ML Assignment 4

Monsoon 2024
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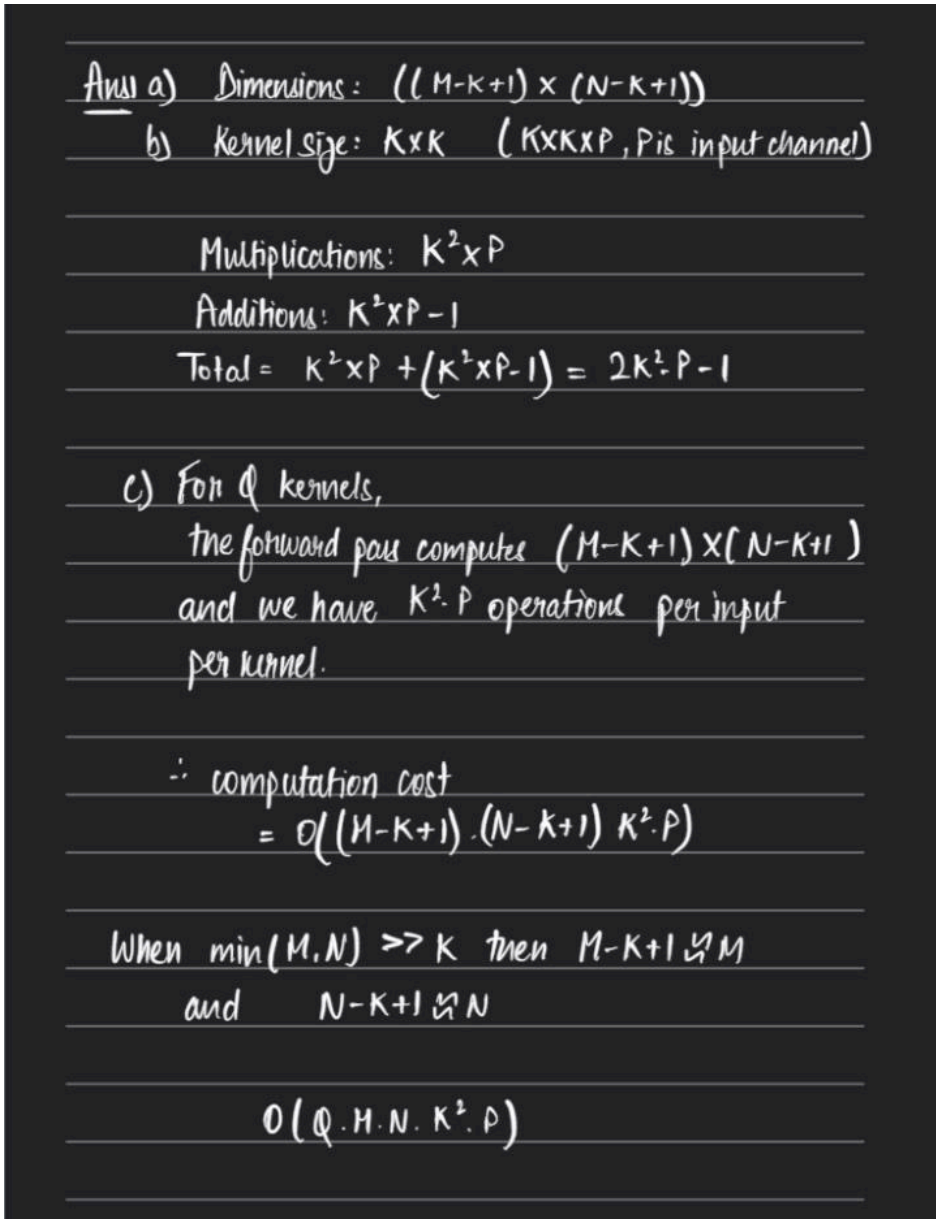
Section A:



Ans a) Dimensions: $((M-K+1) \times (N-K+1))$

b) Kernel size: $K \times K$ ($K \times K \times P$, P is input channel)

Multiplications: $K^2 \times P$

Additions: $K^2 \times P - 1$

Total = $K^2 \times P + (K^2 \times P - 1) = 2K^2 \cdot P - 1$

c) For Q kernels,
the forward pass computes $(M-K+1) \times (N-K+1)$ and we have $K^2 \cdot P$ operations per input per kernel.

