Graphcode: Learning from multiparameter persistent homology using graph neural networks

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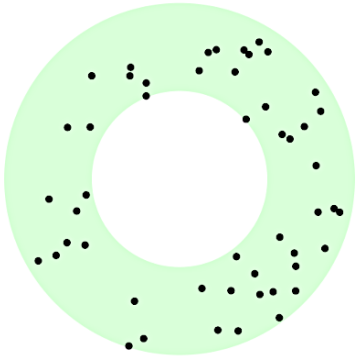
Learning from Topological Features of Datasets



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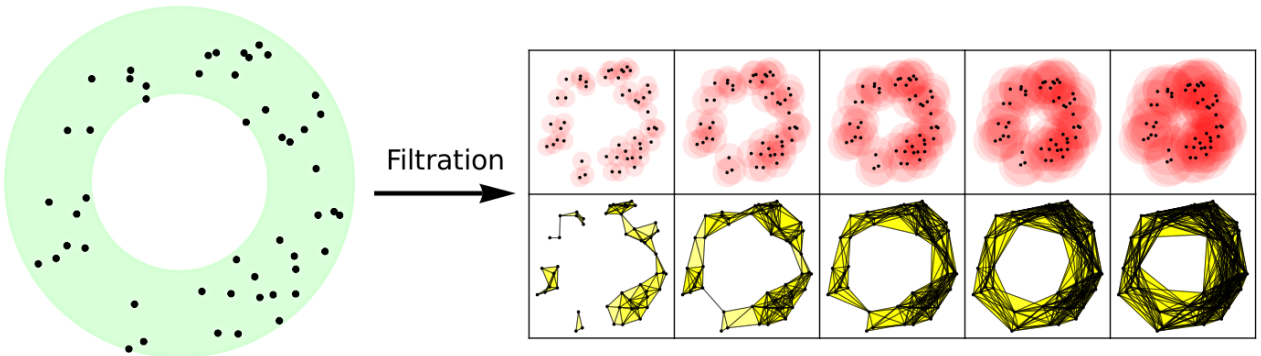

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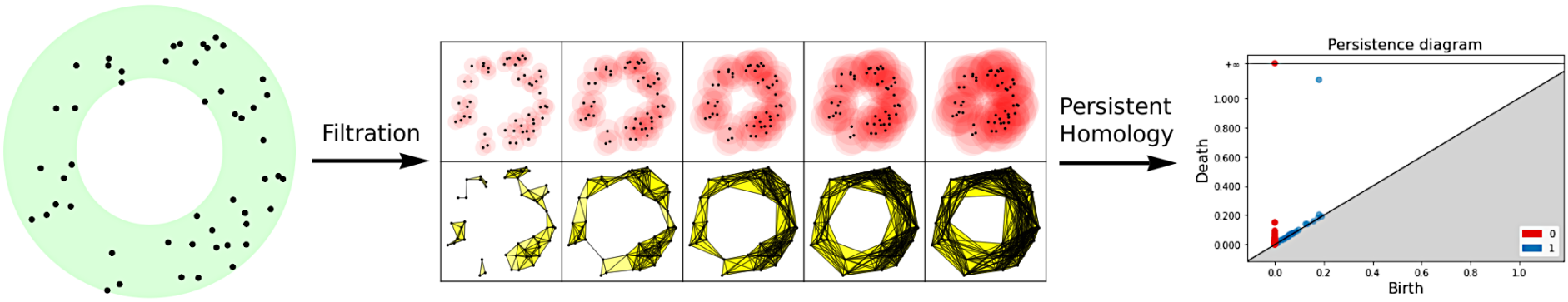

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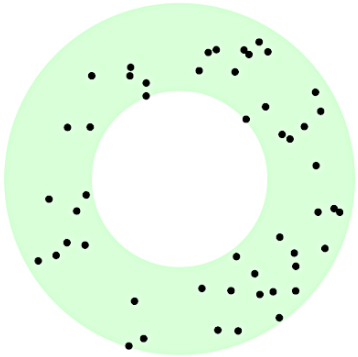
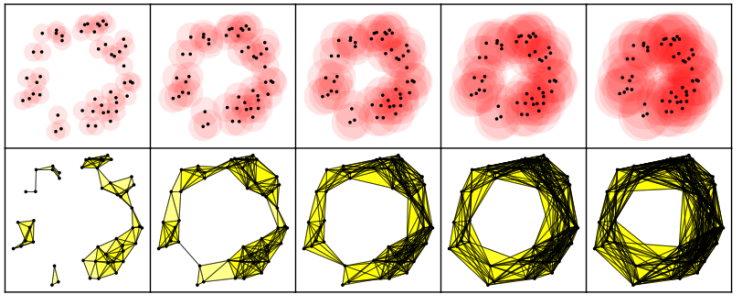
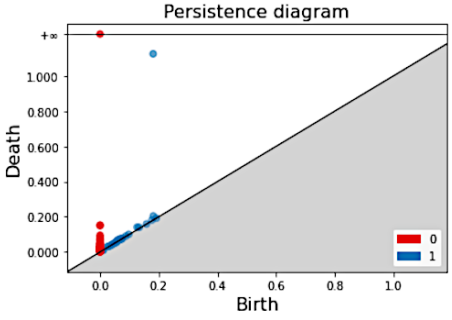
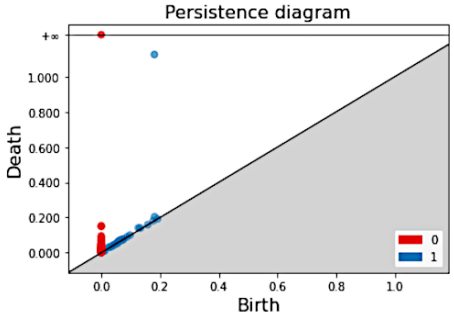


