Manifold Learning Comparison

Introduction

My comparison between different methods is based on the following aspects:

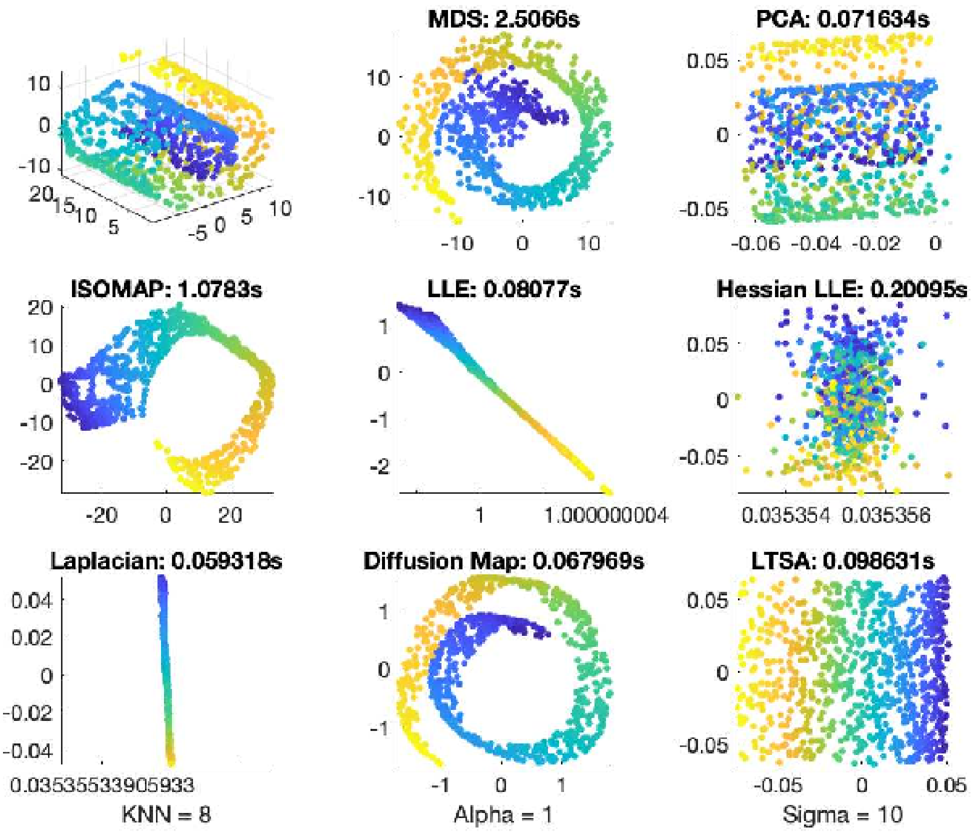
- Time Used
- Sensitivity to the parameters throughout

Other possible considerations are:

- Non-convexity
- Manifold Geometry
- Sparse Data
- Curvature
- Non-uniform Sampling
- Clustering
- Corners
- Noise

