# Critical Thinking 5 - Morphology Operations for Handwritten Text Enhancement

Karl Estes

Colorado State University Global

CSC 515: Foundations of Computer Vision

Dr. Brian Holbert

November 14th, 2021

# Critical Thinking 5 - Morphology Operations for Handwritten Text Enhancement

## 1. Preprocessing

As per the assignment requirements, four morphological operations (dilation, erosion, opening, and closing) were applied to a scanned image of a sticky note containing cursive text (see figure 1). To ensure the morphological operations were correctly applied, a few preprocessing steps were taken. The image was first converted to grayscale and then binarized (see figure 2) via a combination of OpenCV's THRESH_BINARY_INV and Otsu's Binarization. Otsu's Binarization method automatically determines the optimal global threshold value from an image histogram, eradicating the need for an arbitrarily chosen value (OpenCV, n.d.). The THRESH_BINARY_INV ensured the black text in the original image would appear white in the binarized copy. This was necessary for OpenCV's *erosion* and *dilation* to work on the text and not the background since white pixels are treated as the object for morphological functions. A Gaussian filter with a 5x5 kernel was also used prior to binarization. Many images have some level of default Gaussian noise, and de-noising is an import preprocessing step for accurate morphological operations (Dharavath et al., 2014).

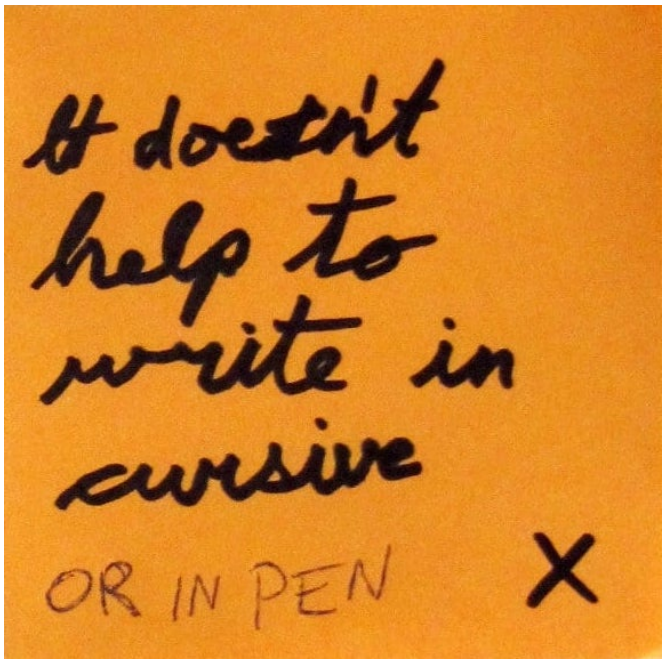
## 2. Results

The resulting morphological transformations are displayed in figure 3. Each morphological operation was applied with a rectangular 5x5 structural element.

### 2.1 Erosion

Eroding the image text maintained the overall shape of the words did not seem to introduce loss to any of the textual features in the cursive writing. The remnants of the light "OR IN PEN" text from the original image was removed entirely. If the focus were entirely on the

**Figure 1 Original Scanned Sticky Note**




*Note.* Scanned image of sticky note with cursive writing. This image was the original image that the morphological operations were applied to

**Figure 2 Binarized Image**

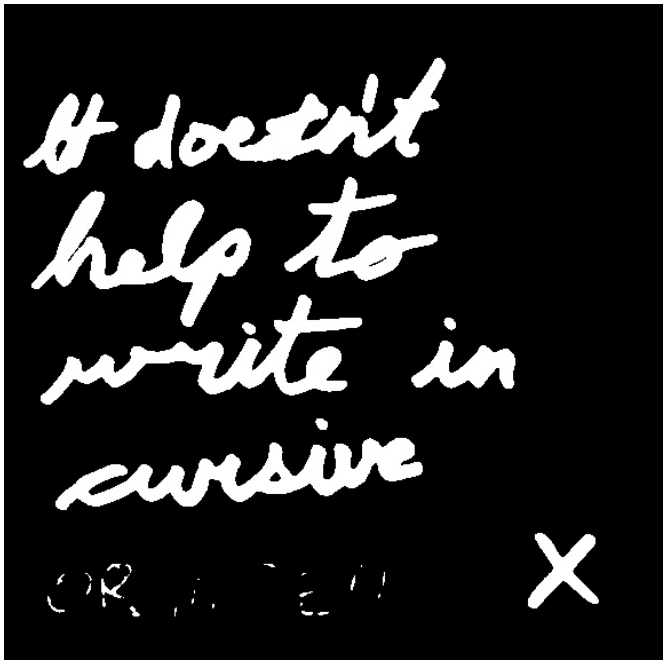
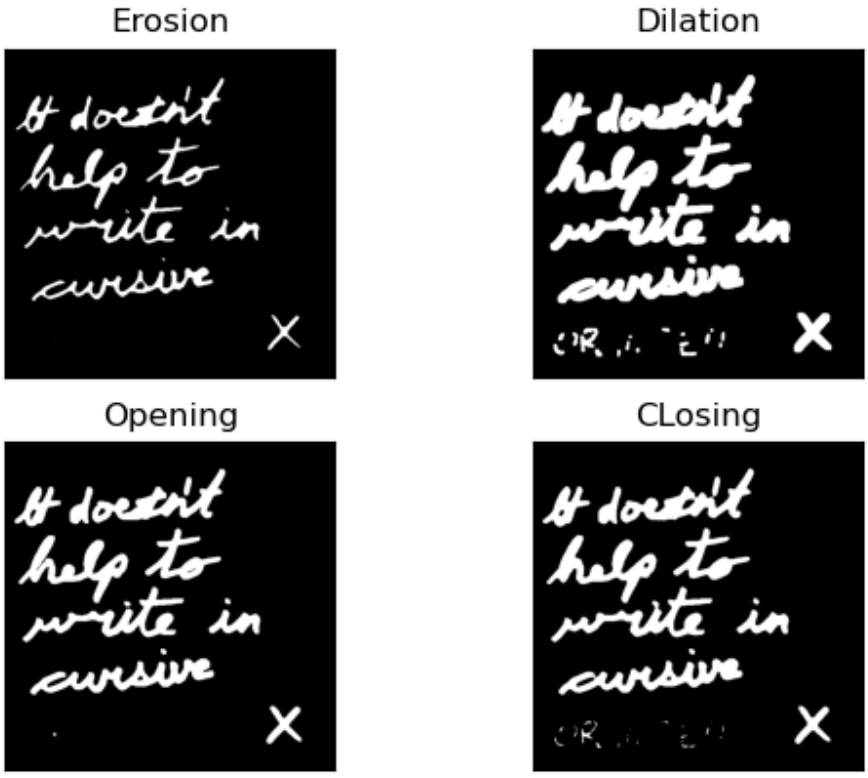