Filtration

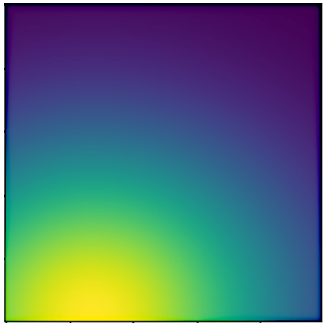


Persistent Homology





Vectorization



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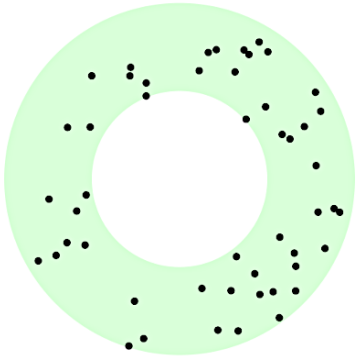
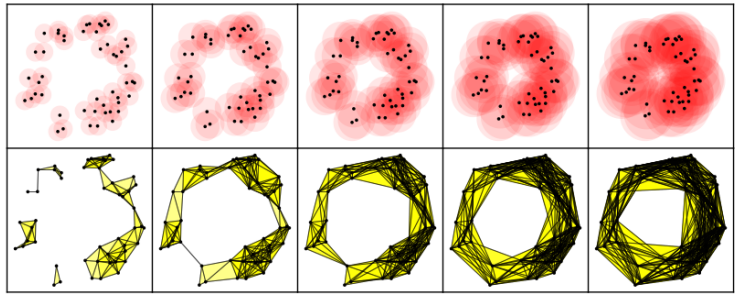


Filtration



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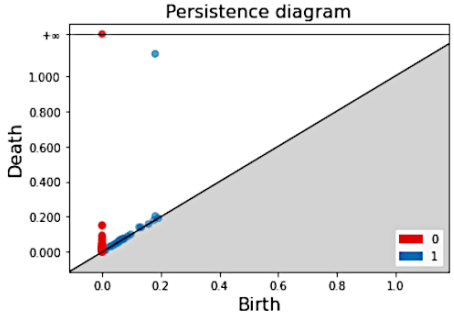

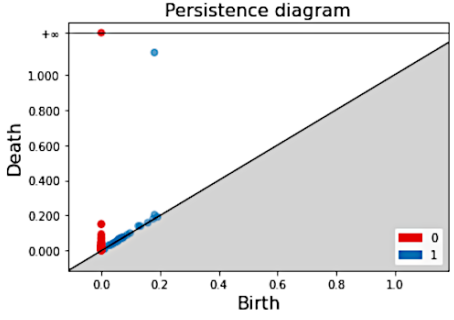

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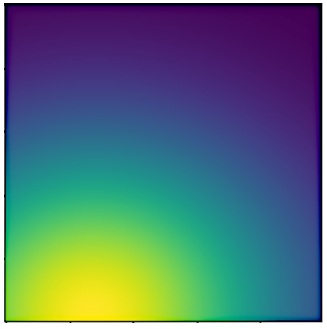
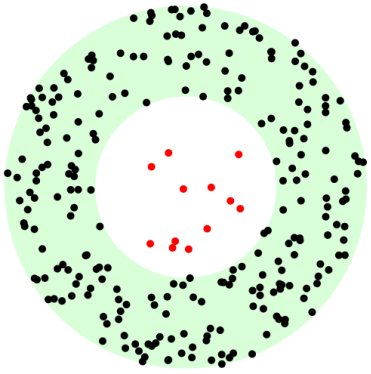


Input

Machine Learning Pipeline

Learning from Topological Features of Datasets



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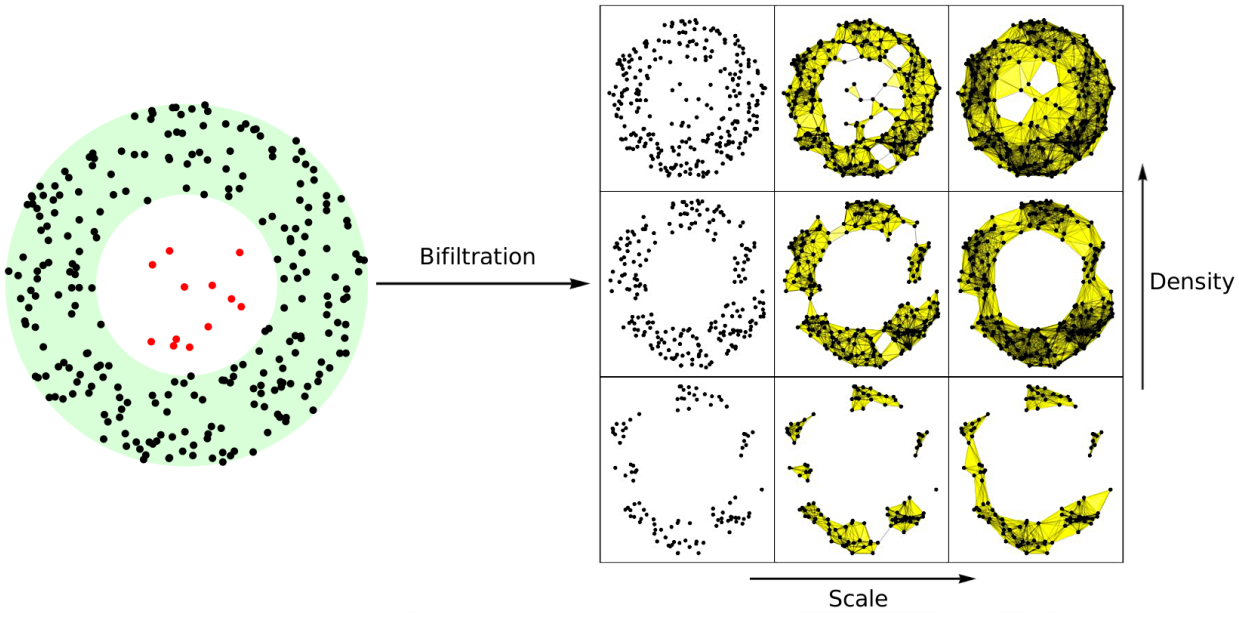

