McMaster University
Dept. of Electrical and Computer Engineering
COE 4SL4- Term I (Fall) 2023

Assignment 5. k-Means Clustering for Image Segmentation and Compression

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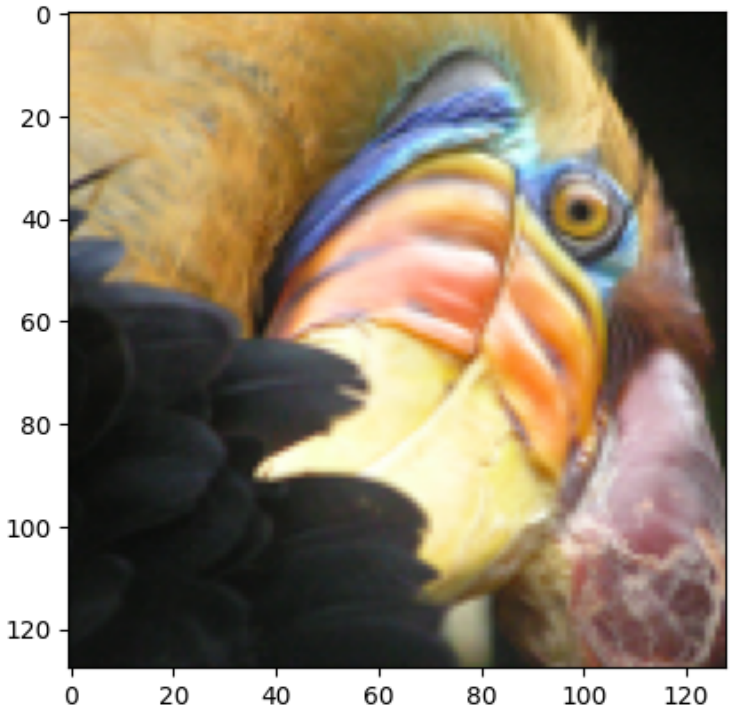
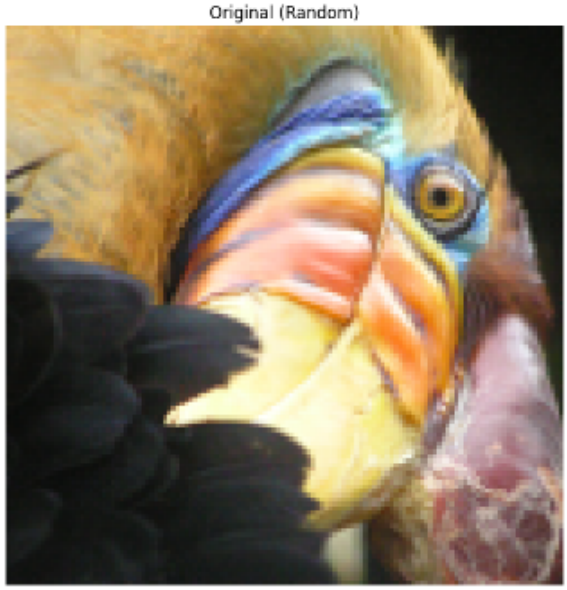
For the original image, I start with a png pic with size of 128*128:



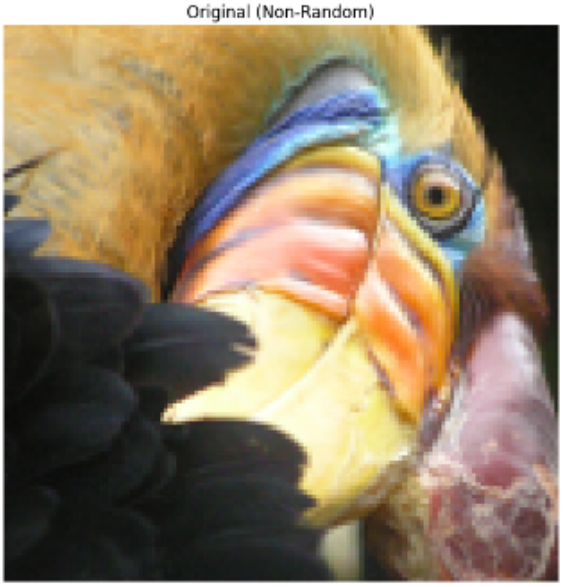
And I start to iterate the K mean list, starting with K =2: below is the reconstructed picture:

Original (Random)



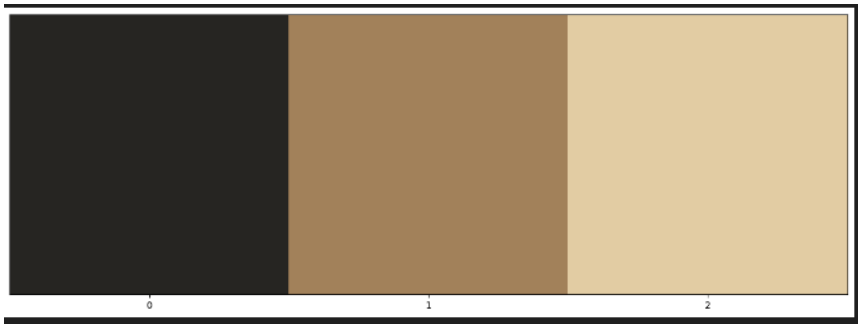
Compressed with 2 colours (Random)