Experiments

Swiss Roll

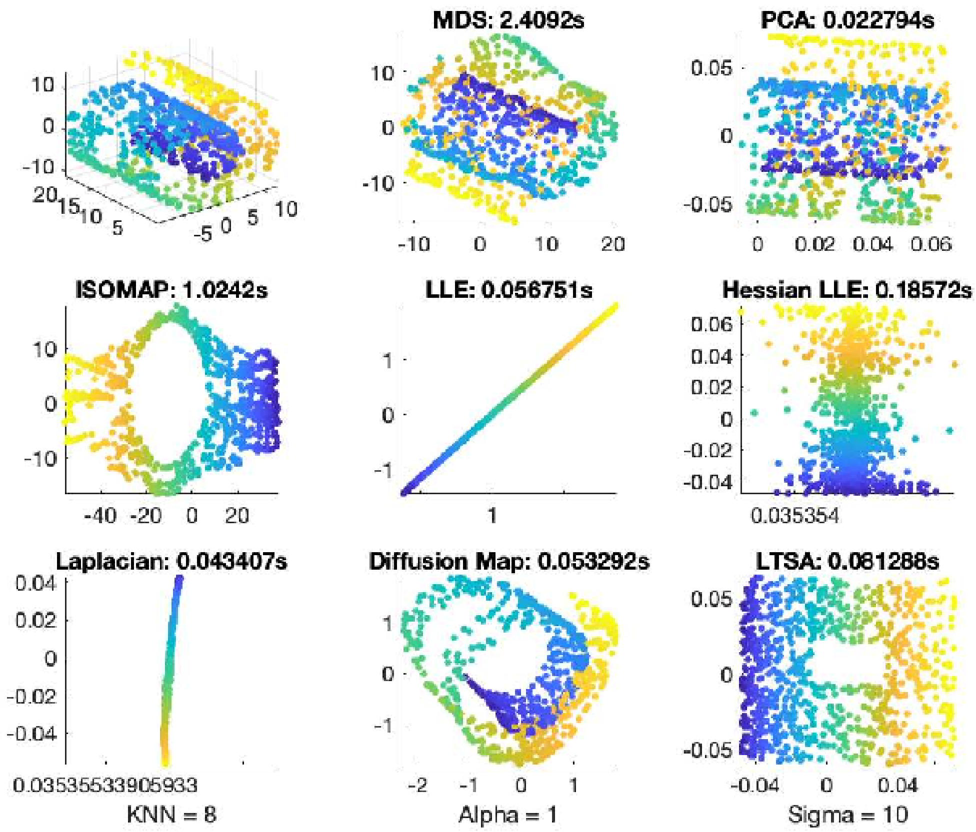


We see that

1. Slow methods are MDS>Isomap>Hessian LLE
2. MDS and PCA cannot unfold the Swiss Roll, no manifold info is used
3. Laplacian cannot handle this data properly
4. Diffusion Maps and Swiss Roll cannot unfold the Swiss Roll either

Swiss Hole (Non-Convexity)

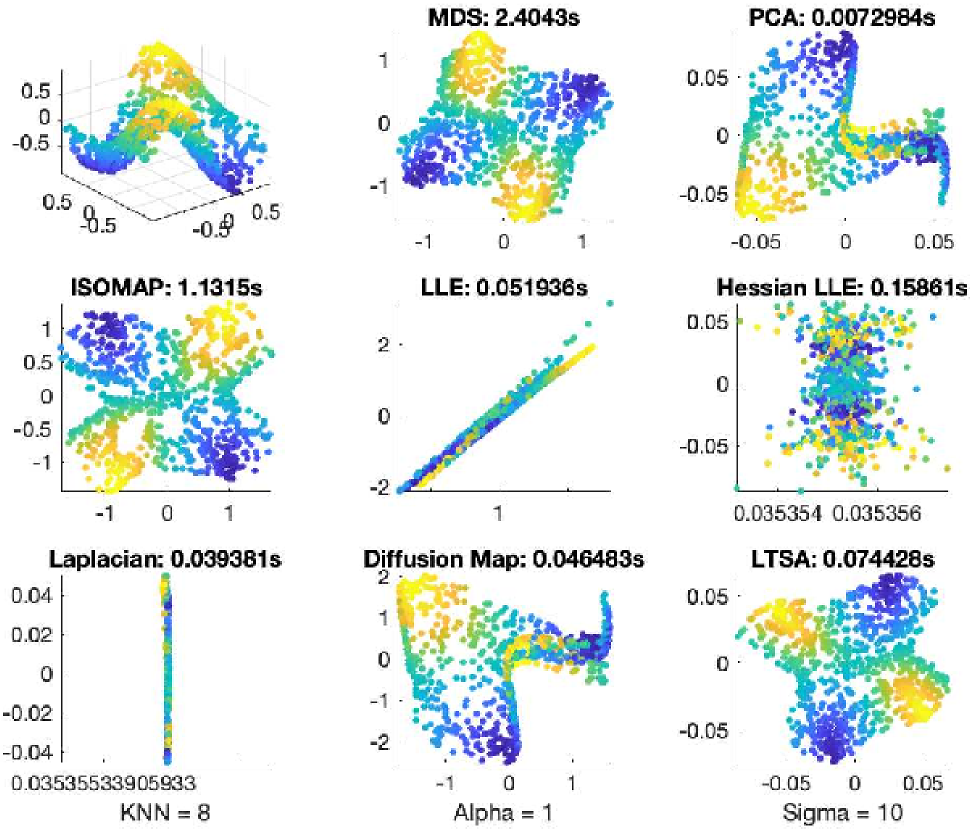
Can the Swiss Roll be unfolded if there exists a hole?