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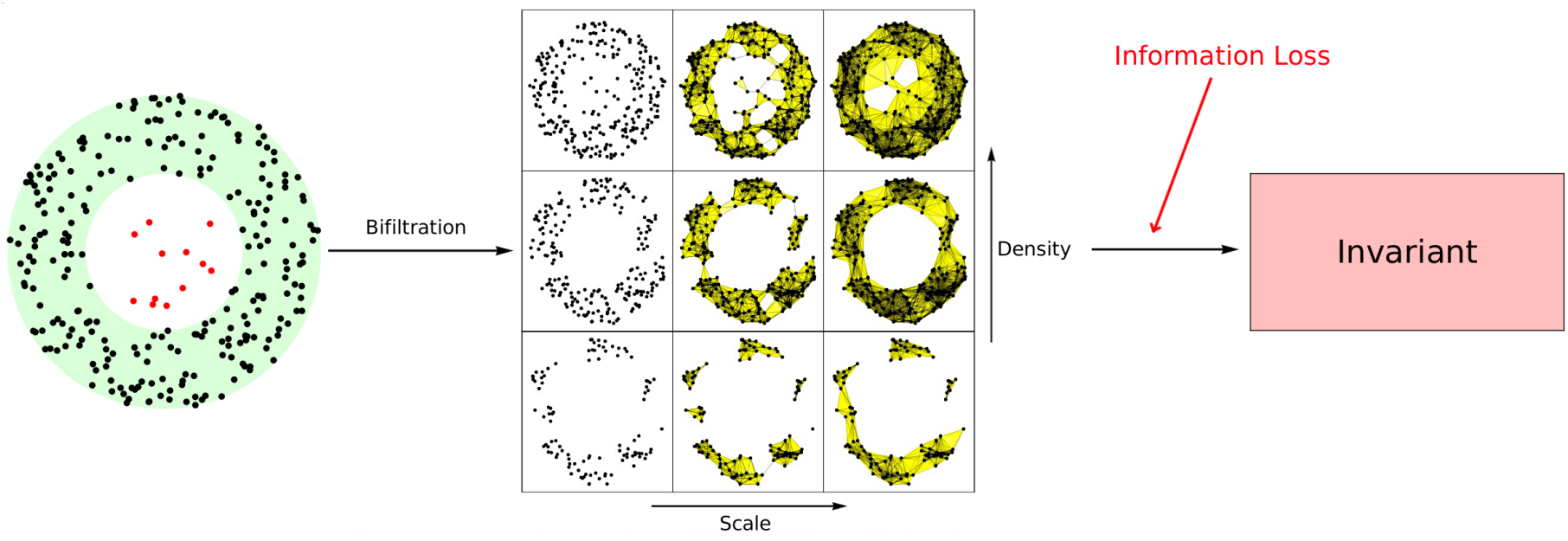

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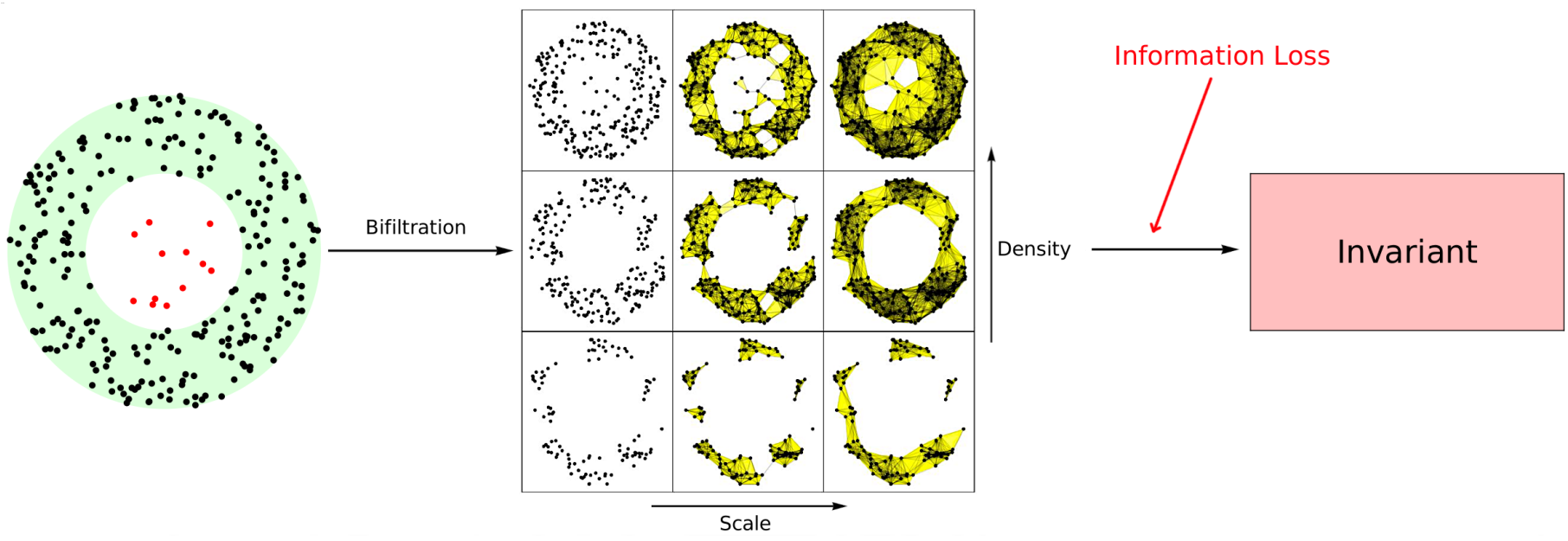