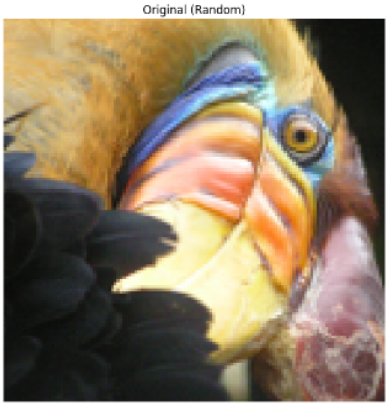
Original (Non-Random)



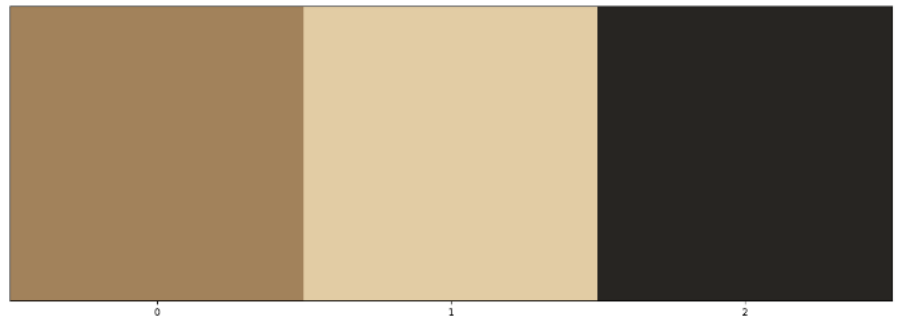
Compressed with 2 colours (Non-Random)

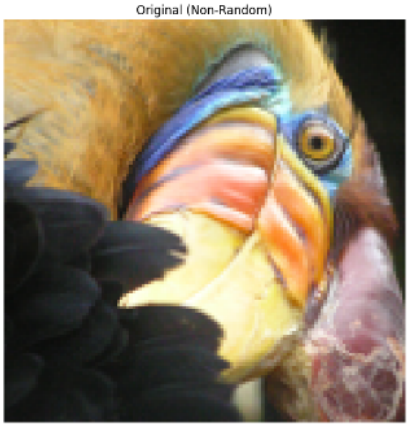
When K =3:


0
1
2


Original (Random)

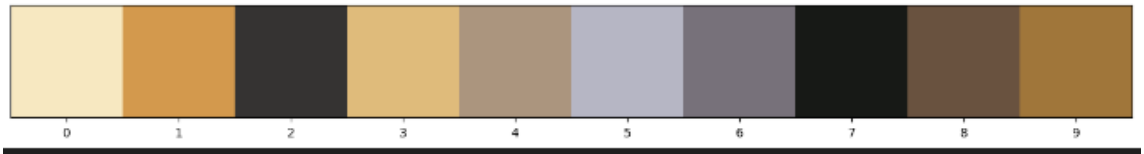

Compressed with 3 colours (Random)

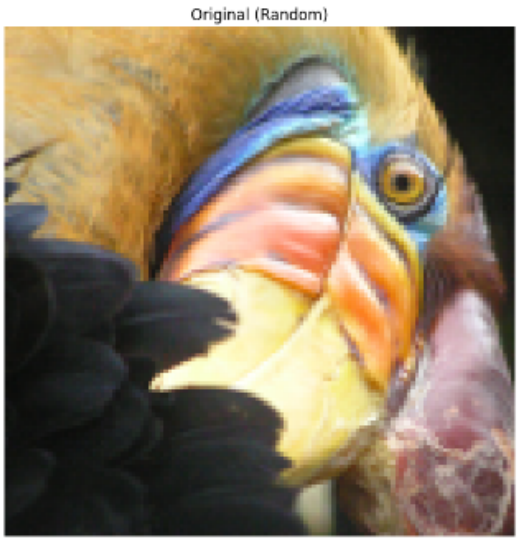

0
1
2


Original (Non-Random)

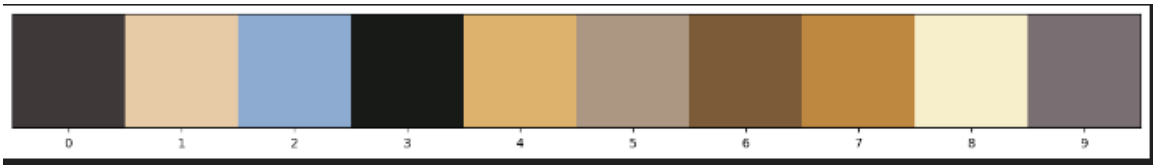

Compressed with 3 colours (Non-Random)

