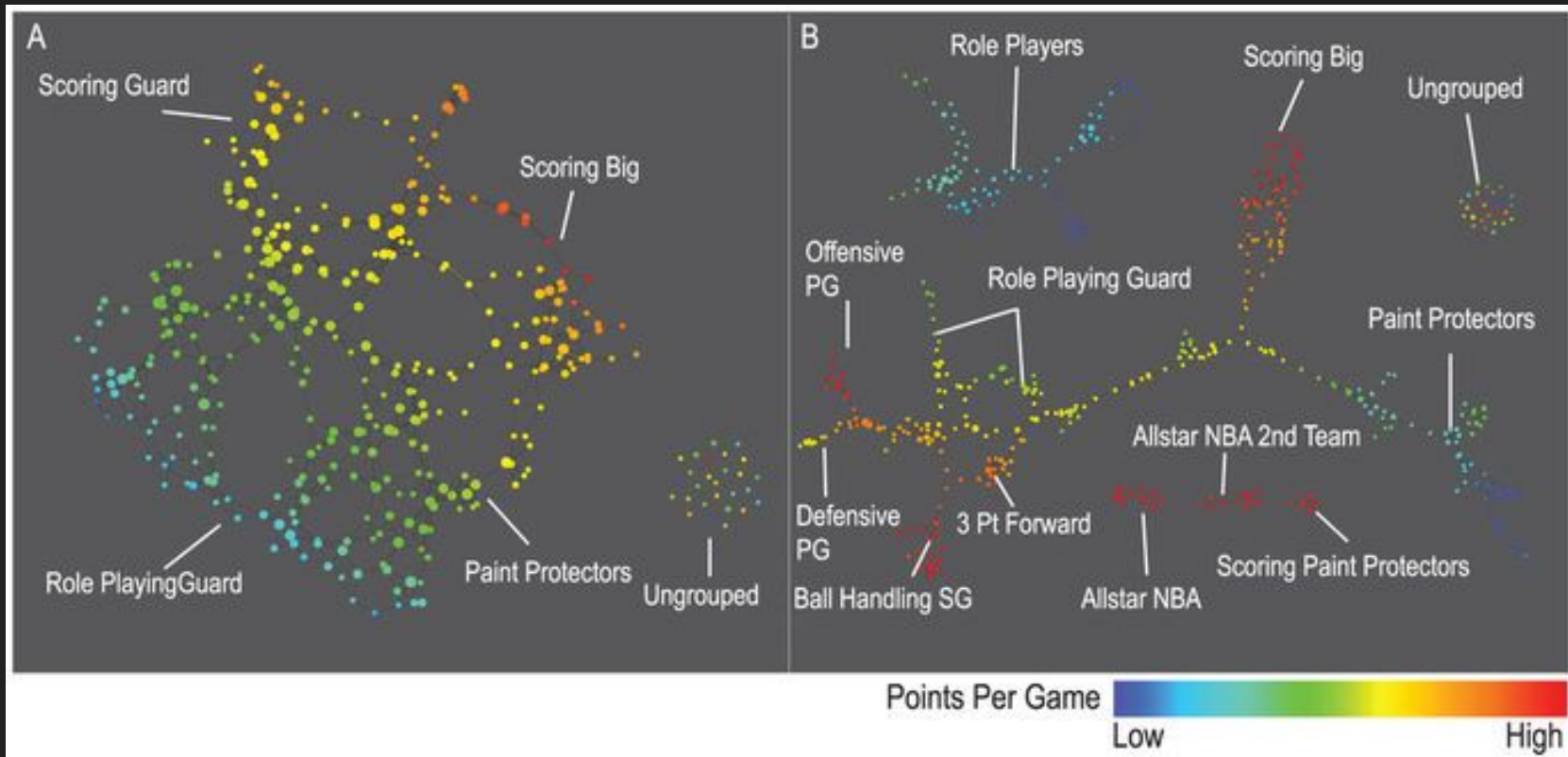


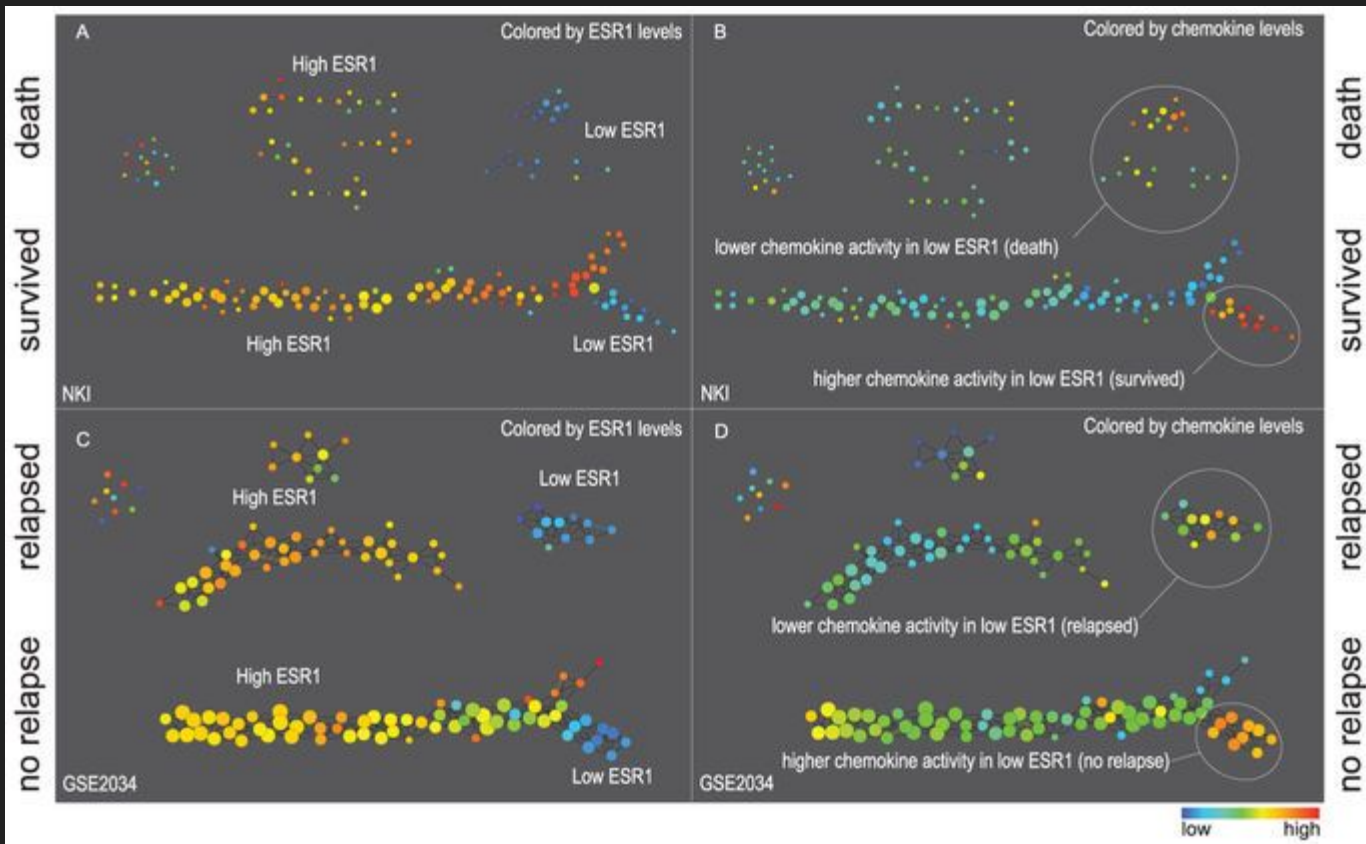
Clustering

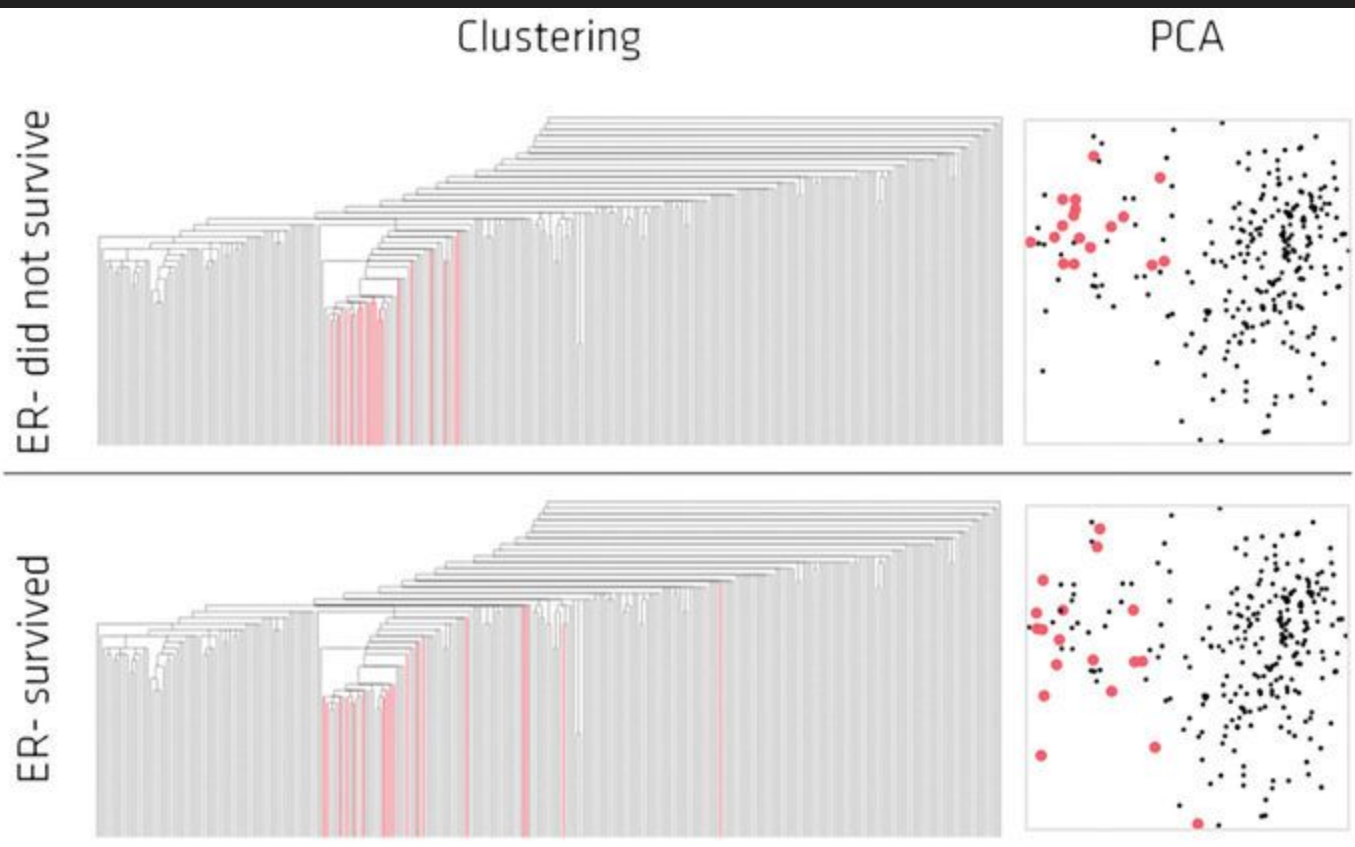
D Clustering and network construction



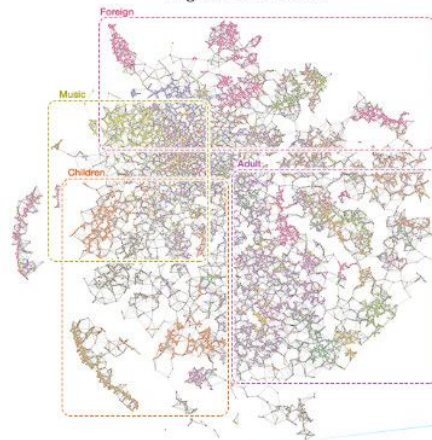
Examples



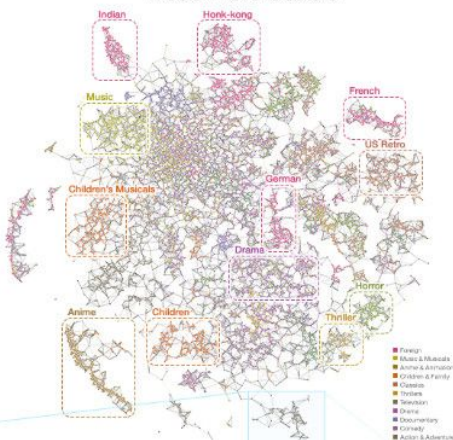




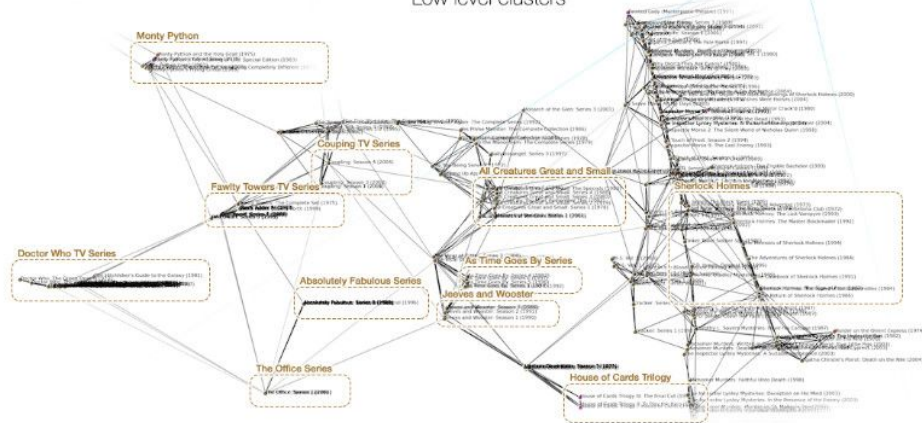
High level clusters



Medium level clusters



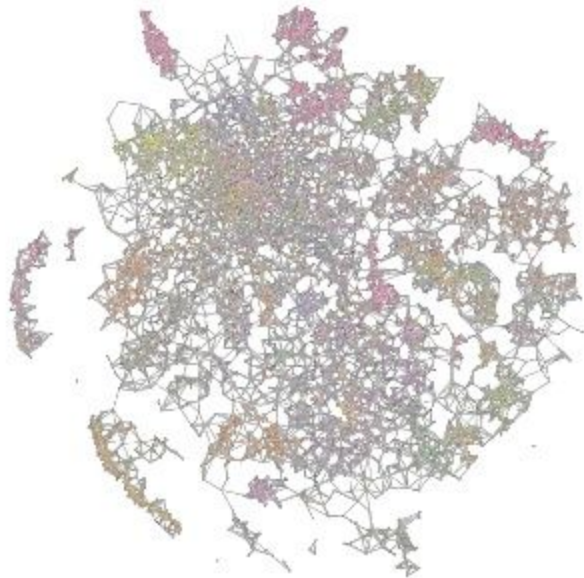