∴ computation cost
$= O((M-K+1) \cdot (N-K+1) K^2 \cdot P)$

When $\min(M, N) >> K$ then $M-K+1 \approx M$
and $N-K+1 \approx N$

$O(Q \cdot M \cdot N \cdot K^2 \cdot P)$

Ans2 Assignment:

i) each data point is assigned to the cluster with the nearest centroid

ii) distance is computed b/w each point and all centroid.

iii) point x_i is assigned to cluster C if

$$j = \arg\min \|x_i - \mu_j\|$$

μ = centroid of cluster j

Update:

i) the centroids of the clusters are recomputed

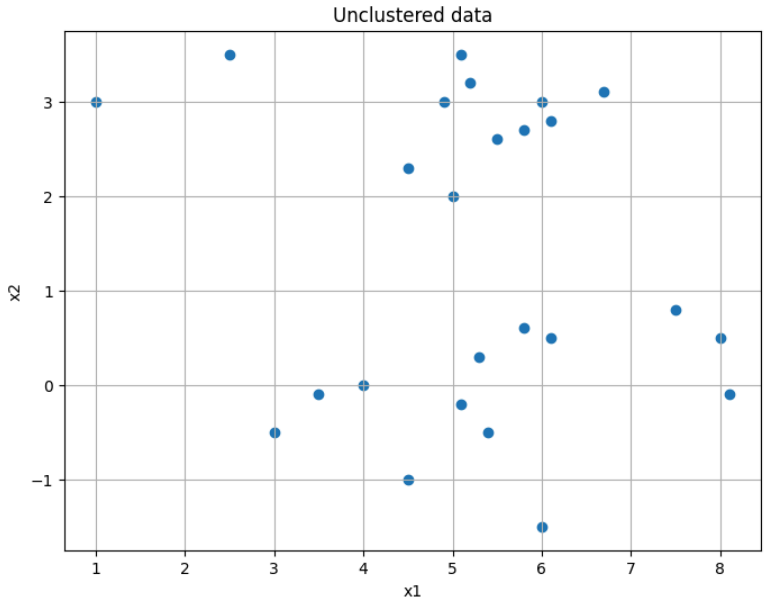
$$\mu_j = \frac{1}{|C_j|} \sum_{x \in C_j} x$$

↳ number of points in cluster j.

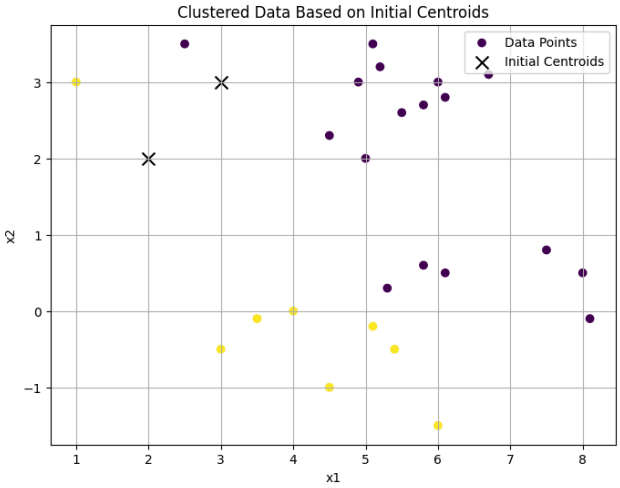
We can determine the optimal number of clusters or K by using the elbow method. It calculates the sum of squared distances for different numbers of K. The optimal k is the elbow point where increasing K results in diminishing returns.

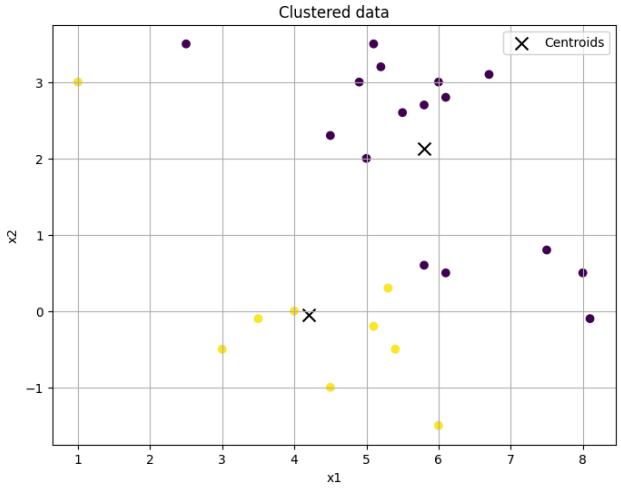
We cannot reach global minimum b randomly assigning centroids. We will only reach local minima.