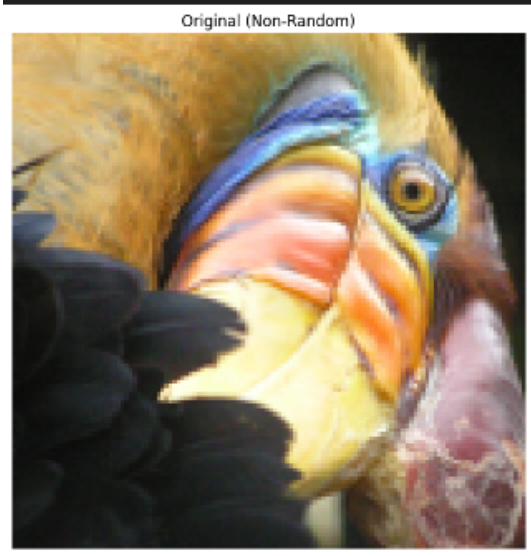
When k =10:

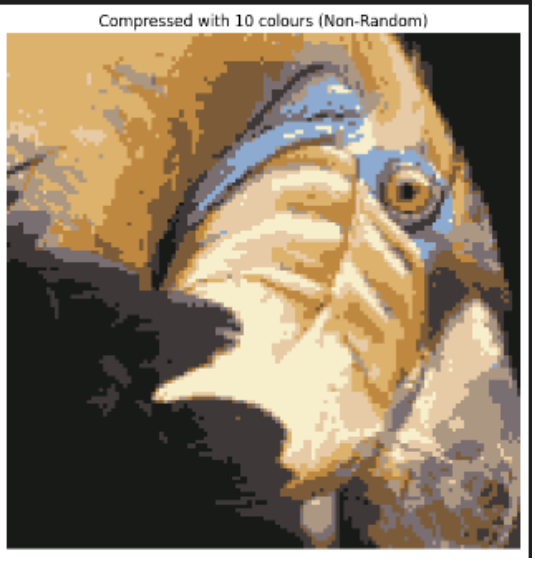

0
1
2
3
4
5
6
7
8
9


Original (Random)


Compressed with 10 colours (Random)


0
1
2
3
4
5
6
7
8
9


Original (Non-Random)

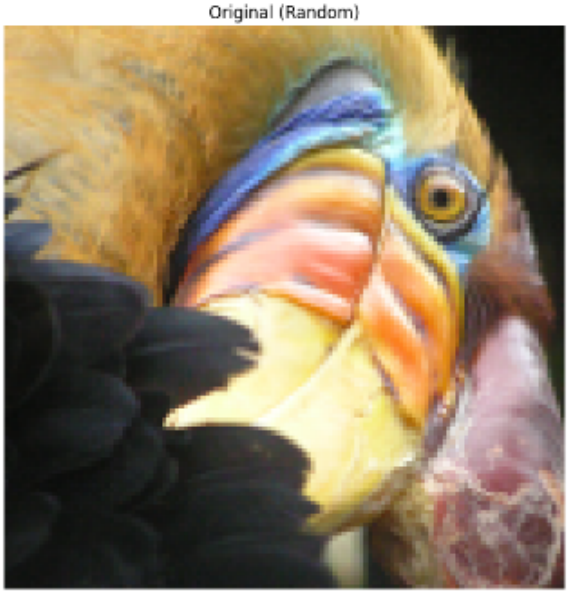

Compressed with 10 colours (Non-Random)

When k =20:


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Original (Random)
Compressed with 20 colours (Random)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Original (Non-Random)
Compressed with 20 colours (Non-Random)

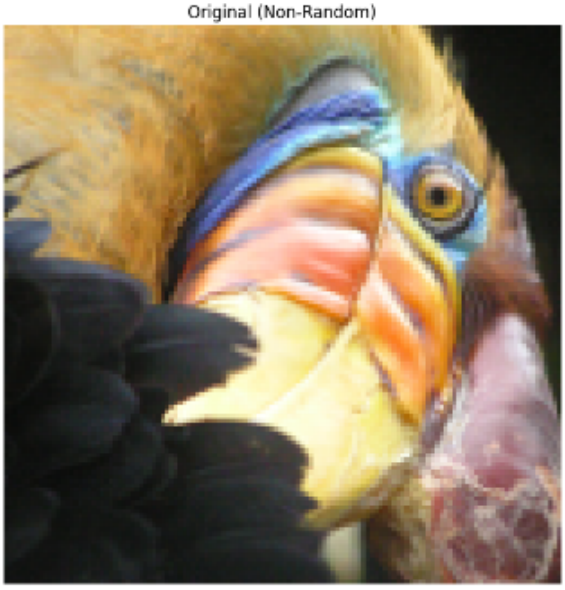
When k=40:

Original (Random)



Compressed with 40 colours (Random)

Original (Non-Random)