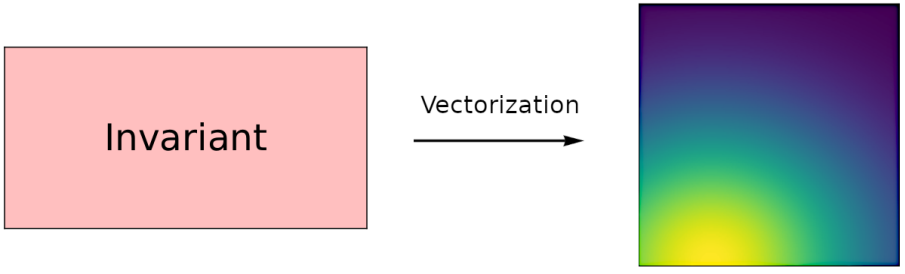

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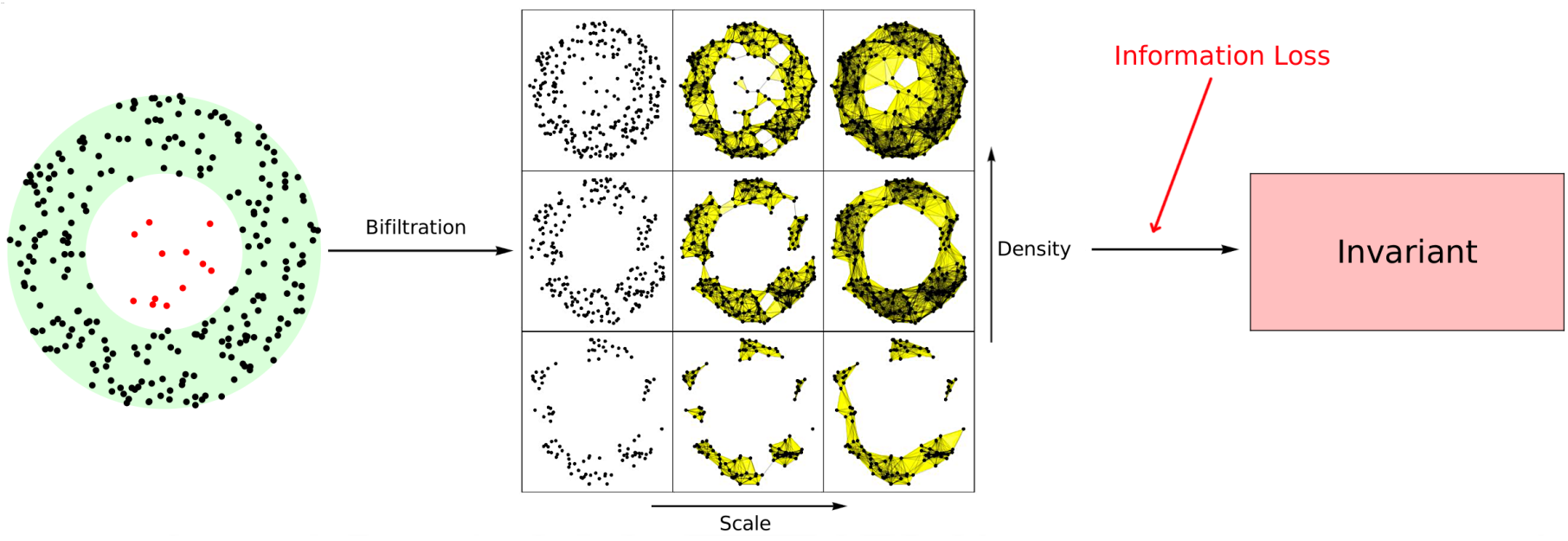

