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Course: 25FC - CSC515 - 1 [Module 5 – Morphology]

Critical Thinking Assignment [OpenCV in Morphology Operations for Handwritten Text Enhancement]

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GIT LINKS

Document Link – [25FC-CSC515-1/MODULE5/ csc515-1-module5-critical-thinking-aditya-sandhu00.docx at main · 65AR645ASAN/25FC-CSC515-1](https://github.com/65AR645ASAN/25FC-CSC515-1/blob/main/MODULE5/%20csc515-1-module5-critical-thinking-aditya-sandhu00.docx)

Python File – [25FC-CSC515-1/MODULE5/ csc515-1-module5-critical-thinking-aditya-sandhu03.py at main · 65AR645ASAN/25FC-CSC515-1](https://github.com/65AR645ASAN/25FC-CSC515-1/blob/main/MODULE5/%20csc515-1-module5-critical-thinking-aditya-sandhu03.py)

Morphology in the context of image processing refers to a set of operations that process images based on their shapes. It works by probing an image with a structuring element, a (kernel) which is a small shape or mask. It modifies the original image depending on how this shape fits or overlaps with the image’s features. Morphological operations are primarily used on binary images (black and white) but can also be applied to grayscale images. Binary images contain only two-pixel values, typically 0 (black) and 255 (white) which represent the complete absence or presence of a feature, such as text or shapes. They are often used for object detection and morphological processing. Grayscale images represent intensity variations using shades of gray, where pixel values range from 0 (black) to 255 (white), capturing brightness information without any color. They help in refining shapes, removing noise, filling gaps, and extracting structures.

Conceptually, an image can be imagined as a grid of 1s (white) and 0s (black), where morphological operations modify these values to refine shapes and structures. Erosion removes the outer layers of 1s, effectively shrinking objects in the image. Dilation adds layers of 1s around the shapes, making them thicker or more connected. Opening, which combines erosion followed by dilation, smooths object boundaries and removes small white specks or noise. Conversely, Closing, which performs dilation followed by erosion, fills small black holes and gaps inside white areas. These operations have wide-ranging applications such as enhancing handwritten text, reducing noise, detecting edges, analyzing shapes, and preprocessing images for segmentation tasks.

Figure 1 - Python script demonstrating morphological operations (dilation, erosion, opening, and closing) on a scanned image of handwritten text using OpenCV to enhance readability and prepare the image for Handwritten Text Recognition (HTR) or Optical Character Recognition (OCR).

A screenshot of a computer program

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Importing Required Libraries - The script begins by importing the essential Python libraries used for image processing and visualization. cv2 (OpenCV) provides functions for reading, processing, and displaying images. matplotlib.pyplot (as plt) allows visualization of intermediate and final image results. These libraries together form the foundation for performing morphological operations efficiently.

The descriptive comment block explains the purpose of the script. It states that the program demonstrates morphological operations, specifically dilation, erosion, opening, and closing on a scanned image of handwritten text. The main objective is to enhance handwritten text for Handwriting Recognition (HWR) or Optical Character Recognition (OCR) by reducing noise, smoothing boundaries, and filling gaps in characters. Users are instructed to replace 'handwritten\_sticky.jpg' with their own scanned image file path.

original = cv2.imread(img\_path, cv2.IMREAD\_GRAYSCALE)

This code simplifies processing by converting the image into shades of gray (values between 0 and 255), removing unnecessary color information while retaining brightness and texture details. This is an essential preprocessing step before performing binary thresholding or morphological transformations. Its Greyscale creation.

*if* original *is None*:  
 *raise* FileNotFoundError(f"Image not found at {img\_path}. "  
 f"Please provide a valid path to a scanned handwritten sticky note image.")

Here we have an if statement that is catch code for missing images.

*# Apply binary thresholding to create a binary image (dark text = 0, light background = 255)*\_, binary = cv2.threshold(original, 127, 255, cv2.THRESH\_BINARY\_INV)

This line converts the grayscale image into a “binary image” by applying a threshold value of “127”, where pixel intensities below this value become black (0) and those above become white (255). The `cv2.THRESH\_BINARY\_INV` flag inverts the result, making the “handwritten text white on a black background” to improve visibility for morphological operations.

# Define a structuring element (3x3 rectangle for basic enhancement)

kernel = cv2.getStructuringElement(cv2.MORPH\_RECT, (3, 3))

This line creates a 3×3 rectangular structuring element (kernel) used to probe and modify the image during morphological operations. It defines the shape and size of the neighborhood that influences how pixels are added or removed when performing dilation, erosion, opening, or closing.