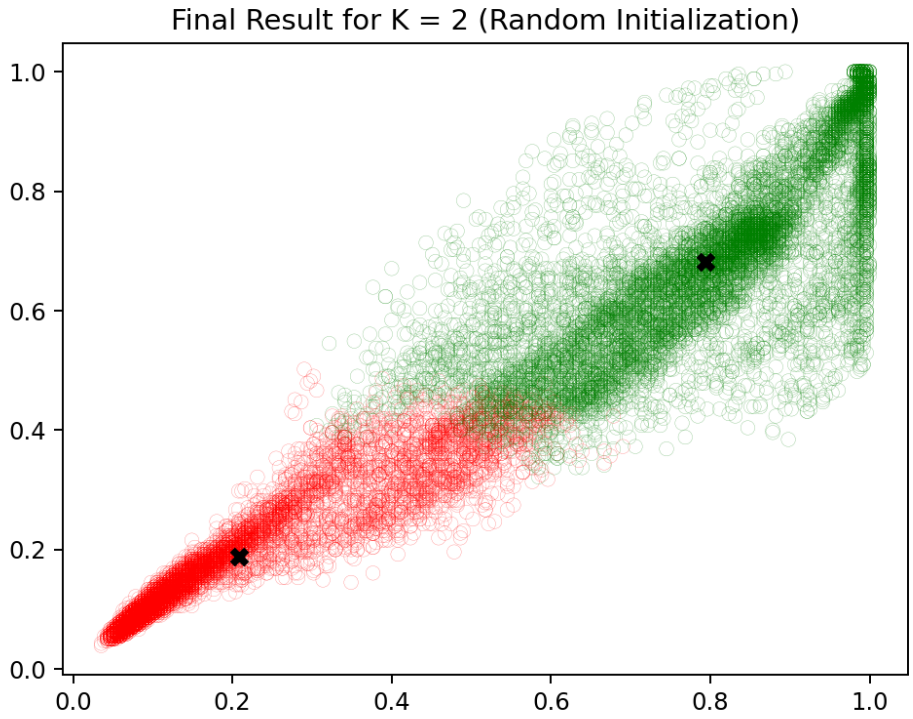
Compressed with 40 colours (Non-Random)

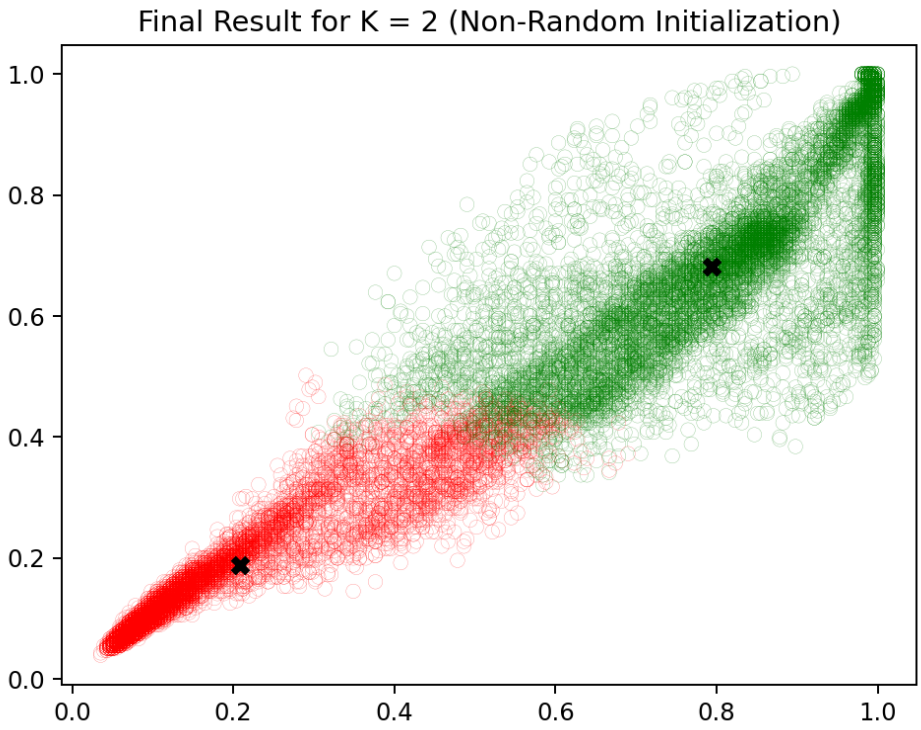
The MSE of each case as below table:

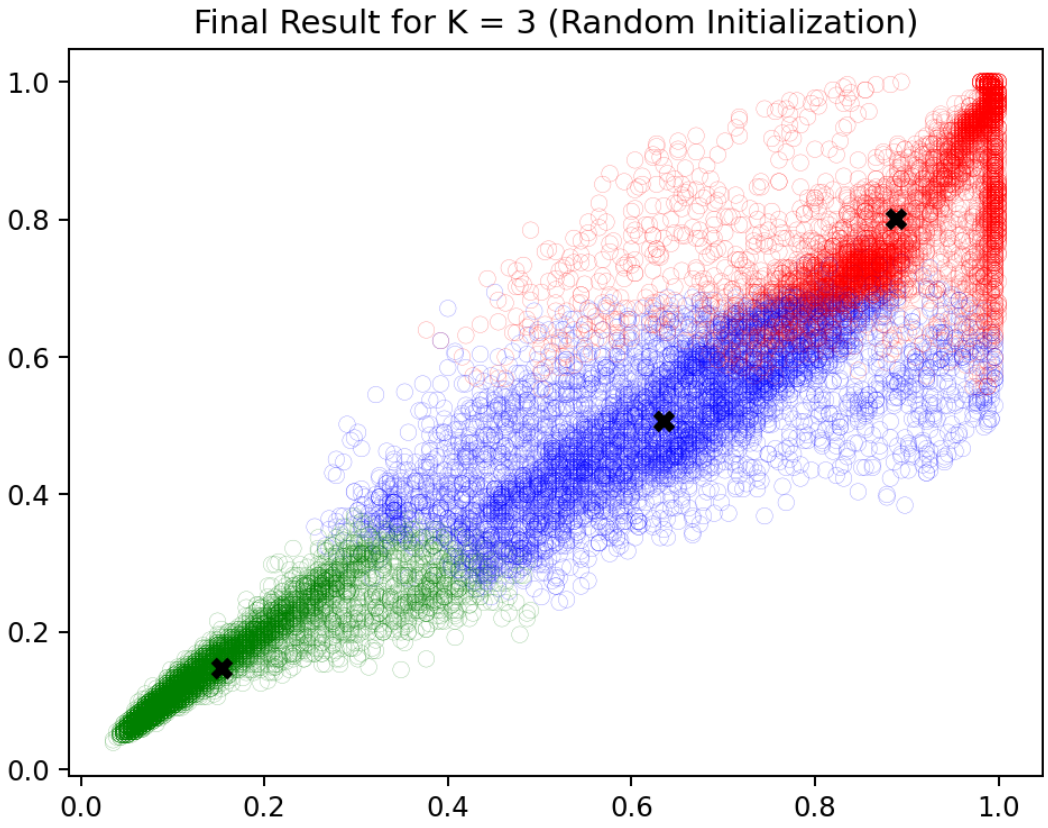
K-values	random MSE	non-random MSE
2	0.02320592852	0.02320592852
3	0.01329816489	0.01329834321
10	0.003864533876	0.003825596006
20	0.002007256859	0.001960307905
40	0.001106723479	0.001104954227

