Morphological Operations

Neighborhood

Face

Edge

Vertex

Clusters

Dilation

Erosion

Open

Close

Morphological Operations

Morphological operations are usually applied to binary images, (though they can be made to apply to other images).

Morphological operations, unlike other filters, are selective, i.e., they respond to local (neighborhood) features of the image in predictable ways.
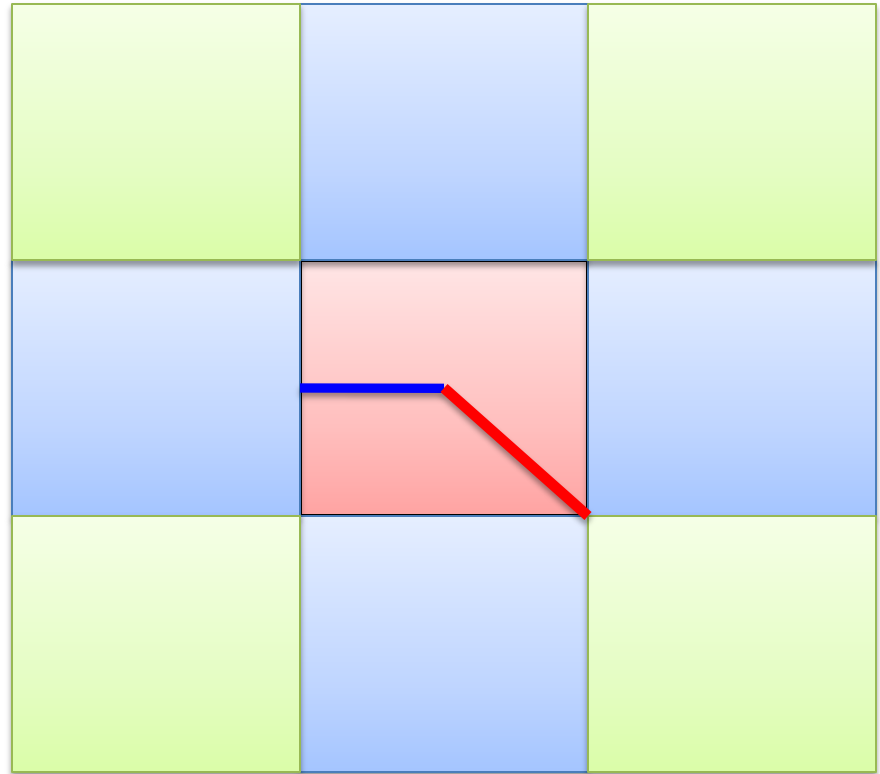
What's a Neighborhood?

A neighborhood is a set of adjacent pixels or voxels.

Because there are different ways to define adjacency (touching on a face, edge or vertex), there are different sized neighborhoods.
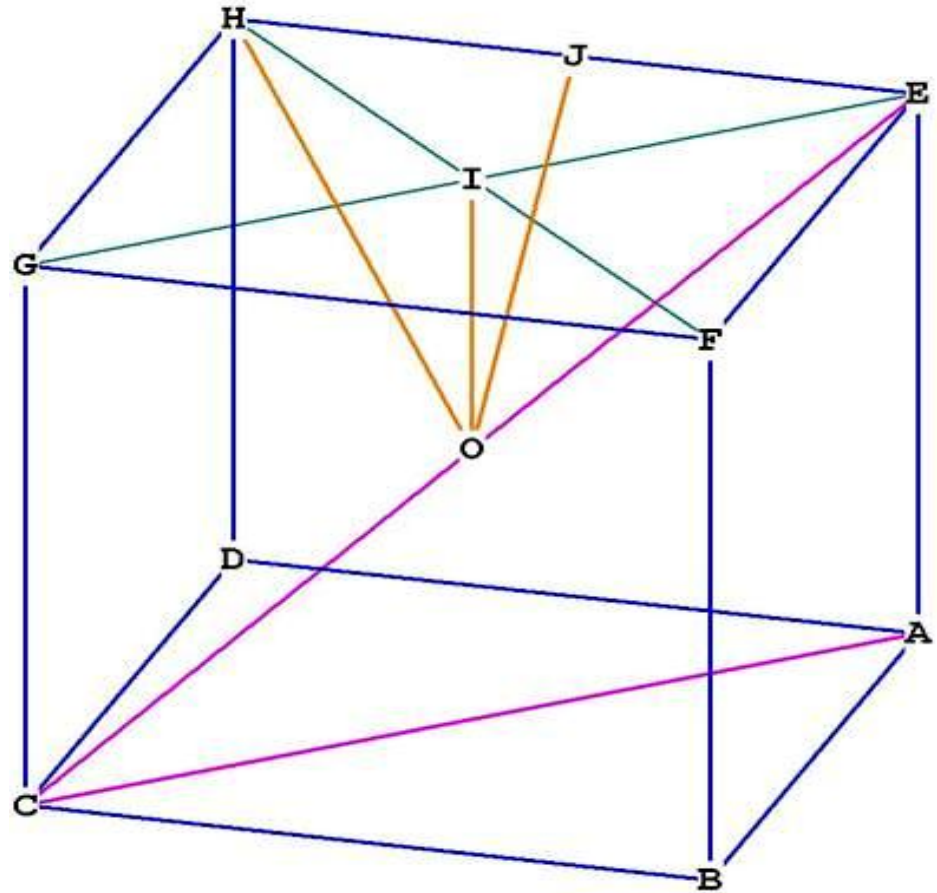
2D Neighbors