Section B:

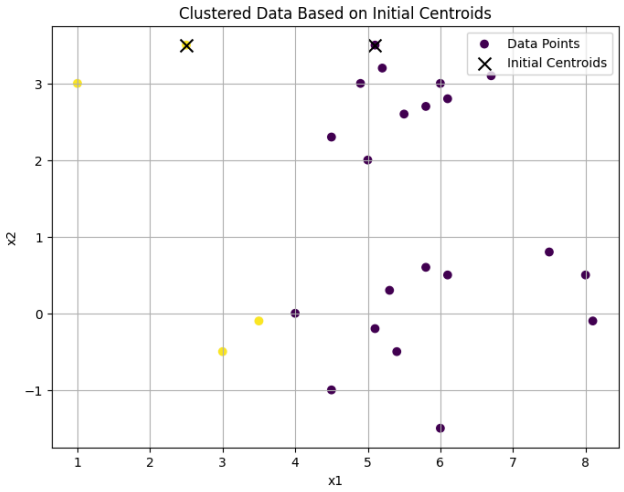


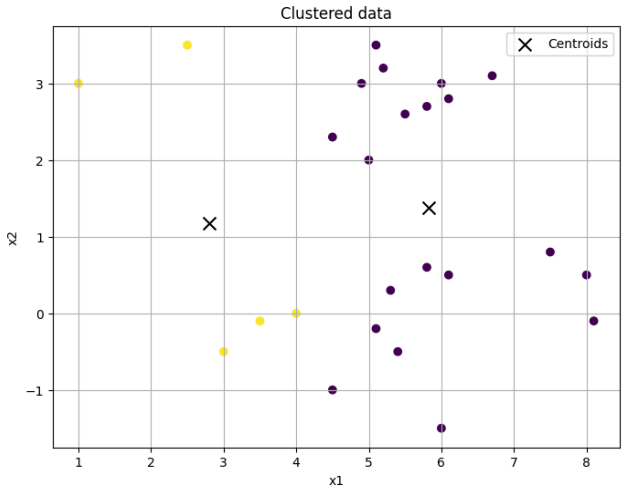
Initialized centroids = (3.0, 3.0) (2.0, 2.0)
Centroids obtained after 3 iterations = (5.8, 2.125) (4.2, -0.055)



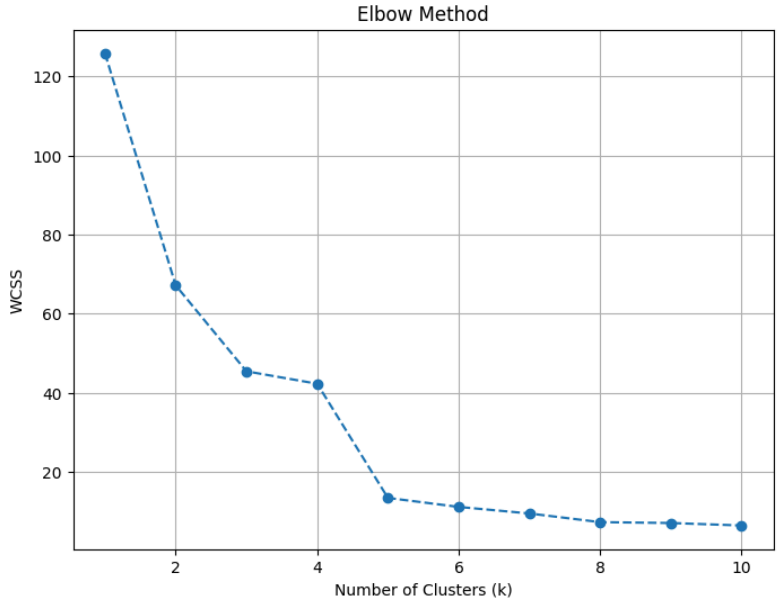


Randomly initialized centroids = (5.1, 2.5) (3.5, 2.5)