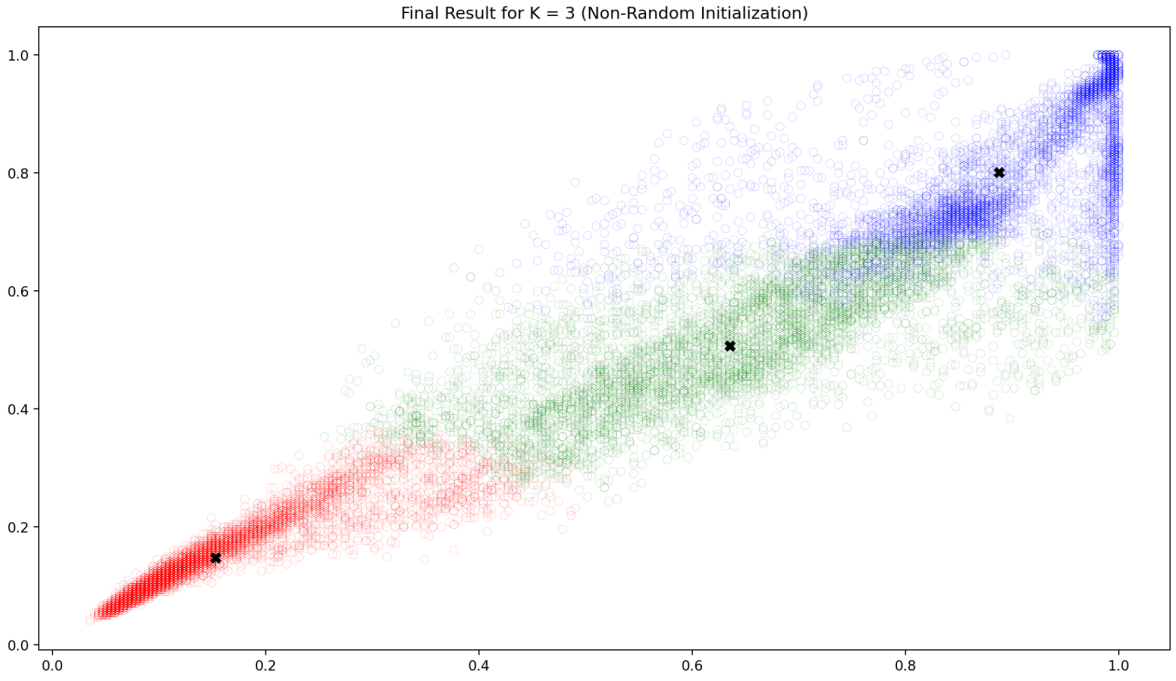
As we can see, the non-random initialization generally has lower MSE compared to random initialization when the K value increases. When the K value is small, random or non random does not lead to a big difference.