Low level clusters



Case study: Netflix competition

Result comparison: TDA with other techniques

Topological Data Analysis



LLE



LTSA



PCA



Hessian LLE

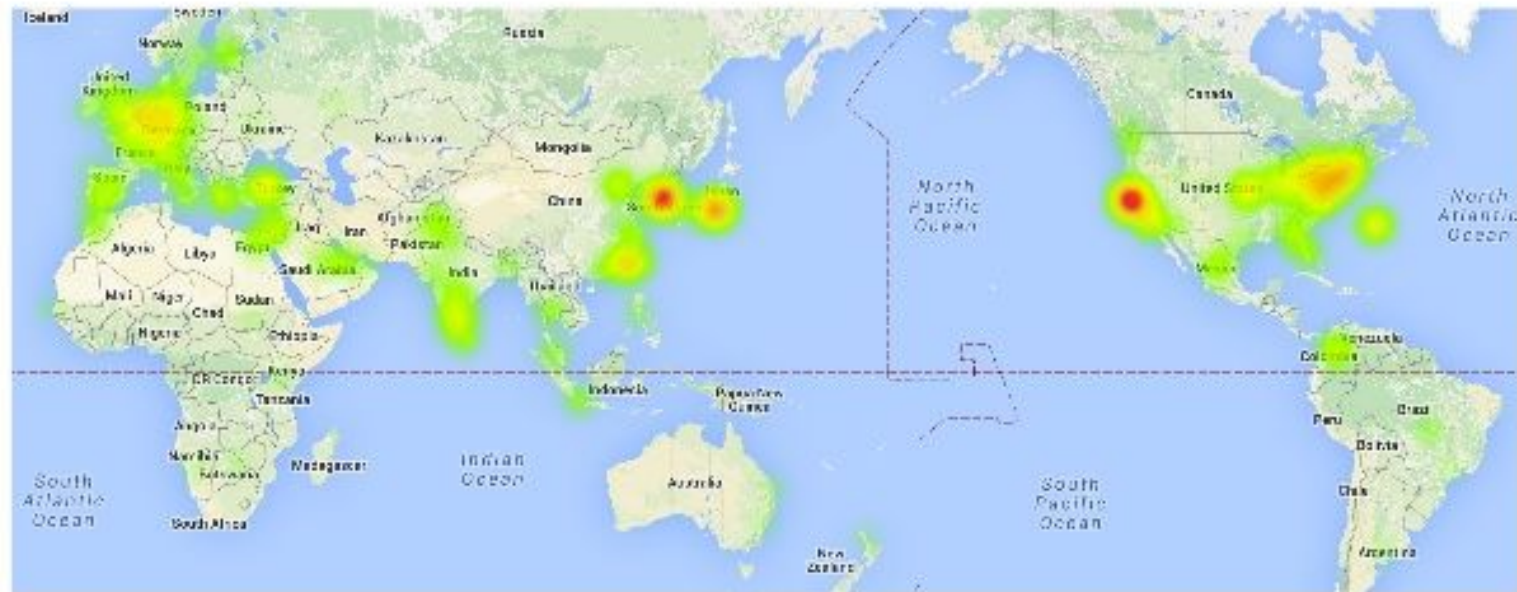


Spectral Embedding




Academia

World Interests for TDA



Heat map for viewers of my TDA slide at slideshare (for 2500 viewers during 2015.2.14. - 2014.11.31.)

Industry