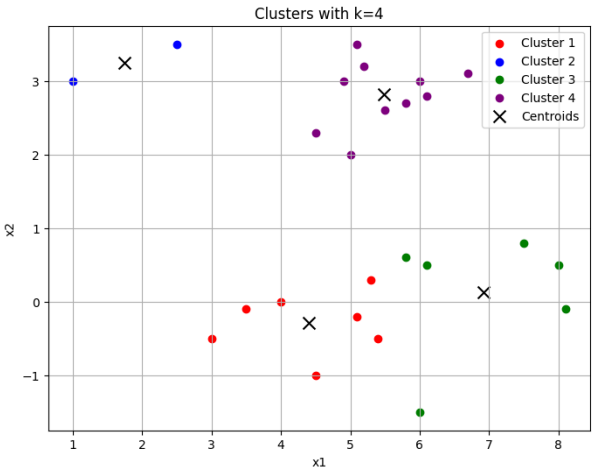


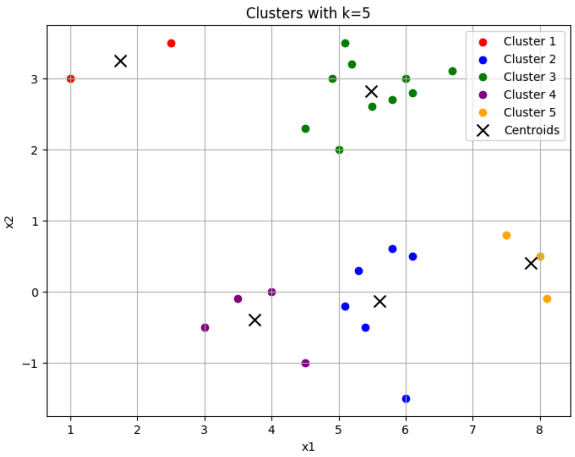


The clusters created using the initial centroids have more points in the yellow cluster and seems to have a better split whereas in the random centroid initialization the clusters could have been better. However, both converge after 3-4 iterations depending upon the random centroids.



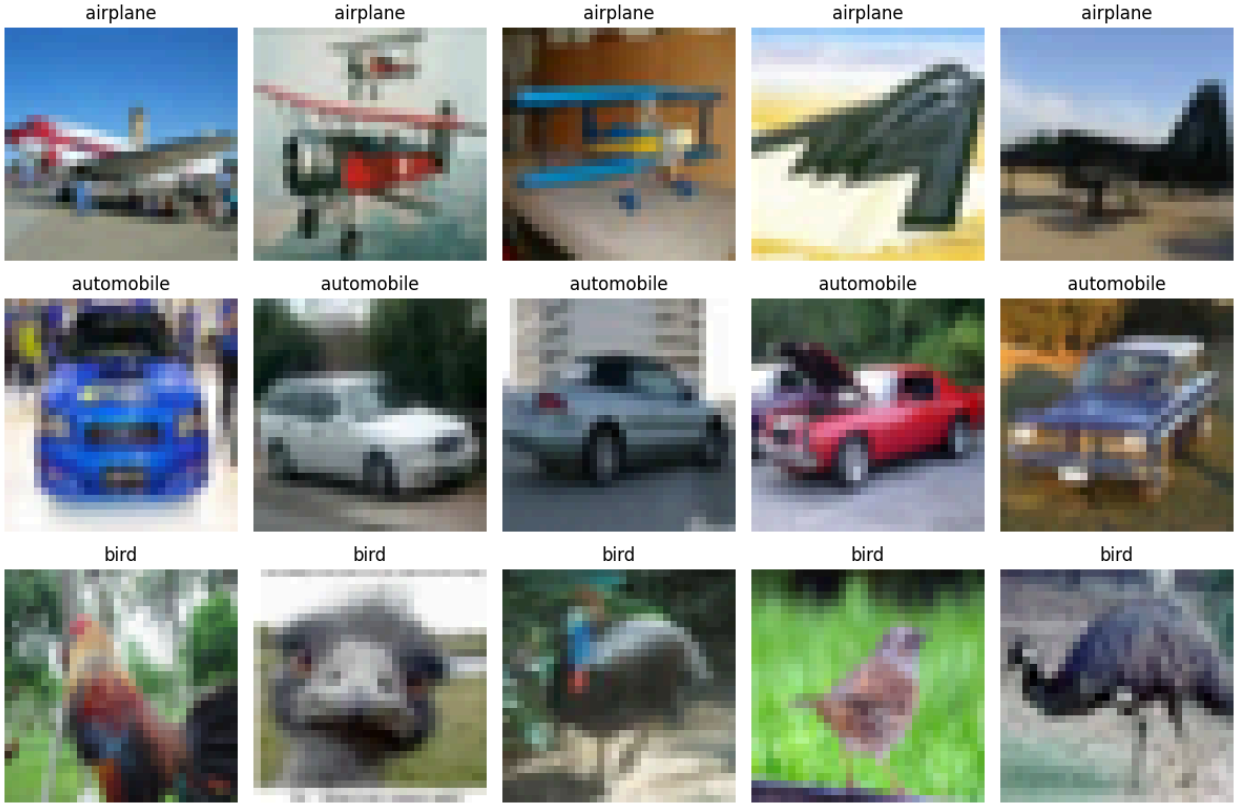
As it is clear from the plot that there is not much gain after k=4,5 therefore the optimal k can be 4 or 5 depending on the desired output.