We see clearly that:

1. Only LTSA handles the non-convex Swiss Hole successfully
2. Isomap gets a flat swiss hole with distortion
3. MDS, PCA and Diffusion Map fails to unfold the Roll
4. LLE and Laplacian fails totally

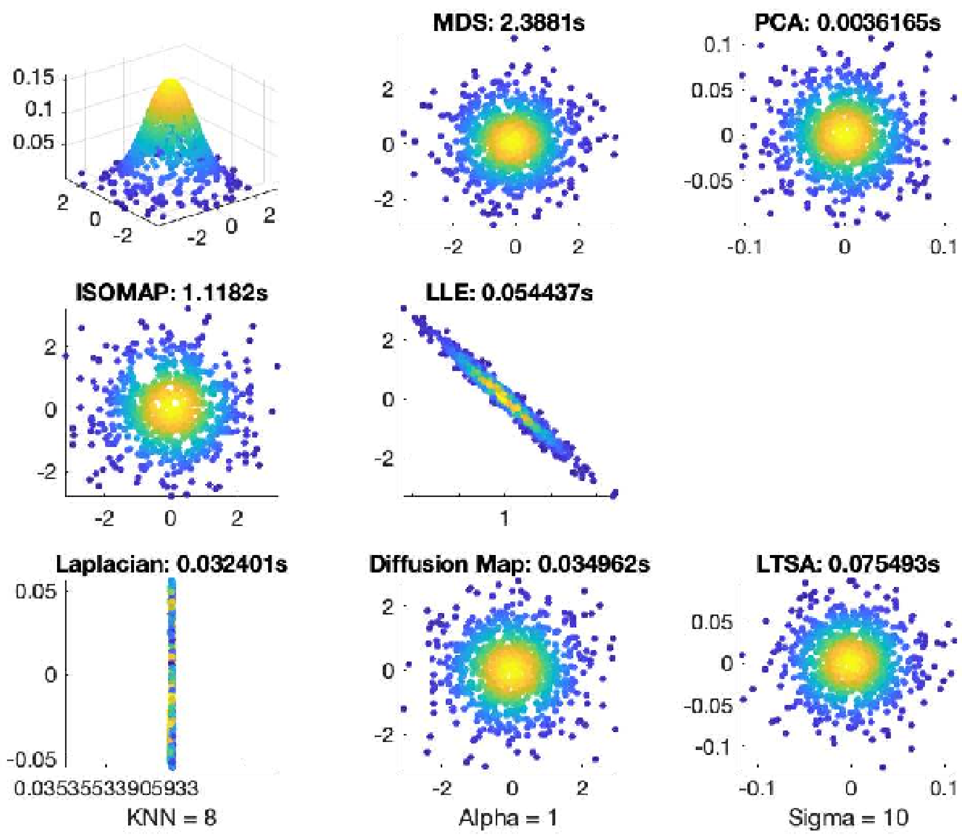
Twin Peaks (Curvature)



We see that:

1. LLE, Hessian LLE and Laplacian fails
2. All other method successfully unfold with distortion to different degree
3. The best result is given by MDS

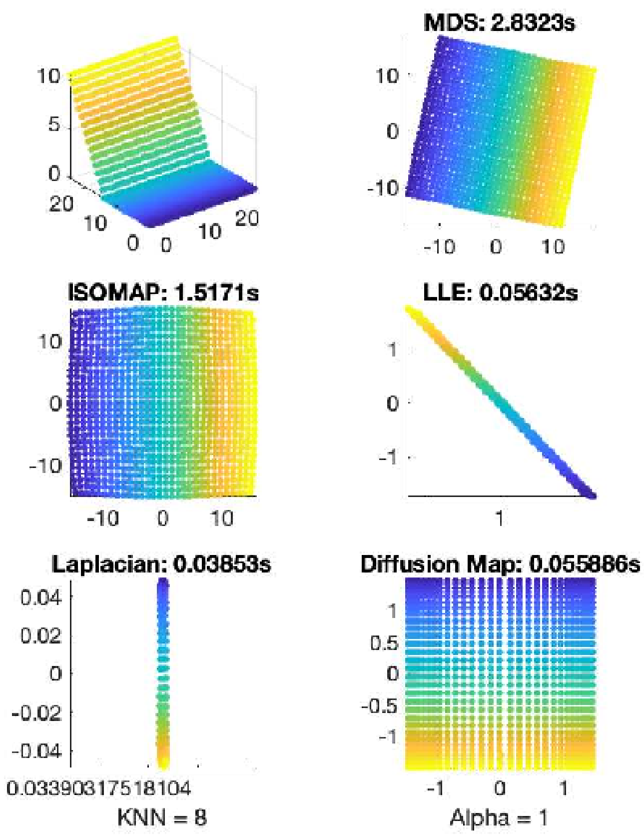
Gaussian (Non-uniform Sampling and Curvature)