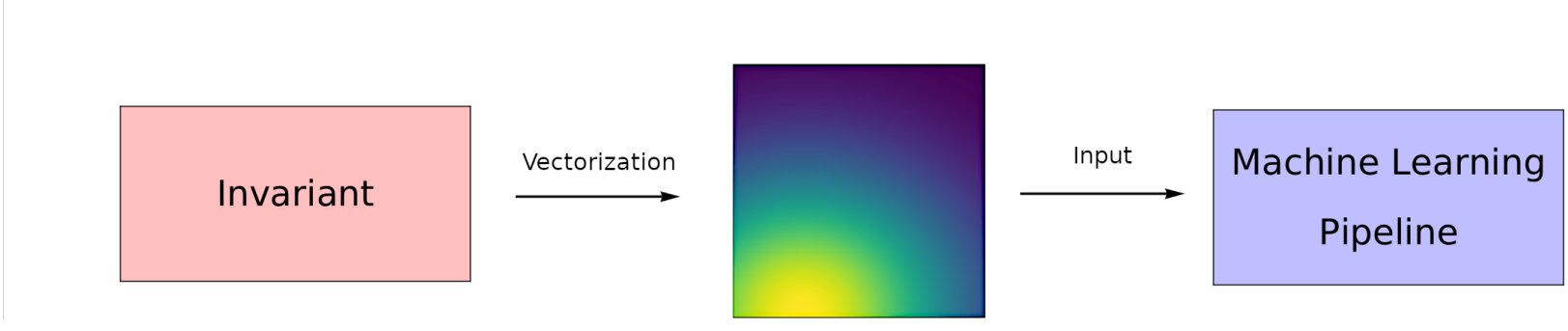

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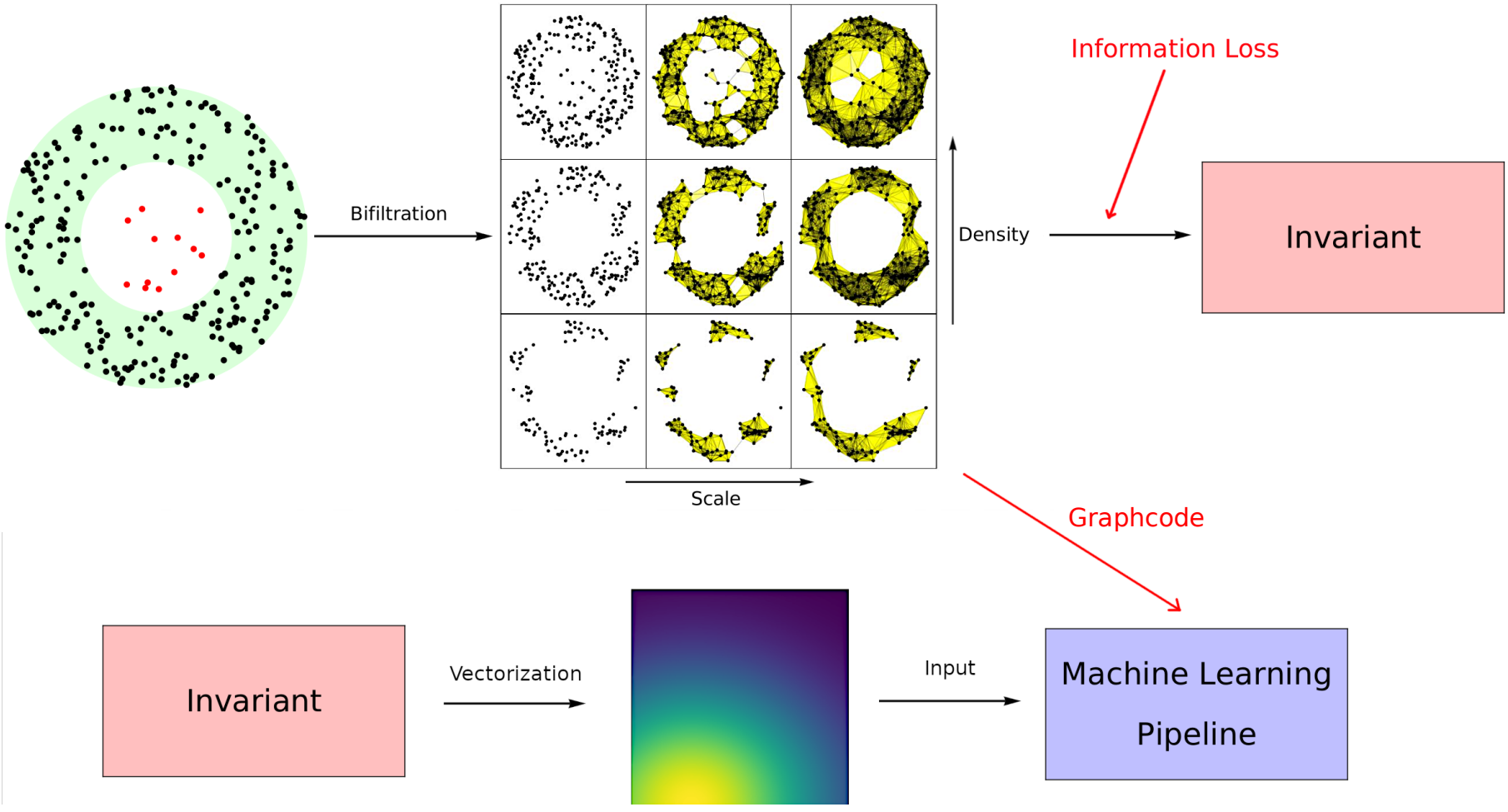
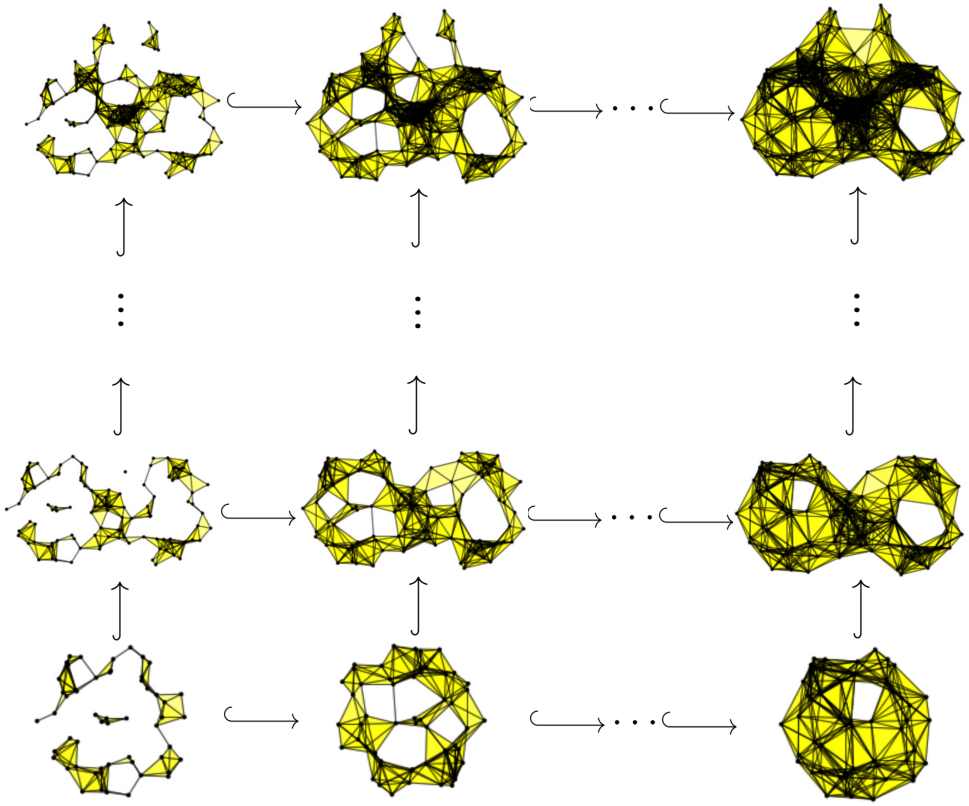