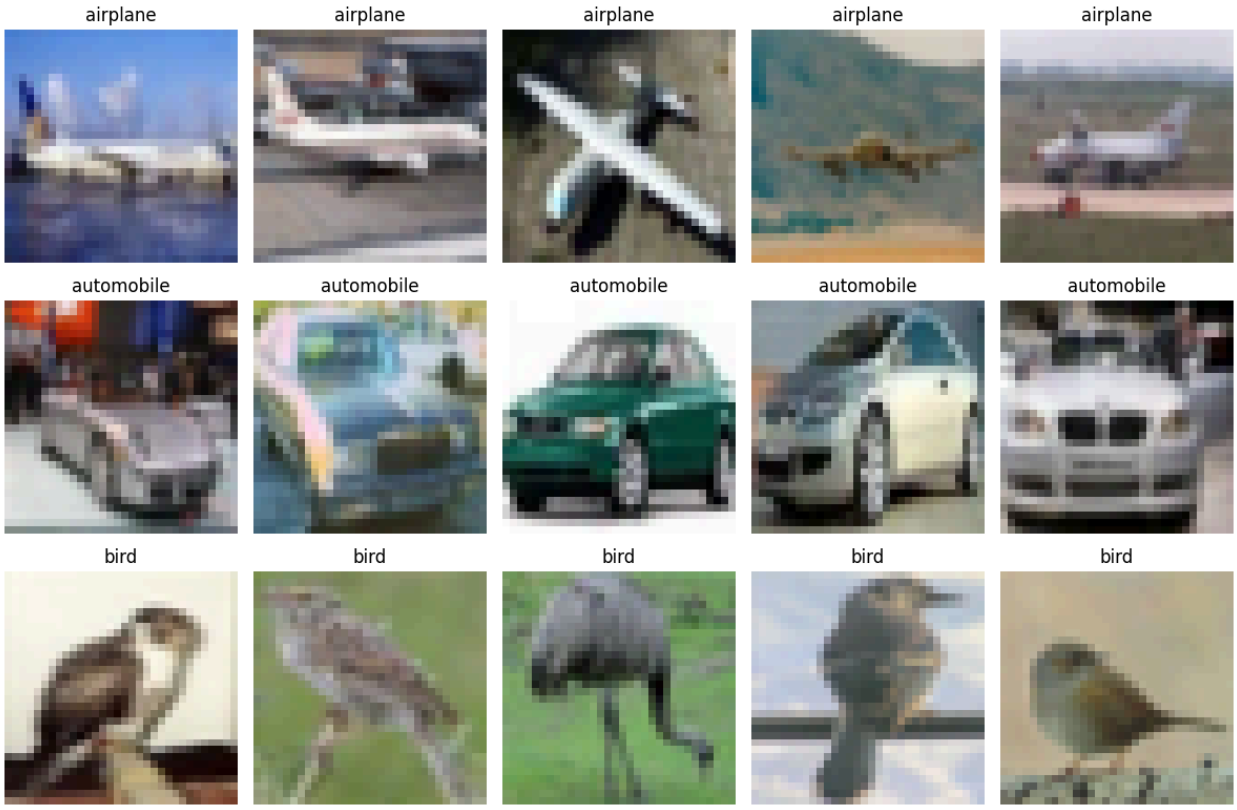


Section C:

Training Images:



Validation Images:



CustomCNN class built in code.