**Figure 3** Morphological Transformations - Kernel=(5,5)




*Note.* Each image in this figure corresponds to the processed image after the morphological operation listed was applied. Each operation was applied only once with a 5x5 rectangular structuring element.

cursive text, this would be an excellent enhancement to the image. If this text were necessary, the binarization process would need to be revisited since fragmentation of the writing occurred during this preprocessing step.

**2.2 Dilation**

Dilation of the text introduced ambiguity into some of the cursive words. Dilation is used to fill holes and gaps in continuous objects (Srisha & Khan, 2013). The majority of cursive characters are connected, which creates a continuous word. Thus, the application of dilation will fill space between these connected characters, rendering them unreadable.

If the number of iterations was extended, however, dilation could be used to determine word groupings. When comparing the Erosion and Dilation images in figure 3, the space between the **d** and **o** in the word **doesn't** are noticeably different. If one wanted to segment all letters of a word based on continuity, more robust dilation could ensure that disconnected **d** is included with the remaining letters.

### 2.3 Opening

Applying opening to the image did not seem to induce any significant enhancement or degradation of the cursive text. The noticeable difference was the removal of almost all fragments of the "OR IN PEN" phrase at the bottom of the image. The operation of opening smooths an object's outline and eliminations minor extensions and narrow bridges in an object (Srisha & Khan, 2013). Given the line thickness of the cursive text, opening had little effect compared to the original image.

### 2.4 Closing

The closing operation maintained constancy in the shape of the cursive text, but it did reduce spaces within the letters themselves. Letters such as **p** and **o**, which contain a fully enclosed space, were the most noticeably affected. The spaces within the letters were reduced, and some minor gaps (such as the gap between the stem and the body of the **h** in **help**) were also filled in. The text is still readable, but the operation did eliminate or reduce small holes that are typically part of the individual letters.

## 3. Related Research in Handwriting Enhancement

Kanungo and Haralick (1998) and Roy et al. (2008) present applications of morphological operations for handwriting enhancement and detection. Kanungo and Haralick

(1998) discuss the use of the four basic morphological operations to extract physical morphological features of numerical digits. One of the extracted features they discuss are *blobs*. “Blobs are formed in [an] image when loops or a configuration of pen stroked get connected into an ‘ink blot’ when the image [is closed] with a big structuring element) (Kanungo and Haralick, 1998, p. 4). This is similar to the resulting closure of spaces in letters such as **p** and **o**, as discussed in the closing operation results. Diminishment of these letter spaces would result in blobs that could subsequently be used to analyze morphological features during a subsequent letter identification phase.

On the other hand, Roy et al. (2008) primarily focused on the morphological operations of dilation and erosion. One appreciable application of erosion was in the generation of what they called foreground seed components (FSCs). When analyzing the connected script, isolated eroded components could generally be treated as representative of a *word*. While their research was focused on various forms of Indian script, the principle could be applied to cursive English. The eroded image in figure 3 did retain connection among continuous components while widening space between the words themselves. Segmentation of the image into its constituent FSCs would result in the general isolation of the individual words. However, as previously noted, the few cursive characters which do not connect would be separated and subsequently treated as their own FSC. Additional processing would need to be done to ensure individual letters are not left off of words.

## References

Dharavath, K., Talukdar, F. A., & Laskar, R. H. (2014). Improving face recognition rate with image preprocessing. *Indian Journal of Science and Technology*, *7*(8), 1170–1175.

Kanungo, T., & Haralick, R. (1998). *Character recognition using mathematical morphology*.

OpenCV. (n.d.). *OpenCV: Image thresholding*. Retrieved November 12, 2021, from https://docs.opencv.org/3.4/d7/d4d/tutorial_py_thresholding.html

Roy, P., Pal, U., & Lladós, J. (2008). *Morphology based handwritten line segmentation using foreground and background information*.

Srisha, R., & Khan, A. (2013, December 11). *Morphological operations for image processing: Understanding and its applications*.