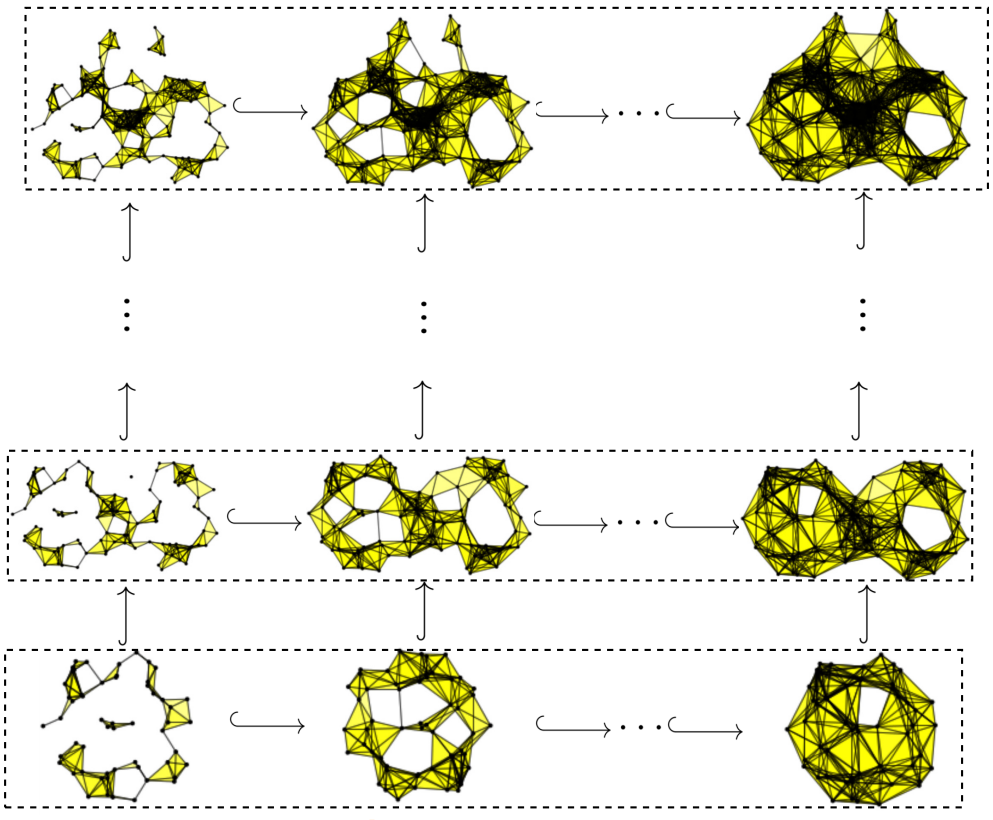
Graphcodes



Bifiltration

Graphcode

Graphcodes



Bifiltration

Graphcode

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