We see that:

1. Simple methods like MDS, PCA, Isomap, Diffusion Map and LTSA perform perfectly
2. We see LLE and Laplacian fails
3. We see poor Hessian LLE breaks down

Corners Planes

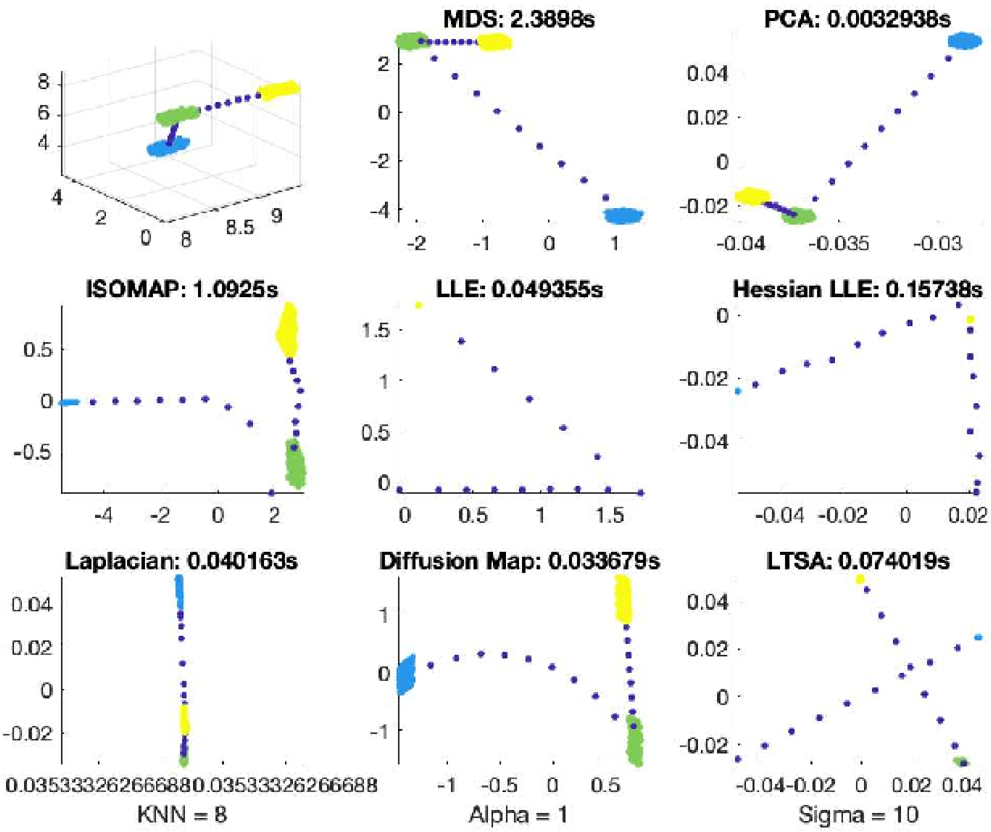


We see that:

1. The performance is similar to the case of Gaussian.
2. Simple methods like MDS, PCA, Isomap, Diffusion Map and LTSA perform perfectly
3. We see LLE and Laplacian fails
4. We see a Hessian LLE with chaos

3D-Cluster(Cluster and Sparsity)

A good mapping should preserve the clustered data
We generate three non-overlapping clusters with random centers and then connect the clusters with a line.

