Segmentation and Morphological Processing Comparison

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Introduction

This experiment compares the results of image segmentation using the Otsu thresholding method, both with and without morphological processing. Morphological operations such as erosion, dilation, opening, and closing were done manually without using any image processing library. The goal is to see how these operations change image clarity, object shapes, and small details.

Note: Most datasets used in this experiment have bright (white or light gray) backgrounds and darker foreground objects. This means the dark parts are the objects, while the background stays white. Because of this, the way erosion and dilation look may seem reversed: *erosion makes the dark parts look thicker*, while *dilation makes them thinner*. This happens because the algorithm sees white as foreground (1) and dark areas as background (0). If the background was dark instead, the usual behavior (erosion shrinks objects, dilation expands them) would apply.

1. Image: Face

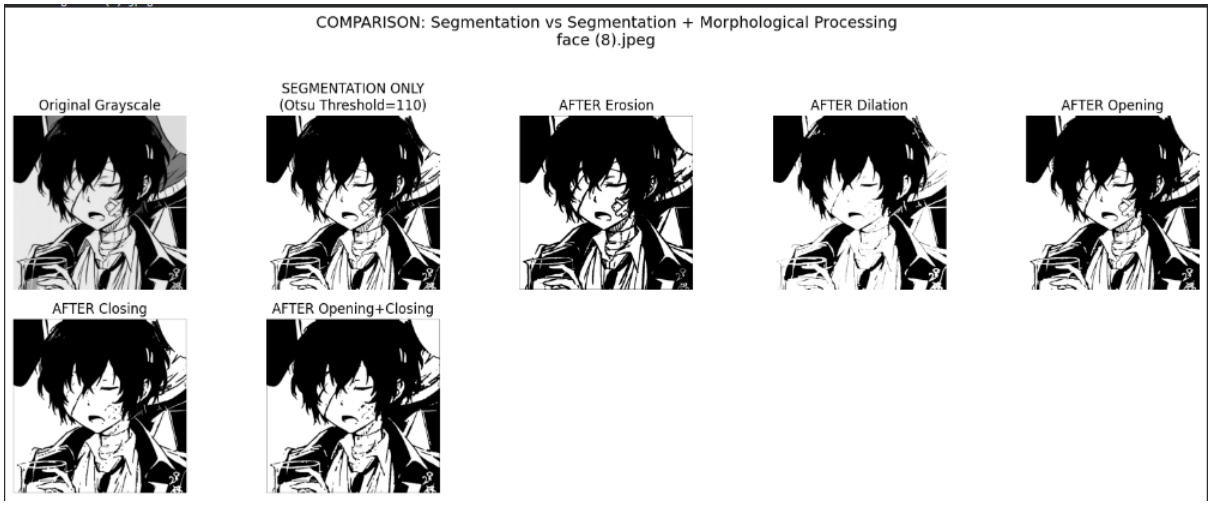

Figure 1: Segmentation and morphological results for the face image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 110)	Otsu thresholding separates dark areas such as hair and clothes from the bright background and skin. Some small white noise remains around the edges and the jacket.
After Erosion	The dark regions become thicker and more defined. This makes the separation between dark and bright parts clearer and helps us see how the segmentation works between hair, clothes, and skin.
After Dilation	The white background grows, making the dark areas thinner and reducing some small details.
After Opening (Erosion then Dilation)	Removes small background noise while keeping the main shape of the face and hair. The image looks smoother.
After Closing (Dilation then Erosion)	Fills some small white gaps inside dark regions, but can blur small details like the bandage.
After Opening and Closing	Produces a clean and balanced result but the dark parts are not as solid as in erosion.
Conclusion	Erosion gives the best result for segmentation clarity because it shows the difference between dark and bright parts most clearly.

Table 1: Analysis of segmentation and morphological results for the face image.