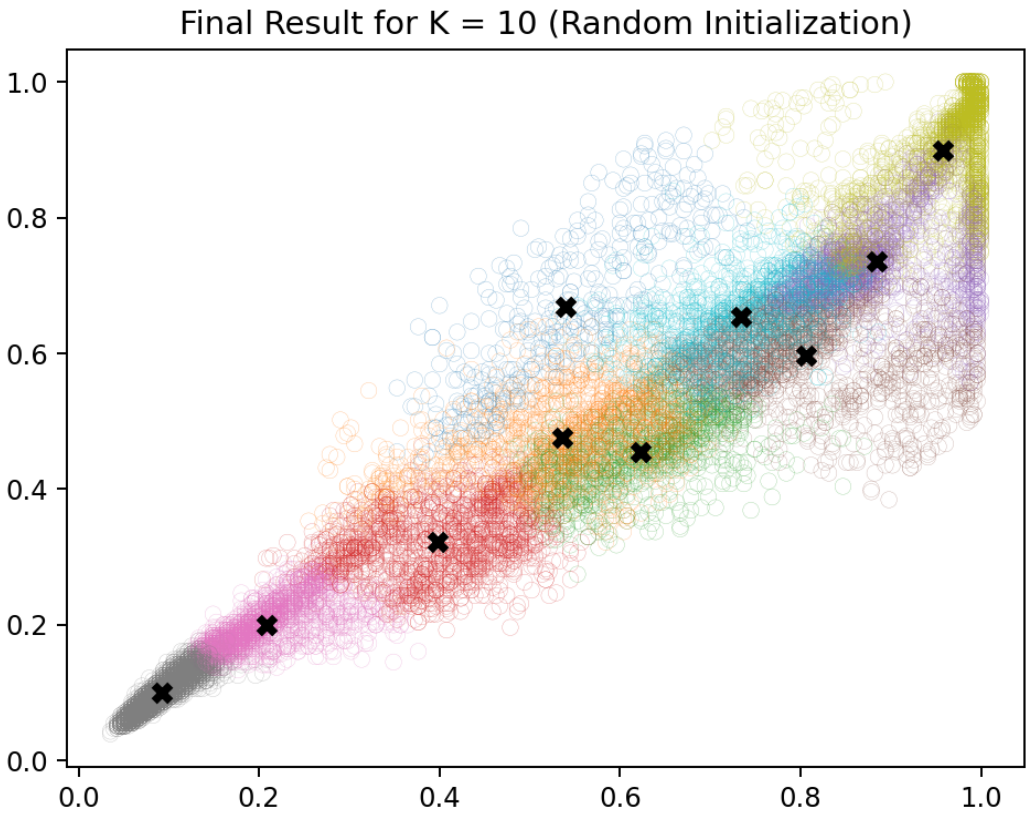
Below is a scatter illustration of the K means color choice:

