AVD613 - Machine Learning for Signal Processing

Assignment - 3 (Programming)

Image Segmentation

Submitted by

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1 Image Segmentation using Clustering

The following sections display the visual results after 5 simulations with different configurations, in addition to the settings in that simulation.

1.1 Clusters (k) = 5, Iterations ($iters$) = 10, Restarts (R) = 5

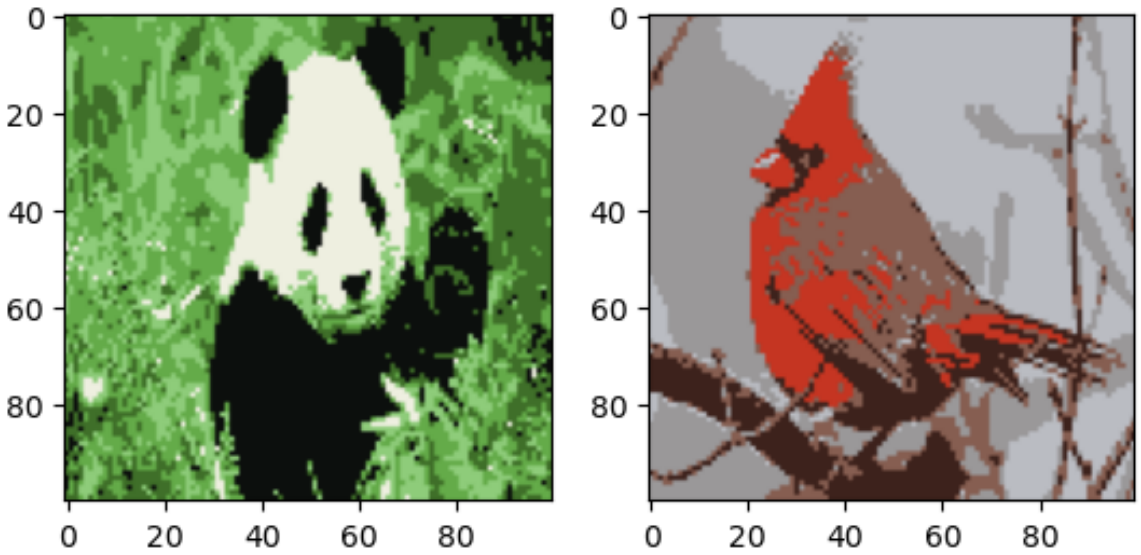

Figure 1: Image segmentation results for $k = 5,\ iters = 10,\ R = 5$.

1.2 Clusters (k) = 5, Iterations ($iters$) = 100, Restarts (R) = 5

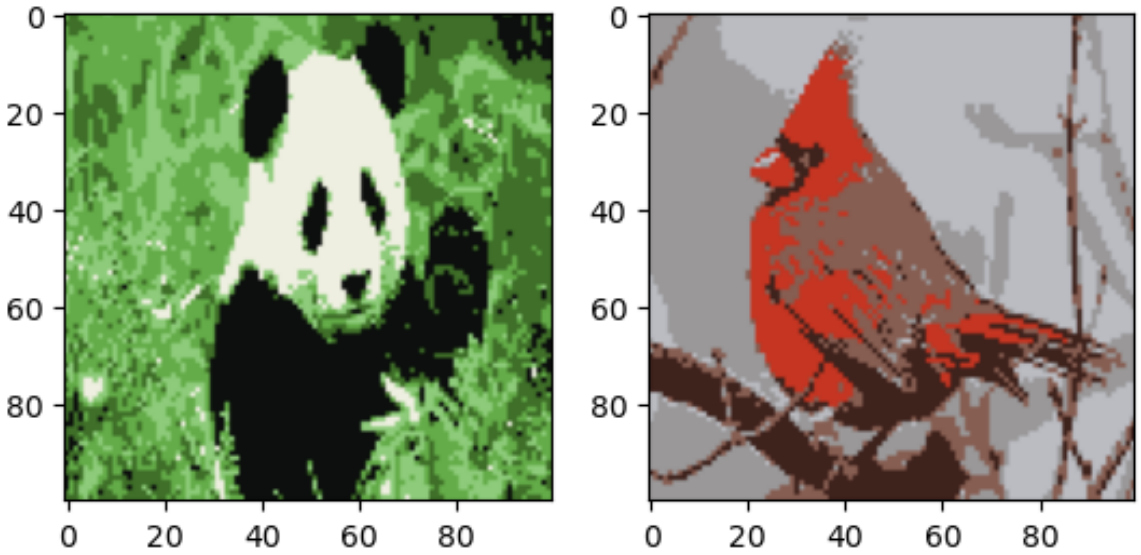

Figure 2: Image segmentation results for $k = 5,\ iters = 100,\ R = 5$.