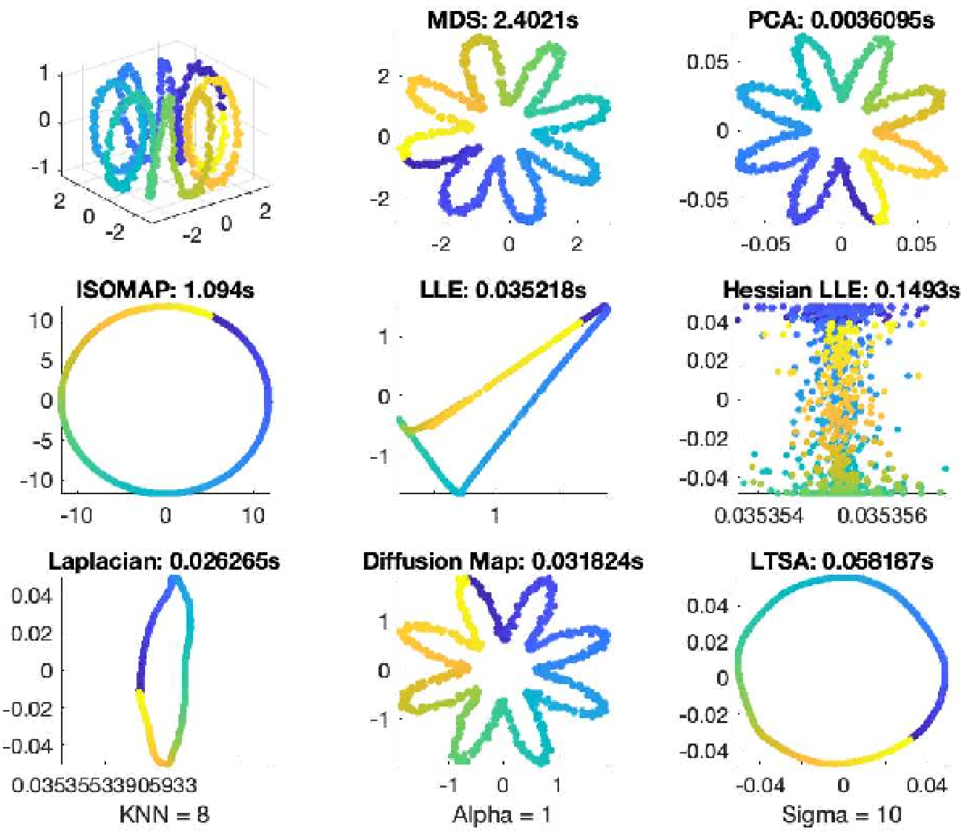


We see that:

1. MDS and PCA works well
2. Isomap and Diffusion Map restore the manifold structure with a little bit distortion
3. LLE, Hessian LLE and LTSA compressed each cluster into a single point
4. Laplacian has overlapped sparse connecting lines.
5. LTSA has crossed sparse connecting lines.

Toroidal Helix (Sparsity)

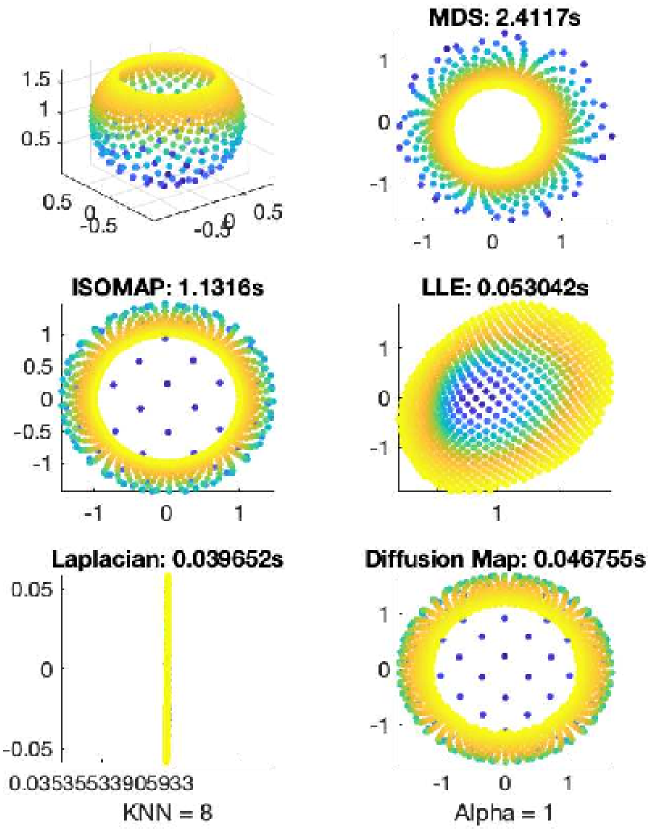
Can the method handle changes from dense to sparse regions?



