

MP1 Report

In this project, I implemented a sequential connected component labelling (CCL) algorithm using 4-connectivity for binary images. The objective is to correctly segment and identify individual objects within the image and ensuring proper label assignment along with minimizing noise if needed. The algorithm was designed carefully to match the method discussed in class.

The input images were first binarized using a fixed threshold of 128 to distinguish foreground pixels from background pixels. Each image was then processed in a two-pass sequential labelling system. During the first pass, the image was scanned row-wise, examining only the left and top neighbors for each foreground pixel. If both neighbors were background, a new label was assigned. If only one neighbor was labelled, that label was propagated. If both neighbors had labels, the minimum of the two labels was assigned, and their equivalence was recorded for later resolution. This first pass produced a temporary label map that accurately identified regions but still contained multiple labels for connected areas due to neighbor label conflicts.

To correctly unite connected regions, I implemented a disjoint set data structure with path compression. This structure efficiently resolved label likeness by assigning a unique root label to each connected component. A second pass through the labeled image replaced each pixel's temporary label with its corresponding root label, ensuring that each distinct object was labelled across the image. Labels were normalized sequentially starting from 1 for clean visuals and analysis.

After labelling, I introduced a size filter that removed components smaller than 50 pixels. While the main purpose of applying this filter was to clean up noise specifically in the **gun.bmp** image, I chose to apply it to all images for consistency and to observe the effect of filtering across different cases. However, the filtering step was primarily intended for gun.bmp to focus on meaningful object structures and eliminate distracting small components.

The number of connected components detected after filtering for each image is shown below:

| Image | No of connected components before filtering | No of connected components after filtering |
|--------------|---|--|
| Face_old.bmp | 6 | 6 |
| Face.bmp | 6 | 6 |
| Test.bmp | 1 | 1 |
| Gun.bmp | 4 | 2 |

The results demonstrate that the sequential labelling approach successfully identifies connected regions in each image, and filtering helps in focusing on significant components. Particularly in **gun.bmp**, filtering significantly improved the clarity of the labeled output by removing small noise points while preserving the main shape. Overall, this project reinforced my understanding of low-level image analysis algorithms, sequential decision-making in image processing.