1.3 Clusters (k) = 2, Iterations ($iters$) = 10, Restarts (R) = 5

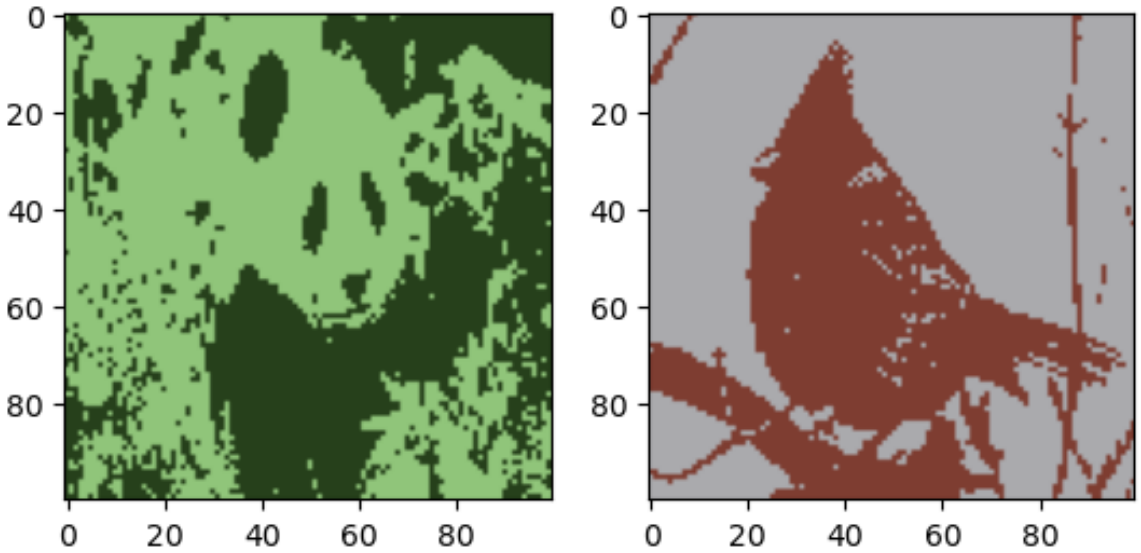

Figure 3: Image segmentation results for $k = 2,\ iters = 10,\ R = 5$.

1.4 Clusters (k) = 2, Iterations ($iters$) = 10, Restarts (R) = 15

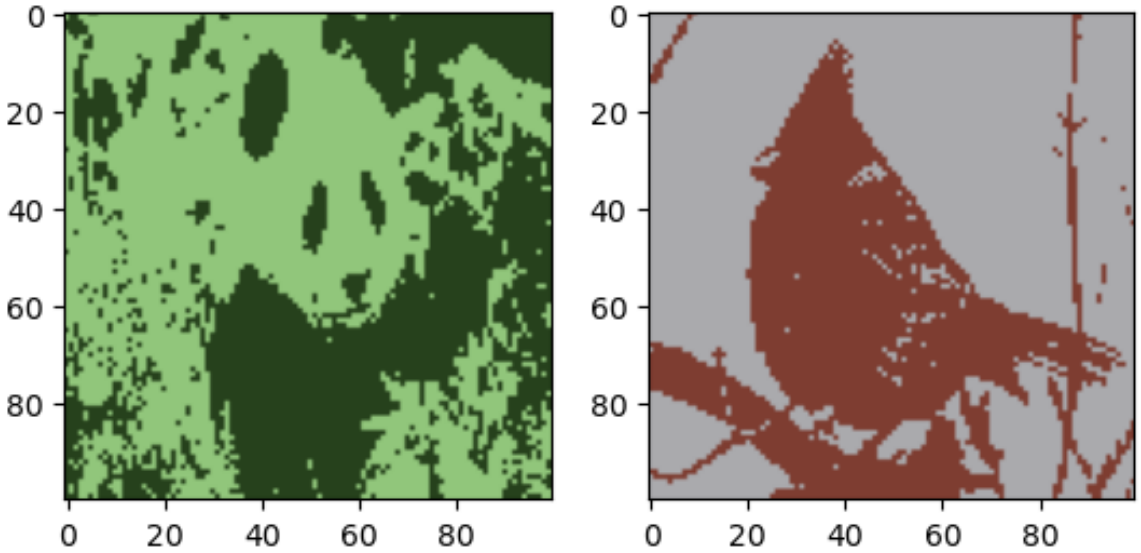

Figure 4: Image segmentation results for $k = 2,\ iters = 10,\ R = 15$.

