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 implemented manually without using any image processing library. The comparison shows how these operations affect image clarity, object continuity, and the preservation of fine details.

Note: In the segmented images, the object areas appear dark (black) and the background is bright (white). Therefore, the visible effects of erosion and dilation appear reversed from the usual behavior. Erosion visually makes dark regions thicker, while dilation makes them thinner, since the algorithm treats white as the foreground.

1. Image: Face

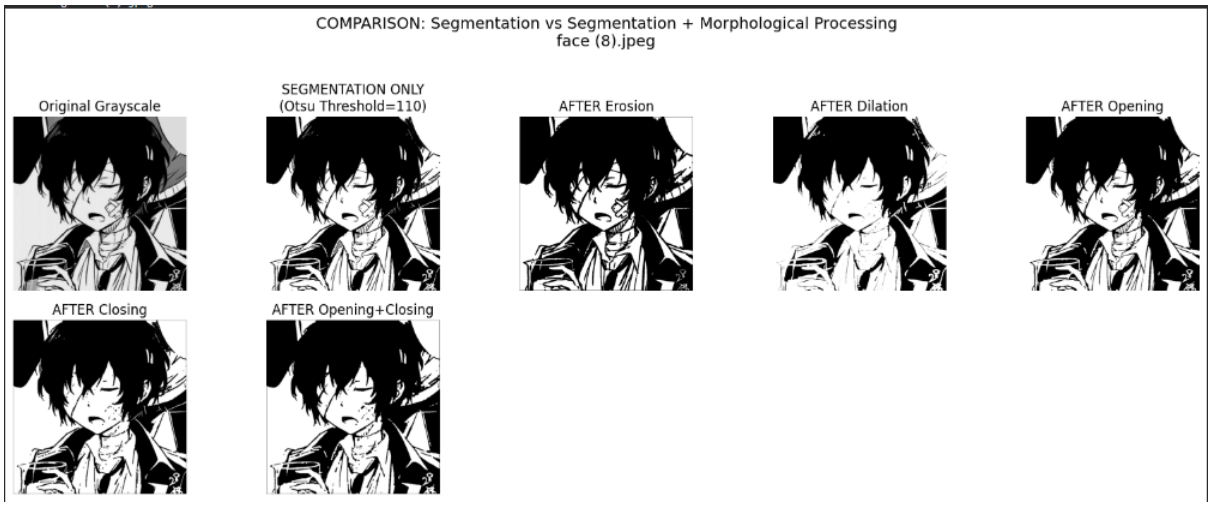

Figure 1: Segmentation and morphological results for the face image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 110)	Otsu thresholding successfully separates dark areas such as hair and clothes from the bright background and skin. Some small white noise remains near the edges and the jacket.
After Erosion	The dark regions become thicker and more defined. This enhances the outlines of the hair and jacket folds while reducing small white noise around the background.
After Dilation	The white background expands, causing dark details such as the bandage and fine clothing lines to fade or thin out. Some object details are reduced.
After Opening (Erosion then Dilation)	Removes small noise around the background while preserving the main shape of the face and hair. The image looks smoother and cleaner.
After Closing (Dilation then Erosion)	Fills small white gaps within the dark regions, making them appear more solid. Some fine details such as the bandage become less distinct.
After Opening and Closing	Produces the cleanest and most uniform result with minimal noise and clear object separation. Very fine details are slightly reduced, but the image looks visually stable.
Conclusion	Morphological processing improves the segmented image by reducing noise and smoothing object boundaries. Erosion enhances dark outlines, while dilation and closing reduce fine white details such as the bandage.