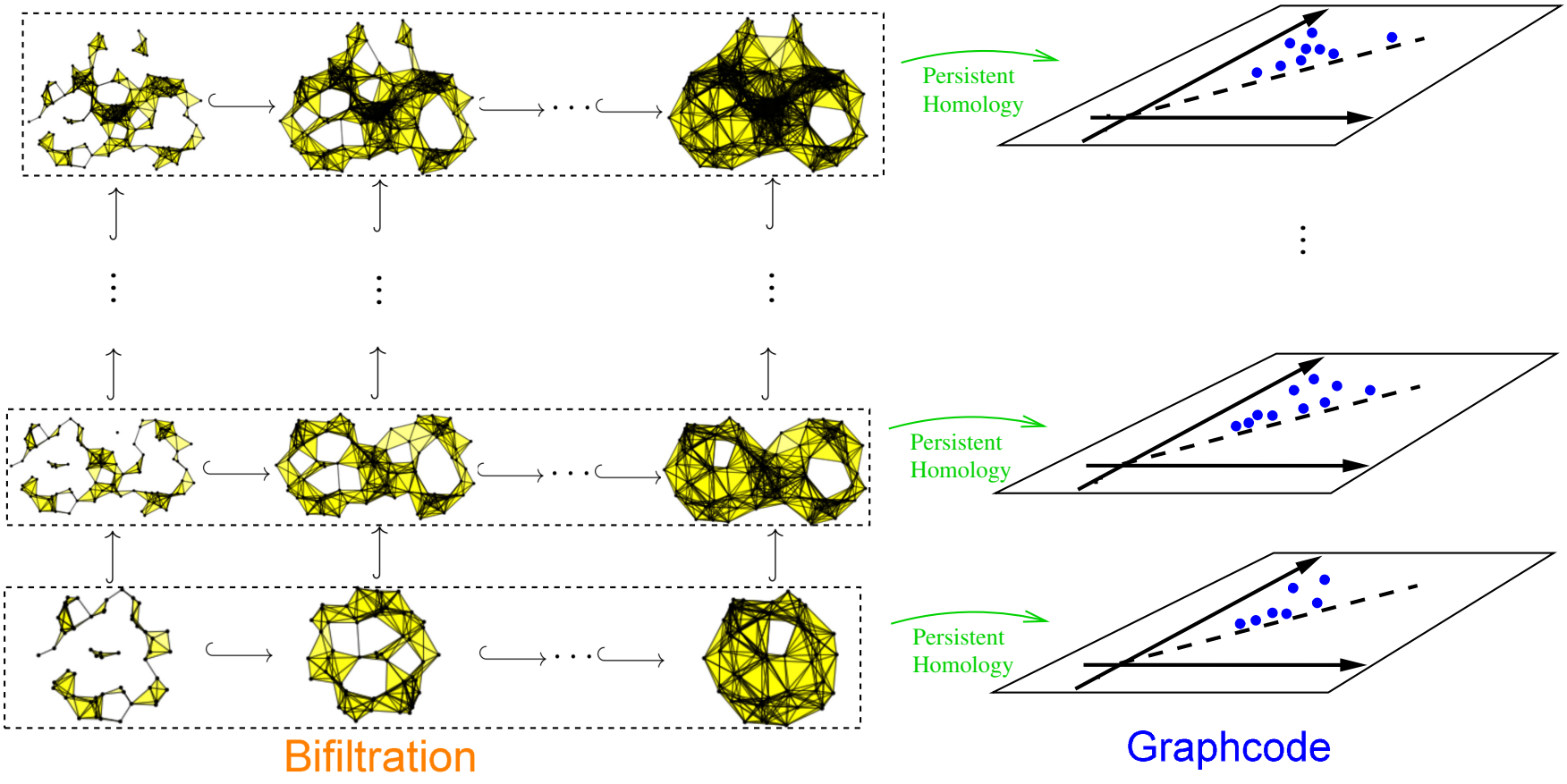
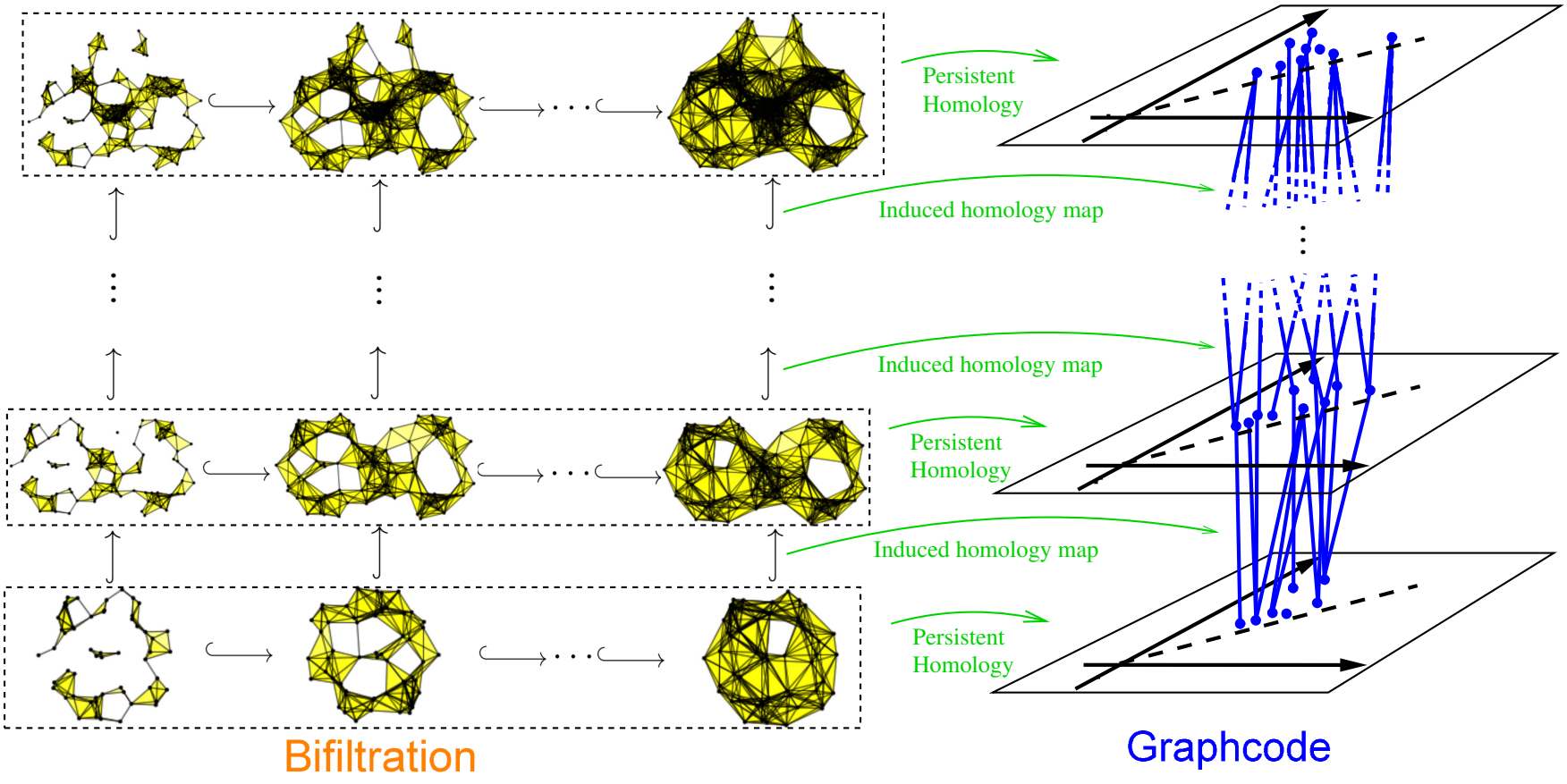
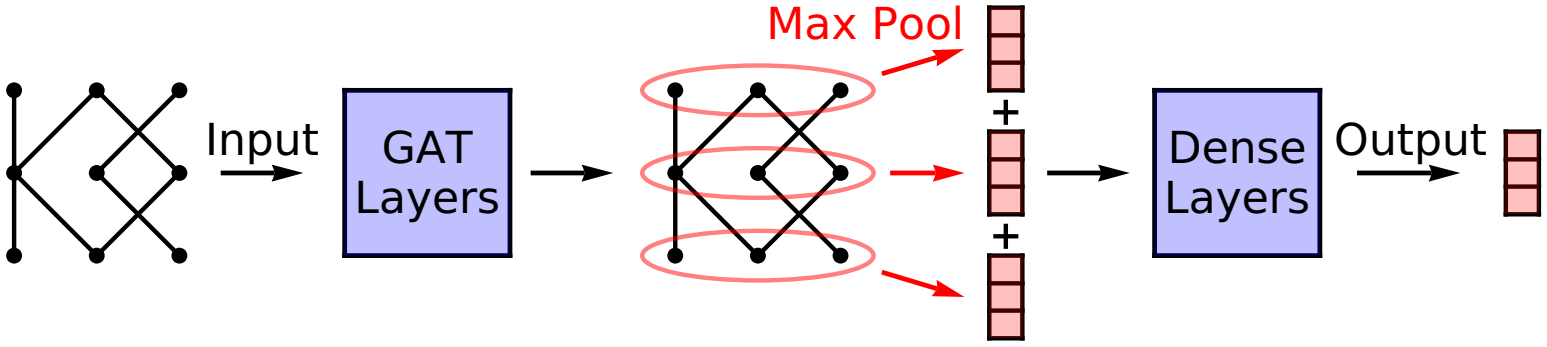

