Ahmet Furkan Bıyık 23.11.2019
21501084
CS 484
Homework 2

1. Local Features

1.1. Gradient-Based Descriptors

1.1.1. Africa

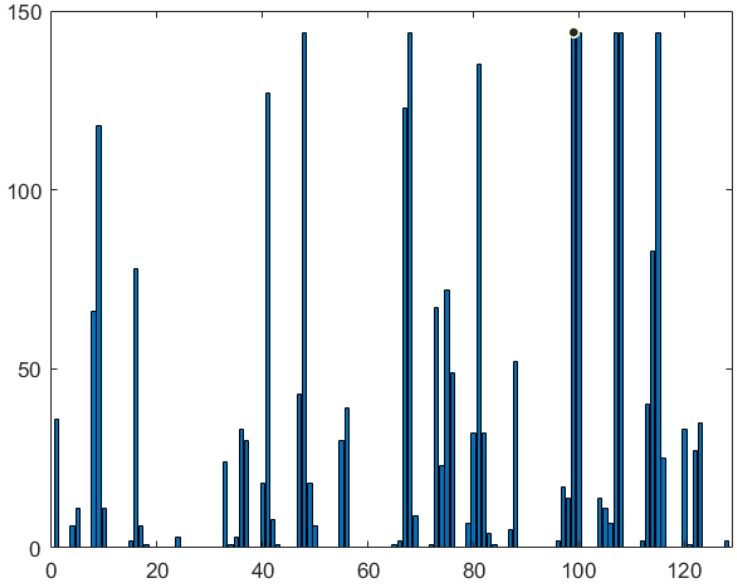


Figure 1: 0.jpg feature 1

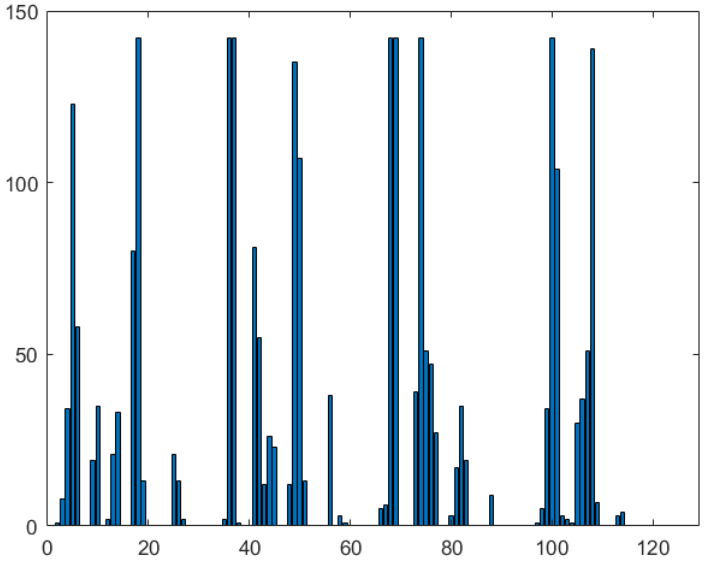
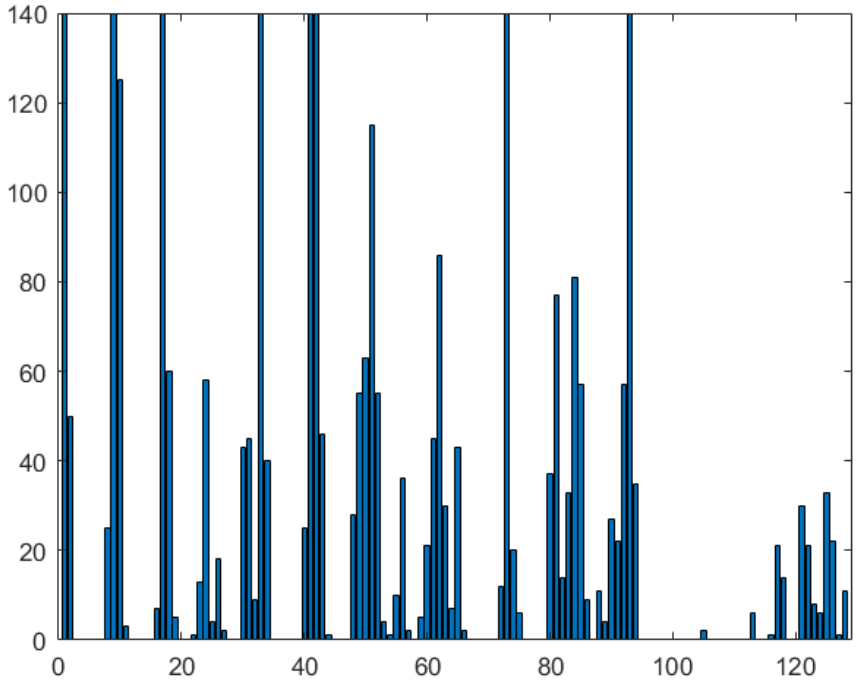