A pixel has 4 edges and 4 vertices, so it has a "4-neighborhood" & an "8-neighborhood"

"Center to edge" is shorter than "center to corner" →
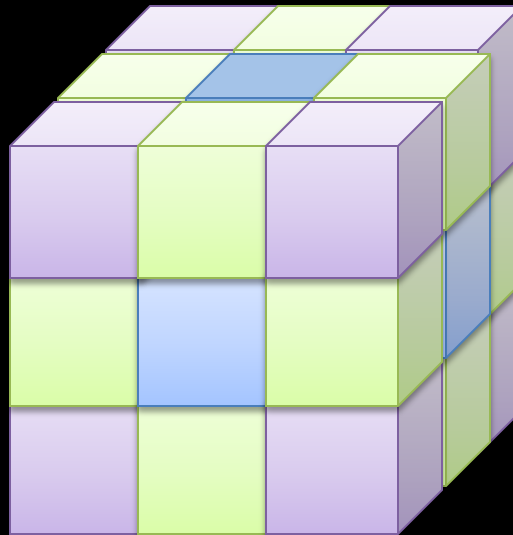Distance defines neighborhoods

Distance from voxel center to face (I) < edge (J) < vertex (H).

→ Distance can define 3D neighborhoods.

3D Neighbors

- A voxel has **6 faces** **12 edges** and **8 vertices (corners)**

- So it has 6, 18 or 26 neighbors

What are Clusters?

At some statistical thresholds, even empty space outside the brain shows fMRI activity.

We can mask the activations, and raise the threshold so that the remaining activity seems more plausible.

We can also require that in order to "count" as statistically significant, a certain number of adjacent voxels must be above threshold.

Clusters are based on Neighborhoods

This adjacency requirement gets rid of single active voxels (or very small neighborhoods if you choose) that probably reflect noise.

The remaining activation clusters are defined by 3D neighborhoods of 6,18, 26 or more neighbors.
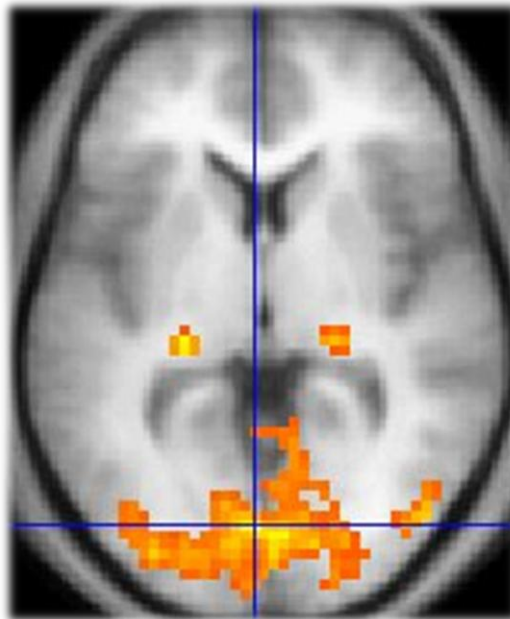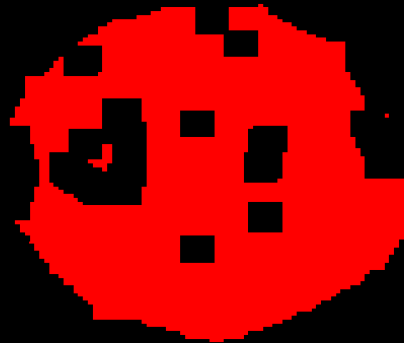
Common Morphological Filters