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

2. Image: Coin

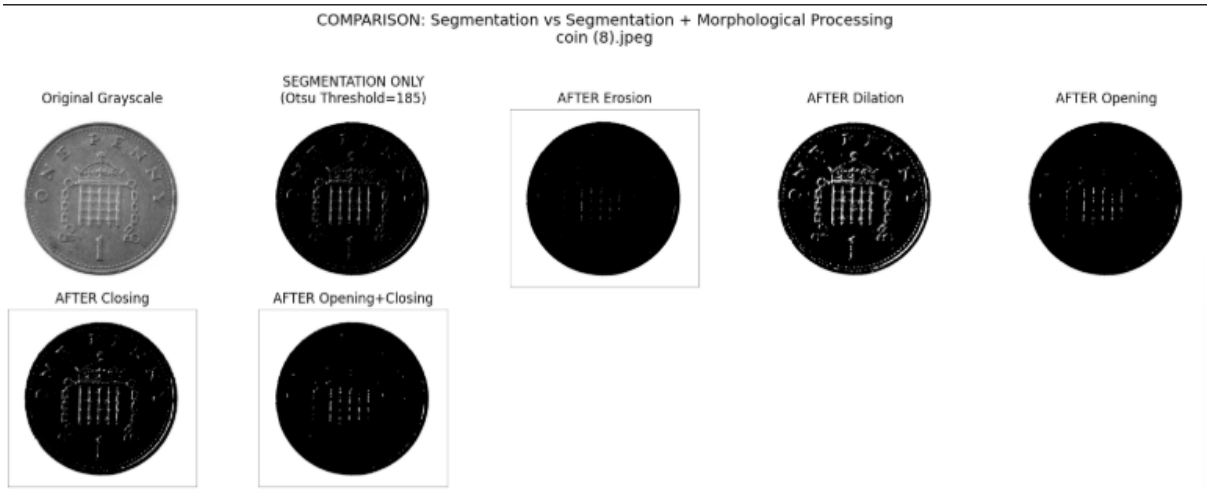

Figure 2: Segmentation and morphological results for the coin image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 185)	The coin outline is clearly separated from the white background, although inner details are incomplete and minor noise remains.
After Erosion	The dark coin areas become thicker and more defined, reducing white noise around the edges. Some fine texture details become heavier or merged.
After Dilation	The white background expands, making the dark coin region thinner. Fine internal features fade slightly.
After Opening	Removes small background noise while maintaining the coin's main shape. The edges appear smoother and cleaner.
After Closing	Fills small white gaps inside the coin, creating a more solid and continuous surface. The edges soften slightly.
After Opening and Closing	Produces a clear and balanced result where the coin is solid and distinct from the background, and inner features are visible.
Conclusion	Morphological operations, especially Opening and Closing, make the segmented coin more solid and visually consistent. Erosion enhances the coin edges, while dilation slightly reduces detail visibility.

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

3. Image: Leaf

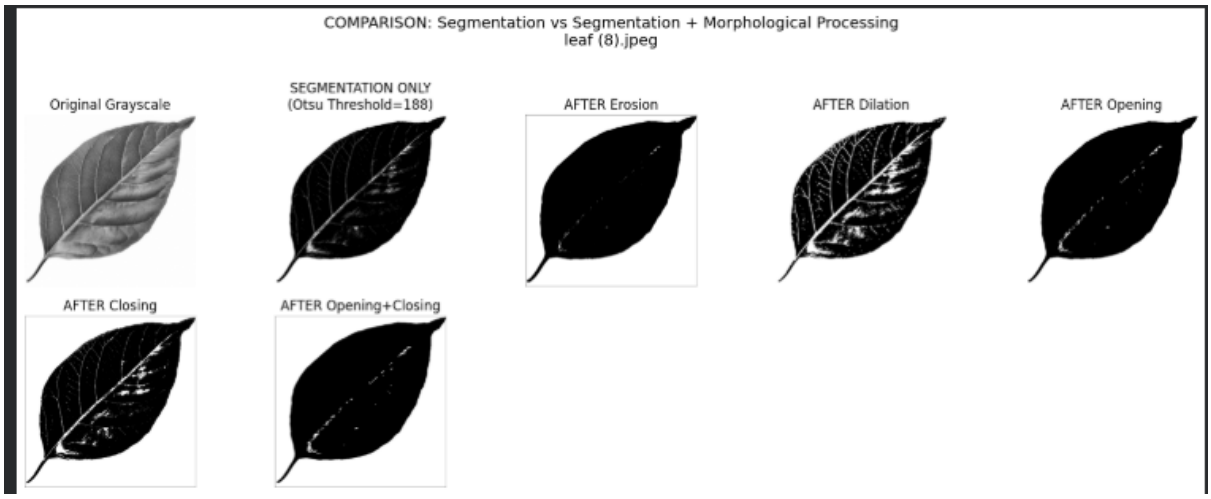

Figure 3: Segmentation and morphological results for the leaf image.

Processing Stage	Observation / Effect
Segmentation Only (Otsu Threshold = 188)	The leaf is well separated from the white background, but the inner vein textures appear as small white noise.
After Erosion	The dark leaf area becomes thicker and more defined, resulting in a smoother appearance and reduced background noise. The leaf shape remains intact.
After Dilation	The white background expands slightly, causing the dark leaf to thin and some inner details to fade.
After Opening	Reduces background noise and smooths boundary irregularities, while preserving the leaf contour.
After Closing	Fills small white gaps inside the leaf, making it appear more solid and uniform.
After Opening and Closing	Produces a balanced and stable result. The leaf shape is continuous and clean with minimal internal noise.
Conclusion	Morphological operations, particularly Opening and Closing, improve segmentation quality by reducing noise and smoothing the leaf shape. Erosion gives the cleanest contour, while dilation tends to thin dark areas.

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

Overall Analysis

Method	Purpose or Effect (Considering Black Objects on White Background)
Otsu Segmentation	Automatically determines the optimal threshold to separate bright and dark regions. Produces a rough binary mask where dark areas represent the object.
Erosion	Removes pixels from the white background, making dark object regions appear thicker and reducing small white noise.
Dilation	Expands white areas in the background, making dark objects thinner and reducing black detail.
Opening (Erosion then Dilation)	Removes small white noise while preserving the overall object shape. Produces smoother and cleaner boundaries.
Closing (Dilation then Erosion)	Fills small white holes inside dark objects, resulting in more solid regions.
Opening and Closing Combined	Combines both cleaning and filling effects, producing the most stable and visually clean segmentation results.

Table 4: Summary of segmentation and morphological processing effects.