

## **Module 5: Critical Thinking**

Brady Chin

Colorado State University Global

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Dr. Bingdong Li

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## **Morphology Operations for Fingerprint Enhancement**

The purpose of morphological operations is primarily for image preprocessing in order to highlight structural features, particularly in fingerprint analysis and handwriting recognition. Morphological operations take shapes in a binary image, apply a defined kernel, and manipulate those shapes. The resulting possibilities range from noise removal to stroke enhancement and gap filling. Similar to the previous example of applying enhancement and recognition en masse, we will use all four morphological operations, dilation, erosion, opening and closing, on a fingerprint image and consider how the morphological operations affected the final output.

### **Enhancements**

The morphological operations that were used in the assignment enhance the fingerprint image by altering its structure. Dilation enlarged the regions of the white pixels. Since the fingerprint was black after it had been binarized, we were able to see the fingerprint pattern more clearly. However, the white pixels were enlarged so much that it started to eliminate the finer fingerprint patterns.

Erosion does the opposite. The regions with the white pixels regions decreased in size and as a result, it made the fingerprint look less defined and more like a blob. Using this filter did not help us process the image.

Opening had a similar effect to erosion but the effects were not as intense. We could still see some patterns of the fingerprint but overall, it still looked like a blob and did not aid in processing the fingerprint.

Closing resulted in a good processed image. The white pixel regions were enlarged but not to the extremes that were present in dilation. As a result, we got a more clear image of the fingerprints pattern but there were still some areas that remained imperfect.

## **Data Loss**

These enhancements created a loss of data. Dilation increased the white background. Hence, the black ridges shrank. When this happened, any finer ridge detail was lost.

In erosion, the white areas shrink and so, by enlarging the black ridges, those eroded areas effectively blended together. When this was done, nearby ridges merged and distorted the actual fingerprint.

While not as severe as erosion, the black ridges were enlarged causing them to merge and result in the fingerprint being unrecognizable.

Closing was still able to preserve the structure but similar dilation, it eliminated finer details.

## **Research**

Based on the research that I have done on fingerprint image enhancement using morphological operations, the results in this assignment were largely in agreement. Whether the foreground color was white or black, the white regions would increase in size when dilation and closing were performed. In contrast, the black regions would enlarge when using erosion or opening (Munshi, A., 2020, October 20).

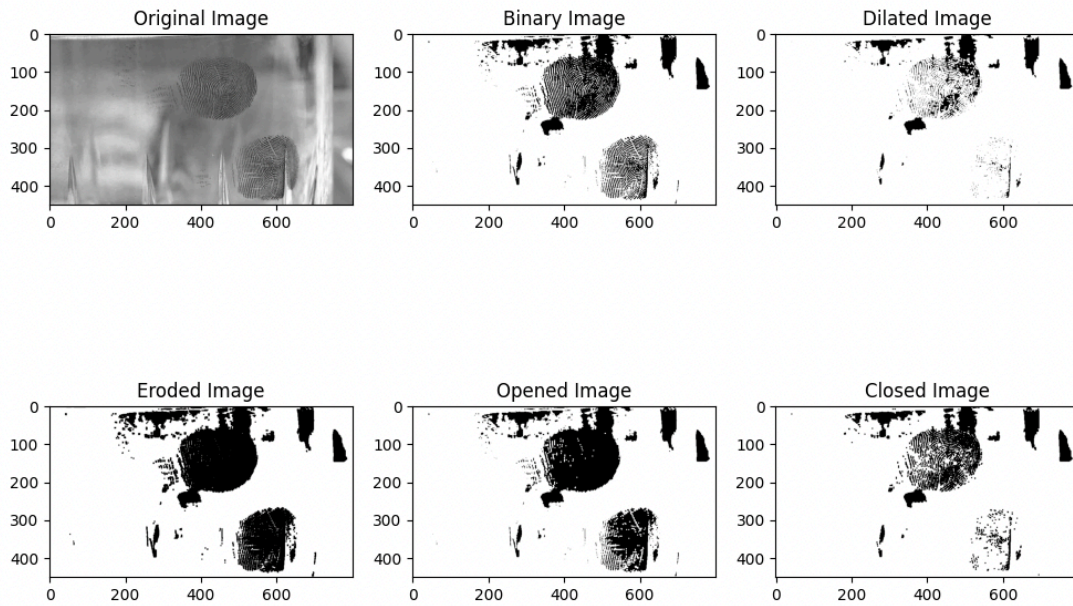
Furthermore, closing is simply the dilation process then the erosion process. This is best used for removing noise of the image. I found this to be the case as finer details were eliminated in my images. On the other hand, opening is the erosion process before the dilation process. This results in a more smooth image ([geeksforgeeks.org](https://www.geeksforgeeks.org/), 2022, December 20). However, in this case, the opening method smoothed the image too much.

## **Conclusion**

Morphological operations can help improve the visibility and appearance of fingerprint images. It is important to learn the structure and purpose of each operation to allow for proper image preprocessing in applications such as fingerprint or handwriting recognition.

## Screenshots of Successful Execution

Figure 1 shows the original image, the binary image, and the images with the morphological enhancements applied.



**Figure 1:** Successful execution of the program.

## References

- geeksforgeeks.org (2022, December 20) *Difference between Opening and Closing in Digital Image Processing*. GeeksforGeeks. <https://www.geeksforgeeks.org/difference-between-opening-and-closing-in-digital-image-processing/>
- Munshi, A., (2020, October 20) *Morphological image processing operations - Dilation, Erosion, Opening, and Closing with and without inbuilt CV2 functions*. Medium. <https://medium.com/@ami25480/morphological-image-processing-operations-dilation-erosion-opening-and-closing-with-and-without-c95475468fca>