The most common types of morphological filters are growing (dilation) and shrinking (erosion).

More complex operations can be built up from these basic types.

Dilation: Adding 1 to neighboring pixels or voxels

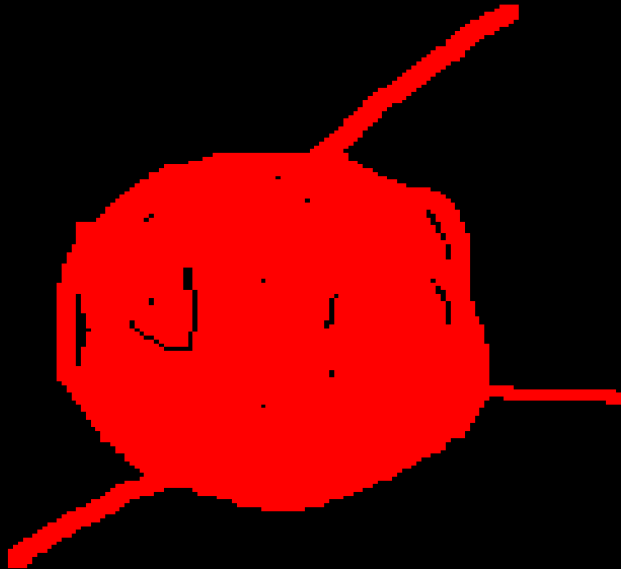# Erosion: Subtracting 1 from neighboring pixels or voxels

Opening

Erosion followed by dilation:

Effect: small features like dots or fine lines are removed by the erosion.

The remaining structures are smoothed and grown back to approximately their original shape.
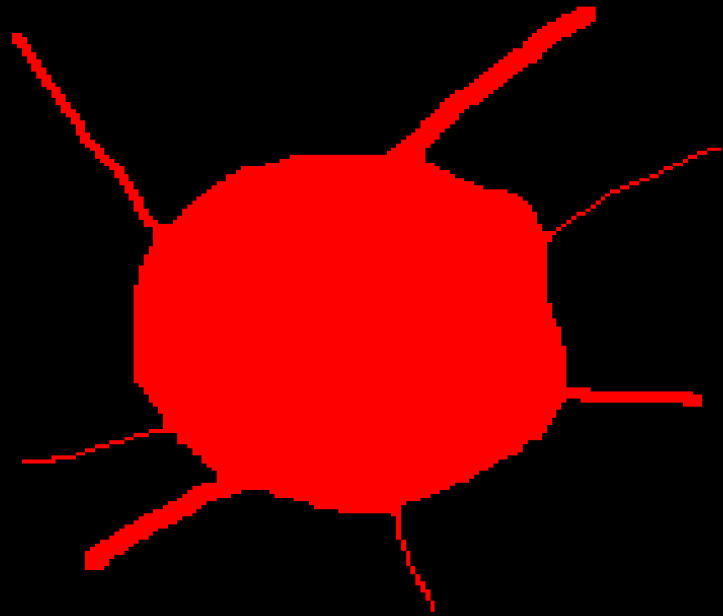
Opening

Closing

Dilation, followed by erosion

Effect: closes small holes or fissures with the initial dilation.

Returns large objects to approximately their same size and shape with the erosion step

Closing

Thought Experiment

- Given dilation and erosion, how could you generate an outline?

Summary

Morphological operations depend on the concept of neighborhoods.

Neighborhoods are used to define clusters in fMRI* experiments.

Dilation & erosion are the most basic morphological operations.

Opening and closing are more complex operations built on top of dilation and erosion.

(* VBM, TBSS and other procedures may also use clustering)

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