# Apply morphological operations

dilated = cv2.dilate(binary, kernel, iterations=1) # Expands text lines

eroded = cv2.erode(binary, kernel, iterations=1) # Shrinks text lines, removes thin noise

opened = cv2.morphologyEx(binary, cv2.MORPH\_OPEN, kernel) # Erosion then dilation: removes noise, separates characters

closed = cv2.morphologyEx(binary, cv2.MORPH\_CLOSE, kernel) # Dilation then erosion: fills gaps, connects broken parts

This section applies the four main morphological operations to the binary image using the defined kernel. First, is dilation (cv2.dilate) expands bright regions, making text lines thicker and connecting nearby components. Then there is erosion (cv2.erode) shrinks bright regions, removing small white noise and refining thin strokes. Opening (cv2.morphologyEx with MORPH\_OPEN) performs erosion followed by dilation to eliminate small noise while preserving text structure and Closing (cv2.morphologyEx with MORPH\_CLOSE) performs dilation followed by erosion to fill small gaps and join broken or incomplete characters.

Figure 2 - Visualization of morphological operations applied to a handwritten text image using a 2x3 subplot grid in OpenCV and Matplotlib, displaying the original grayscale, binary thresholded, dilated, eroded, opened, and closed images for comparison and analysis.

A computer screen with colorful text

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This section visualizes the results of all morphological operations in a 2x3 grid using Matplotlib, allowing easy comparison between the original, binary, and processed images. Each subplot displays a different stage. grayscale, thresholded, dilated, eroded, opened, and closed, for visual analysis of enhancement quality. It then applies a final closing operation to the opened image for combined noise removal and gap filling. Lastly, the enhanced image is saved as 'enhanced\_handwritten.jpg' for later use in OCR or handwriting recognition.

*# Visualize results in a 2x3 subplot grid*fig, axes = plt.subplots(2, 3, figsize=(15, 10))  
images = [original, binary, dilated, eroded, opened, closed]  
titles = ['Original Grayscale', 'Binary Thresholded', 'Dilation', 'Erosion', 'Opening', 'Closing']

This piece of code creates a **2x3 subplot grid** to display different stages of image processing side by side for visual comparison. It organizes the images and corresponding titles, “original, binary thresholded, dilated, eroded, opened, and closed”, into labeled subplots for clarity.

*for* i, (ax, img, title) *in* enumerate(zip(axes.flat, images, titles)):  
 ax.imshow(img, cmap='gray')  
 ax.set\_title(title)  
 ax.axis('off')

Then, this **for loop** iterates through each subplot, image, and title simultaneously using zip(). For each image, it displays it in **grayscale** (cmap='gray'), sets an appropriate **title** for identification, and hides the axis lines for a cleaner visual presentation.

plt.tight\_layout()  
plt.show()

plt.tight\_layout() adjusts spacing between subplots for a neat display, and plt.show() renders the visualization.   
*# Optional: Save enhanced image (e.g., after opening + closing for combined enhancement)*enhanced = cv2.morphologyEx(opened, cv2.MORPH\_CLOSE, kernel)  
cv2.imwrite('enhanced\_handwritten.jpg', enhanced)  
print("Enhanced image saved as 'enhanced\_handwritten.jpg'")

The final lines apply a **closing operation** to the previously opened image for smoother enhancement, then **save** the result as 'enhanced\_handwritten.jpg' and print a confirmation message.

**Figure 3 -** Output visualization of morphological operations applied to handwritten text, showing the progression from the original grayscale image through binary thresholding, dilation, erosion, opening, and closing, demonstrating improved clarity and noise reduction for OCR and handwriting recognition.

A collage of several images of writing

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The output image demonstrates how morphological operations progressively enhance the quality of handwritten text. The **original grayscale** image shows uneven lighting and faint strokes. After **binary thresholding**, the text becomes distinct against a black background. **Dilation** thickens the text, connecting nearby characters, while **erosion** refines edges and removes minor noise. Finally, **opening** and **closing** smooth the handwriting, removing small imperfections and filling gaps, resulting in a cleaner, more readable image ideal for OCR processing.

This program successfully demonstrates how morphological operations can enhance handwritten text for improved readability and OCR accuracy. By systematically applying dilation, erosion, opening, and closing, the script effectively removes noise, fills gaps, and strengthens character structure. The visualization confirms progressive refinement at each stage of processing. These operations showcase the power of OpenCV in practical image preprocessing tasks. Overall, morphology proves essential for preparing handwritten or scanned text for reliable machine interpretation.