MP2 Report

In this project, I implemented and tested five core morphological operations—**erosion, dilation, opening, closing, and boundary extraction**—using four different structuring elements on binary images. The primary objective was to explore how different structuring elements affect the outcome of each operation and to observe the impact on both structured and noisy image regions.

The structuring elements tested included a basic **2×2 square**, a **3×3 square**, a **cross-shaped** element, and a **circular 5×5** element

Each morphological function was implemented manually using NumPy and applied to two binarized test images, **gun.bmp** and **palm.bmp**. The input grayscale images were thresholded and normalized to binary before applying the transformations. The process involved scanning a padded version of the image and comparing each neighborhood with the structuring element to determine how to update each pixel.

Results and Observations

- **Erosion** consistently removed small details, breaking apart thin structures and shrinking the figure. Larger structuring elements (like the 3×3 and circle) made this effect **more aggressive**, while smaller ones (2×2) retained more fine structure.
- **Dilation** expanded white regions and filled gaps in the figures. Larger elements were more effective at connecting nearby components, though they also **caused small noise clusters** to merge with main structures.
- **Opening** (erosion followed by dilation) helped clean up isolated noise. The circular and 3×3 elements were especially effective here, though they also **risked erasing small parts** of the actual figure when too aggressive.
- **Closing** (dilation followed by erosion) filled small holes and connected nearby white areas within objects. It was most useful in **smoothing internal gaps**, with the circular SE producing the most visually cohesive output.
- **Boundary extraction**, calculated as the difference between the original and its erosion, successfully highlighted contours. Using larger or more symmetric elements (like the circle) **yielded cleaner, more accurate boundaries** in curved and rounded areas.

Final Insights

The code clearly shows that the choice of structuring element plays a critical role in the performance of morphological operations. Smaller elements preserved more detail but struggled with noise, while larger or shape-specific elements like the circular SE helped create smoother, cleaner transformations particularly in the boundary output. However, a trade-off exists between preserving detail and suppressing noise, especially in images with dense white space or thin features. Overall, this experiment offered valuable insight into how structuring elements shape the effectiveness of morphological techniques in computer vision.