Refine your data into
knowledge with Topological
Data Analysis



AYASDI

Tools

Software package 	Creator 	Latest release 	Release date 	Software license ^[6] 	Open source 	Programming language 	Features 
javaPlex 	Andrew Tausz, Mikael Vejdemo-Johansson, Henry Adams	4.2.5 	14 March 2016	Custom 	Yes	Java, Matlab	
Dionysus 	Dmitriy Morozov			GPL	Yes	C++, Python bindings 	
Perseus 	Vidit Nanda 	4.0 beta		GPL	Yes	C++	
PHAT 	Ulrich Bauer, Michael Kerber, Jan Reininghaus	1.4.1			Yes	C++	
DIPHA 	Jan Reininghaus				Yes	C++	
Gudhi 	INRIA	2.1.0	28 January 2018	GPLv3	Yes	C++, Python bindings 	
CTL 	Ryan Lewis	0.2			Yes	C++	
phom 	Andrew Tausz				Yes	R	
TDA 	Brittany T. Fasy, Jisu Kim, Fabrizio Lecci, Clement Maria, Vincent Rouvreau	1.5	16 June 2016		Yes	R	
Eirene 	Gregory Henselman	0.3.7	11 August 2017	GPLv3	Yes	Julia	
Ripser 	Ulrich Bauer	1.0.1	15 September 2016	LGPL	Yes	C++	
the Topology ToolKit 	Julien Tierny, Guillaume Favelier, Joshua Levine, Charles Gueunet, Michael Michaux	0.9.2	25 June 2017	BSD	Yes	C++, VTK and Python bindings	
Software package	Creator	Latest Release	Release date	Software license ^[6]	Open source	Programming language	

Data has shape.

Shape matters.