2. Image: Coin

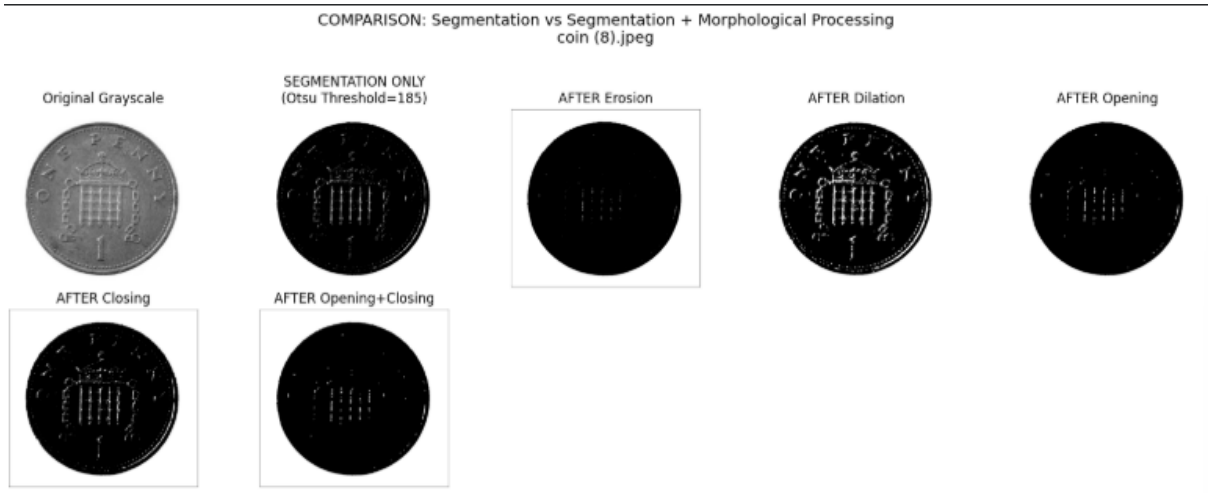

Figure 2: Segmentation and morphological results for the coin image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 185)	The coin outline is separated from the white background, but inner details are not complete and small noise remains.
After Erosion	The dark coin becomes thicker and more solid. The edges are clear, and most small white spots disappear.
After Dilation	The white background expands, making the coin thinner and lighter. Some details fade.
After Opening	Removes background noise but makes the coin slightly less dark.
After Closing	Fills small white gaps, but not fully solid. Some white spots remain inside the coin.
After Opening and Closing	Smooths the shape but does not make the coin fully dark or clean.
Conclusion	Erosion gives the best and darkest result for the coin image. Opening and closing make it smoother but less solid.

Table 2: Analysis of segmentation and morphological results for the coin image.

3. Image: Leaf

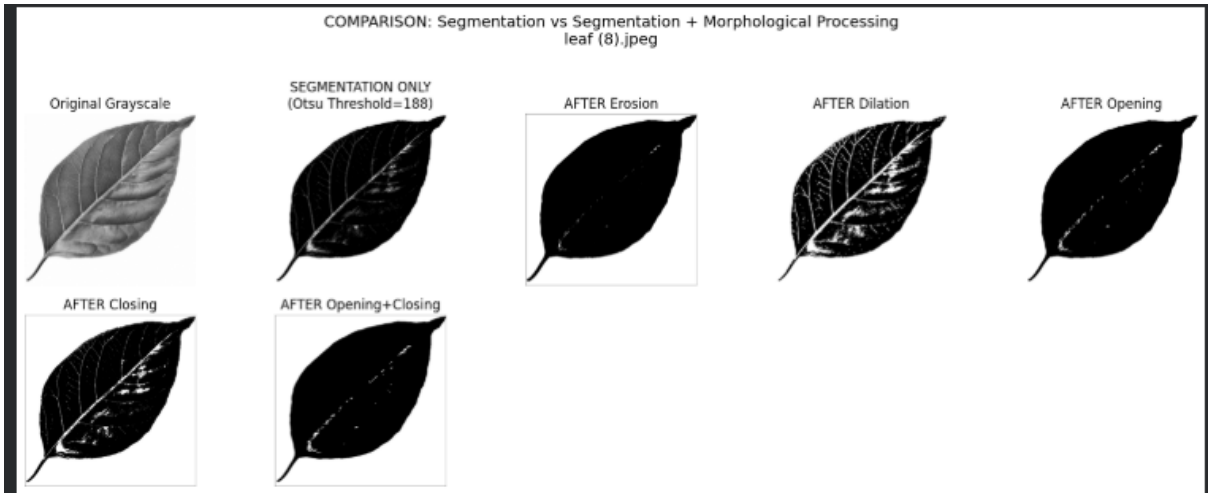

Figure 3: Segmentation and morphological results for the leaf image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 188)	The leaf is separated from the background, but inner vein textures look like white noise.
After Erosion	The dark leaf becomes thicker, smoother, and more solid. Background noise is reduced. This gives the cleanest and darkest leaf shape.
After Dilation	The white background grows slightly, making the leaf thinner and less dark.
After Opening	Reduces noise and smooths boundaries, but makes the leaf a bit lighter.
After Closing	Fills some small white gaps inside the leaf, but not completely. Some bright parts remain visible.
After Opening and Closing	Smooths the overall shape, but the leaf is not fully dark and small white areas still exist.
Conclusion	Erosion gives the most solid and clear result for the leaf image. Opening and closing make it smoother but less dark.

Table 3: Analysis of segmentation and morphological results for the leaf image.

Overall Analysis

Method	Purpose or Effect (Considering Bright Backgrounds)
Otsu Segmentation	Finds the best threshold to separate dark objects from the bright background. The dark areas represent the main objects.
Erosion	On bright backgrounds, erosion makes dark objects thicker and removes small white spots. Often gives the cleanest result.
Dilation	Expands white areas, making dark objects thinner.
Opening (Erosion then Dilation)	Removes small bright noise but may make objects lighter.
Closing (Dilation then Erosion)	Fills small white holes inside dark objects, but not always fully.
Opening and Closing Combined	Smooths the shape and reduces noise but does not make dark objects as solid as erosion does.

Table 4: Summary of segmentation and morphological processing effects with bright backgrounds.