We see that:

1. Isomap and LSTA are correct
2. LLE AND Laplacian also showed the part of the loop structure, with great distortion though
3. MDS, PCA and Diffusion Maps shows an asterisk
4. Hessian LLE fails

Punctured Sphere (Sparsity)

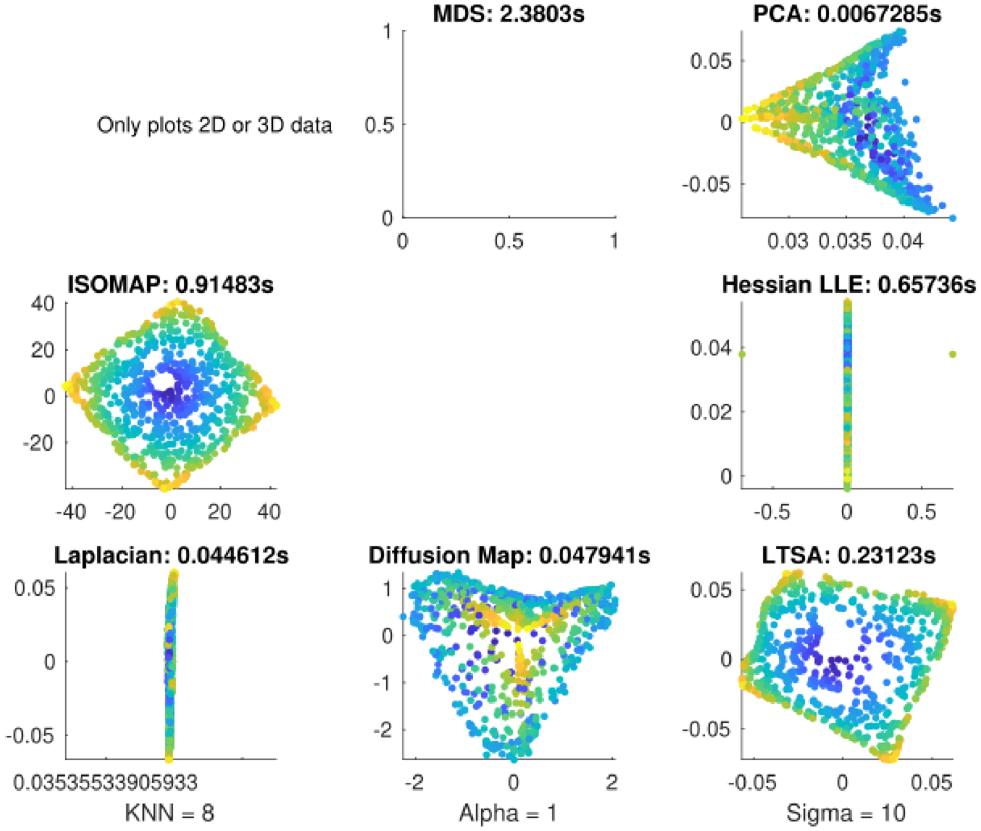


We see that:

1. LLE is right
2. Isomap and Diffusion Maps are also correct but emphasize too much on the sparsity
3. LTSA is kind of correct with a distorted square shape
4. PCA projects the sphere to one side while MDS turns the outside into the heart
5. Laplacian and Hessian LLE fail

Occluded Disk(High-Dimensional Data)

We Create 20*20 images with a disk of fixed radius and random center.



We see that:

1. Some methods break down like MDS, LLE(crashed)
2. Isomap performs good
3. LTSA performs second good
4. Diffusion Map turns the outside into the heart
5. Laplacian and Hessian LLE fail

Summary

1: Handels successfully
0: Fails to handel

Handles?	MDS	PCA	ISOMAP	LLE	Hessian	Laplacian	Diffusion	LTSA
speed	0	1	1	1	0	1	1	1
geometry	0	0	1	1	1	1	Nah	Nah
non-convexity	0	0	0	Nah	1	Nah	Nah	Nah
non-uniform-sampling	1	1	1	1	Nah	0	1	1
curvature	0	0	1	Nah	1	1	1	1
corner	0	0	1	1	0	1	1	1
cluster	1	1	1	1	0	0	1	1
noise	1	1	Nah	0	1	1	1	1
sparsity	1	1	1	1	0	1	0	0
sensitivity	0	0	1	1	1	1	1	1