Persistent
Homology
Persistent
Homology
Persistent
Homology
Bifiltration
Graphcode

Graphcodes


Persistent
Homology
Induced homology map
Induced homology map
Persistent
Homology
Induced homology map
Persistent
Homology
Bifiltration
Graphcode

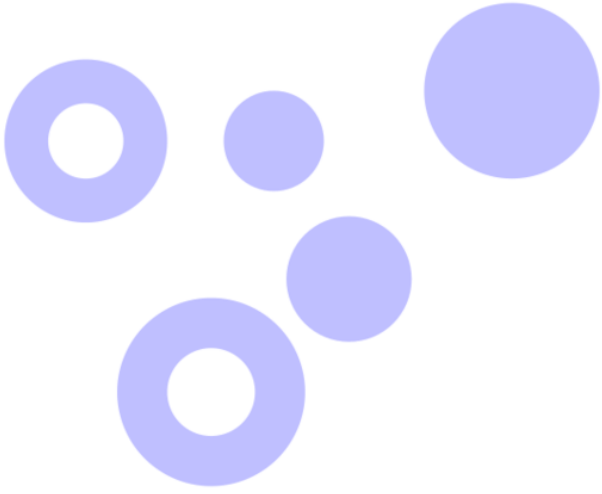
Using Graphcodes as Features for Machine Learning



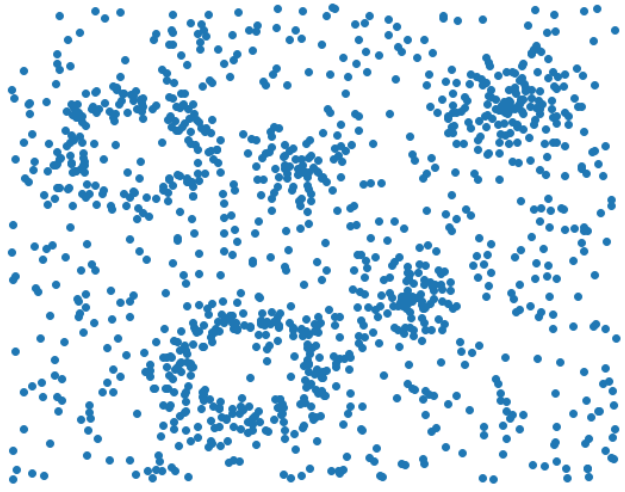
1. **Input:** Graphcode – undirected graph with (b, d) vertex labels.
2. Feed Graphcode into **G**raph (**AT**tention) neural network.
3. Apply slicewise max pooling to vectorize the graph.
4. Feed this vectorization to standard neural network.

Homology Inference Experiments

Task: Predict H_1 of a random shape configuration consisting of disks and annuli from a point sample with noise.



Shape configuration, 2 annuli, 3 disks



Sample from shape configuration with uniform noise

	MP-I	MP-L	P-I	GRIL	MP-HSM-C	GC	GC-NE
Accuracy[%]	64.1±4.7	37.2±1.5	43.6±2.2	74.9±2.7	57.0±2.3	**86.9±1.4**	82.8±1.9
Time[s]	9176	3519	1090	333187	282	**95**	–

Table: Average test set prediction accuracy of topological descriptors.