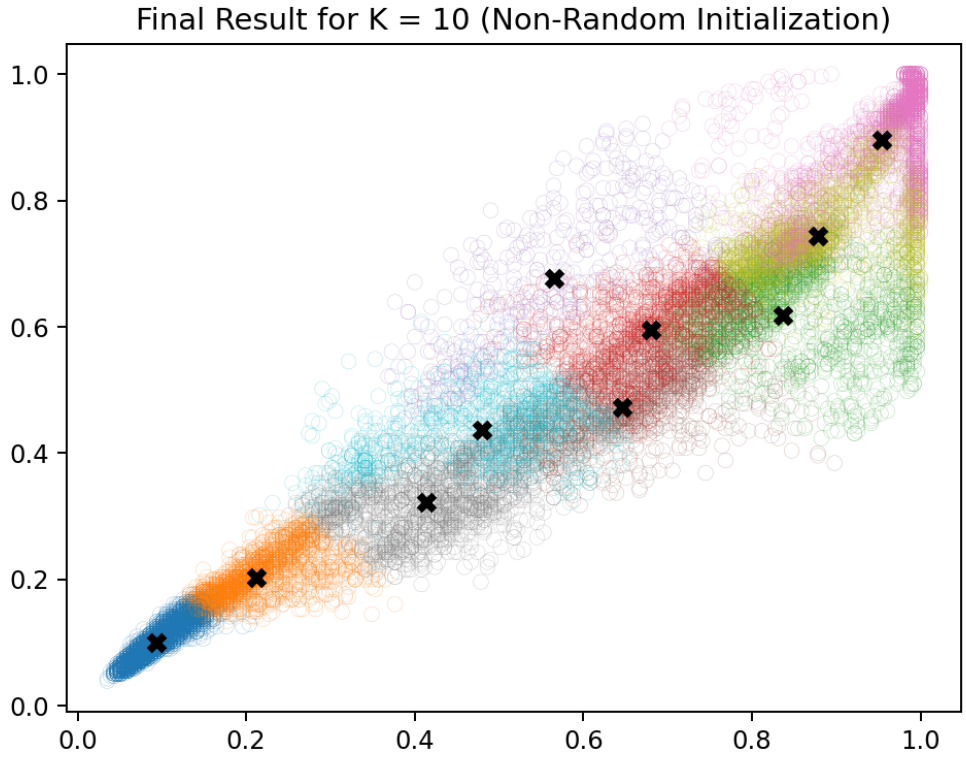

Final Result for K = 2 (Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

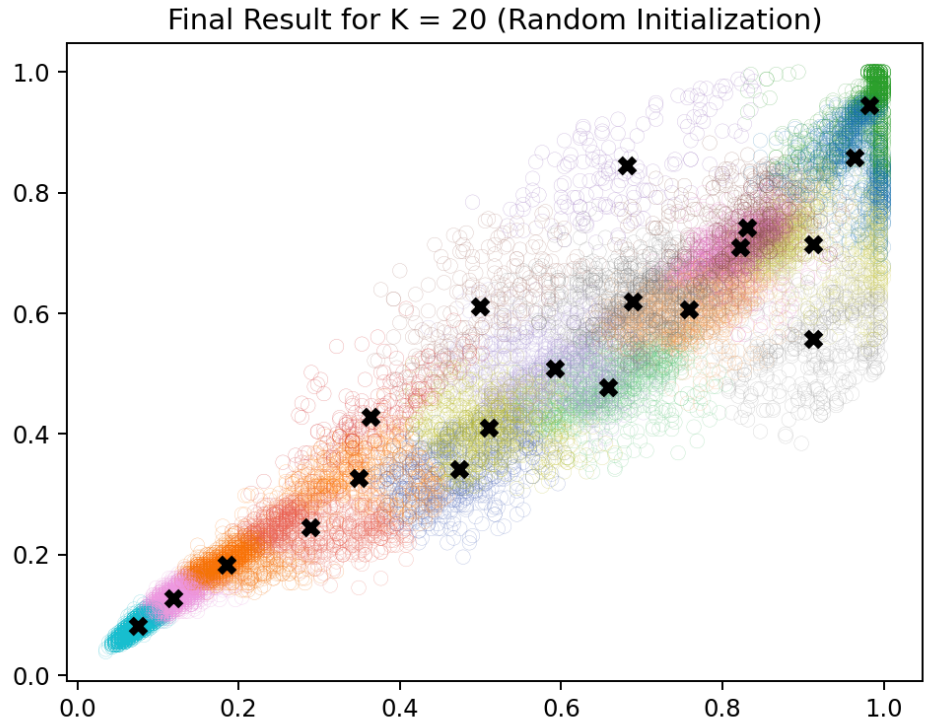

Final Result for K = 2 (Non-Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

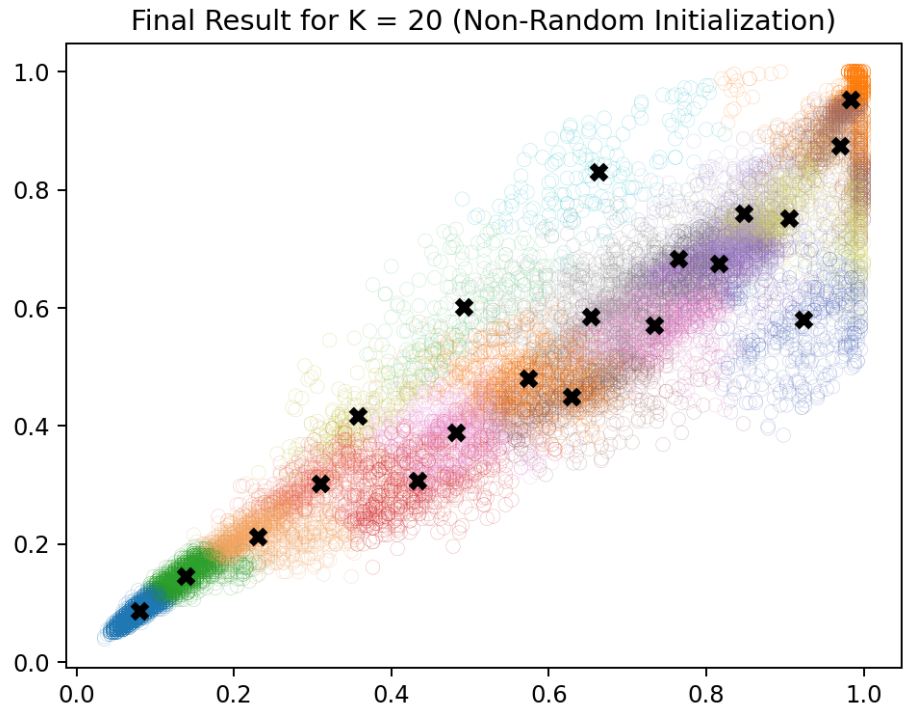

Final Result for K = 3 (Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

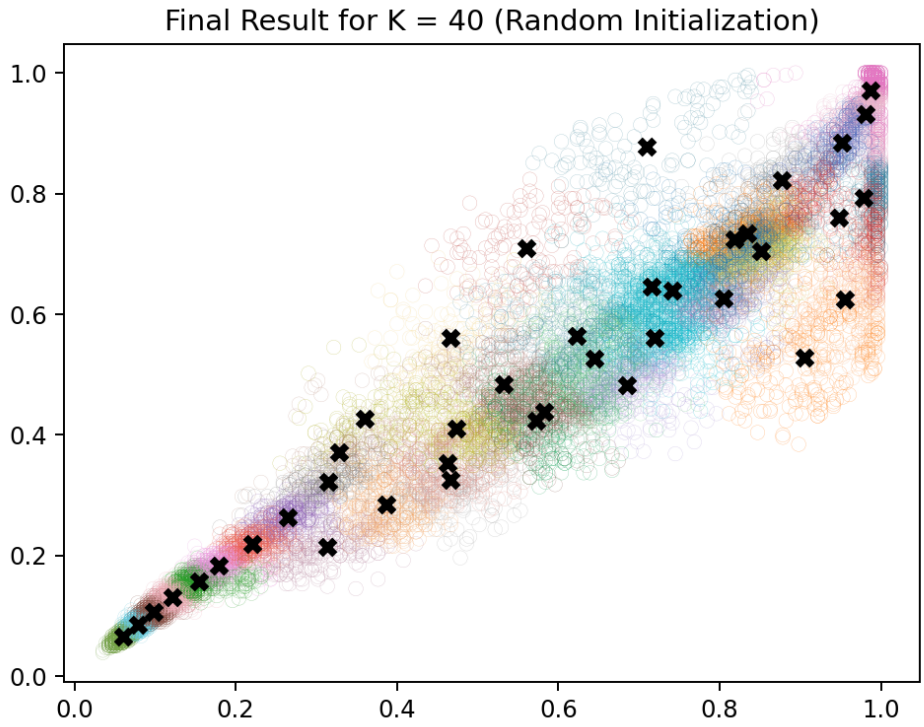

Final Result for K = 3 (Non-Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