1.5 Clusters (k) = 4, Iterations ($iters$) = 30, Restarts (R) = 15

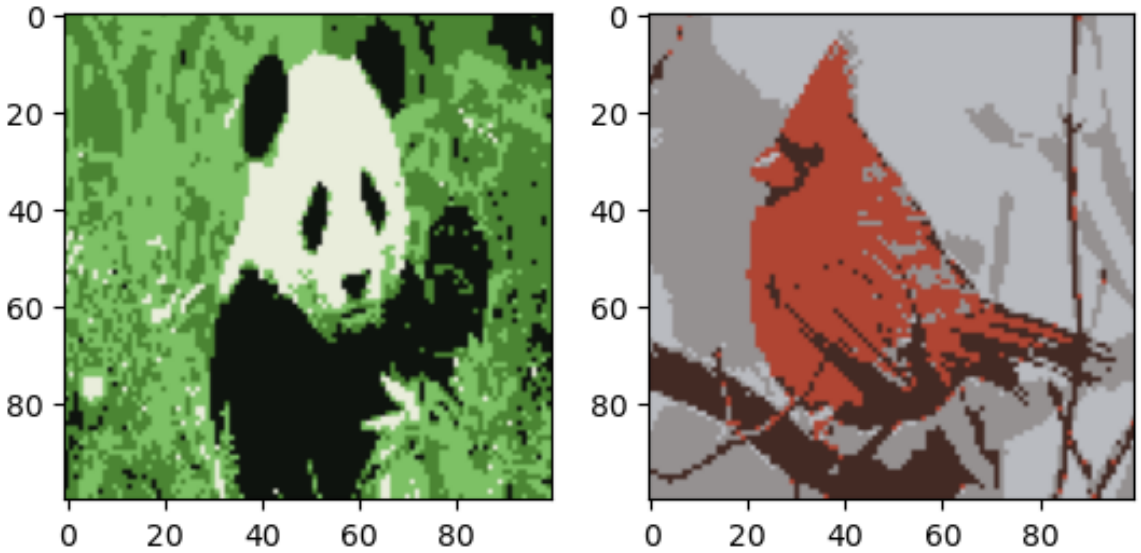

Figure 5: Image segmentation results for $k = 4$, $iters = 30$, $R = 15$.

1.6 Findings

In terms of findings, there are two main categories to evaluate: execution time, image segmentation quality. These can all be observed through the tuning of all three parameters: k (number of clusters), *iterations* (iterations for k-means), and *restarts* (number of times k-means was restarted).

- **Execution time:** The only parameter determined to have a significant impact on time was the *iterations* parameter. *Restarts* had an impact as well, but simply changing iterations from 10 to 100, for example in the first simulation, the execution time increased from 0.6 seconds to 3.2 seconds. As such, we want to keep the number of iterations to a minimum while still providing the k-means algorithm enough time for the cluster centers to converge. As shown in the first two examples of the results, there is not a significant change in quality between 10 and 100 iterations. As such, 10 iterations was chosen as a more optimal configuration.

- **Segmentation quality:** Segmentation quality is an important factor to analyse in any segmentation algorithm. In the findings, $k = 2$ was found to produce a binarised image, while $k = 4$ and $k = 5$ produced more precise representations of the actual underlying features (i.e. edges) of the original image. There is not a significant dip in quality between $k = 4$ and $k = 5$, but $k = 4$ has a slightly smaller execution time due to requiring a fewer number of calculations for cluster centers. As such, $k = 5$ has more precise segmentation quality, but $k = 4$ is more optimal due to the trade-offs between execution time while having strikingly similar segmentation quality.

- **Effect of restarts:** The *restarts* parameter was found to have little to no effect on the segmentation quality of k-means, while only taking longer to run the simulation. This is

possibly due to the chosen values to alternate between (5 and 15). The globally optimal sum of squared distances error for the k-means simulations could have easily been within the first 5 restarts of the simulation, so the quality only differed slightly. The *restarts* parameter might be useful while comparing one or two restarts to 100 starts (i.e. there is a significant gap in restarts), but is useless otherwise. An impact also might not have been noticed due to the low resolution of the image (100×100), so low-level features would not have mattered and only high-level features are detected by the algorithm.

1.7 Conclusion

In terms of parameters, k and *iterations* largely affect k-means the most. k affects the segmentation quality significantly. *Iterations* affects the execution time significantly, but did not impact the segmentation quality a ton. Part of this may be explained by the low resolution of the images. Finally, *restarts* did not show much of an impact at all in the simulations, other than an increased execution time. As such, a configuration of $k = 4$, $iterations = 30$, and $restarts = 15$ produced optimal results in terms of both segmentation quality (being granular but not too granular), while not taking a significant amount of time to run.

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