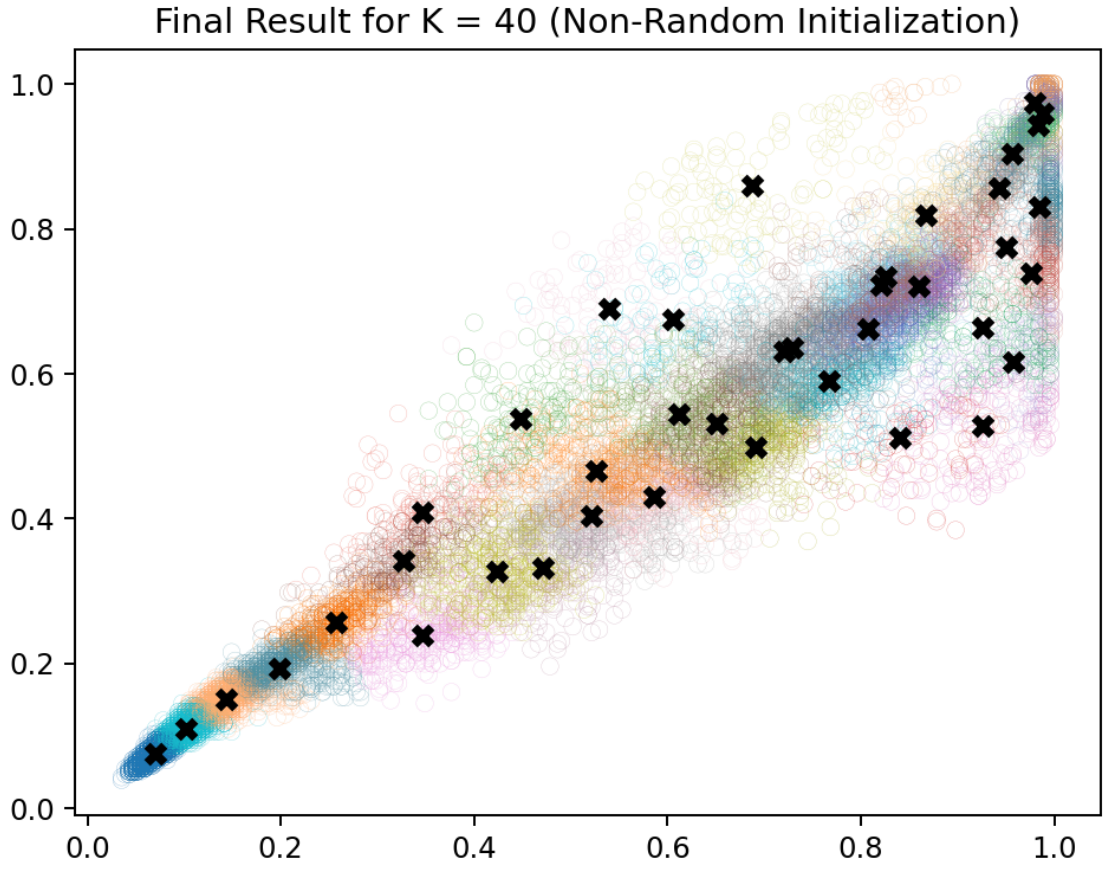

Final Result for K = 10 (Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Final Result for K = 10 (Non-Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Final Result for K = 20 (Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Final Result for K = 20 (Non-Random Initialization)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Final Result for K = 40 (Random Initialization)
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0


Final Result for K = 40 (Non-Random Initialization)
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0

Conclusion:

As evident from the Mean Squared Error (MSE) table and the final results presented above, increasing the value of K does not consistently enhance the image quality as anticipated. Notably, when K is increased from 20 to 40, the image quality does not exhibit a twofold improvement. However, the processing time required for the code increases by more than twice compared to the processing time when K is set to 20.

For K equal to 2, the results are identical in both MSE and visual quality.

When K is 3, random initialization performs better in terms of MSE, while the visual quality remains similar.

Conversely, for K equal to 10, non-random initialization yields better MSE results, and the visual quality appears more saturated, which is preferable to my eyes.

As K increases to 20 and 40, non-random initialization consistently produces better MSE results, and the visual quality remains closely comparable between the two initialization methods.

In summary, a moderately sized K and non-random initialization seem to yield satisfactory results. While larger K values contribute to improved image quality, the incremental gains diminish. It's worth noting that a smaller MSE does not always translate to a more aesthetically pleasing visual reconstruction, as demonstrated in the cases of K equal to 20 and 40, where both images appear visually appealing.