Figure 2: 0.jpg feature 2

1.1.2. Beach



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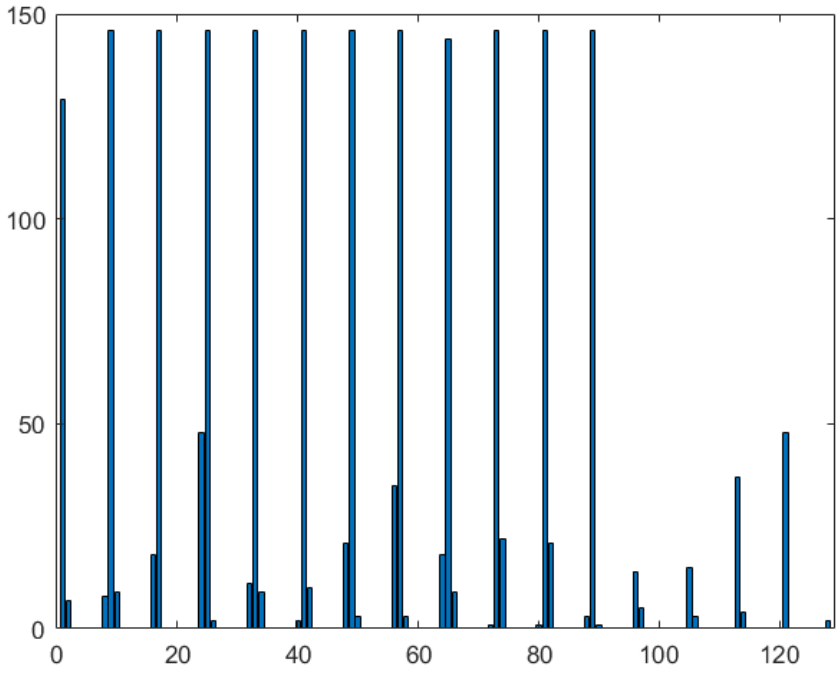
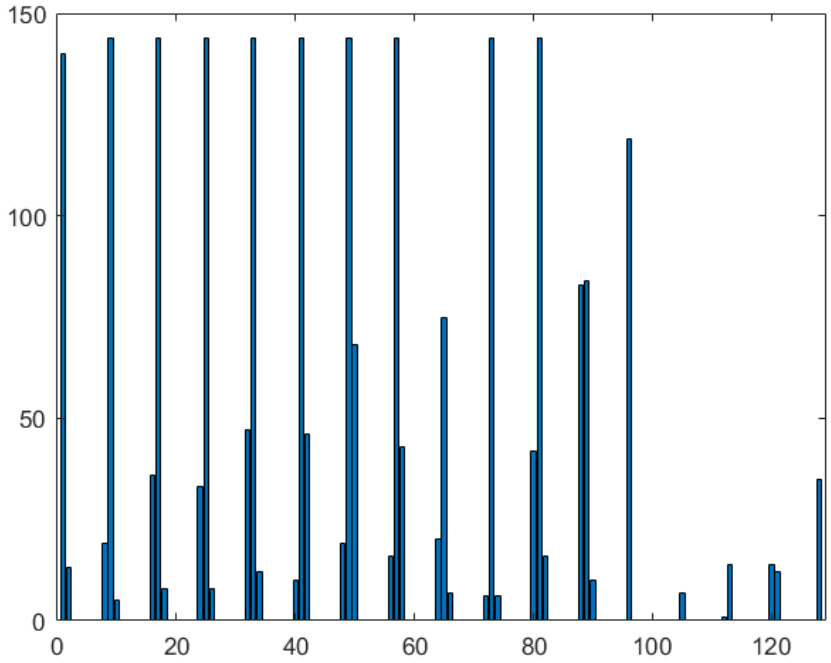


Figure 4: 111.jpg feature 2

1.1.3. Buildings



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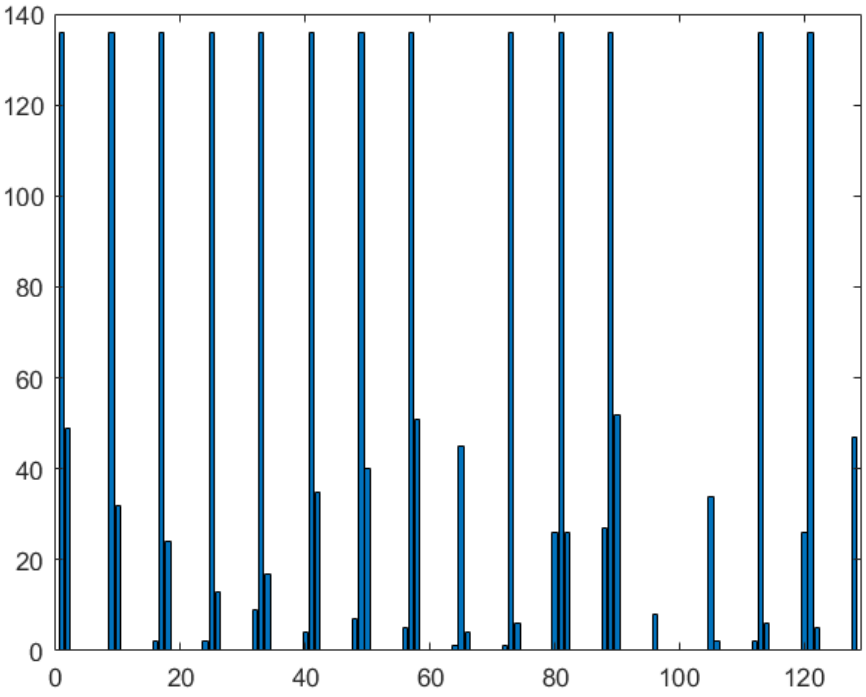

Figure 6: 224.jpg feature 2

1.1.4. Buses

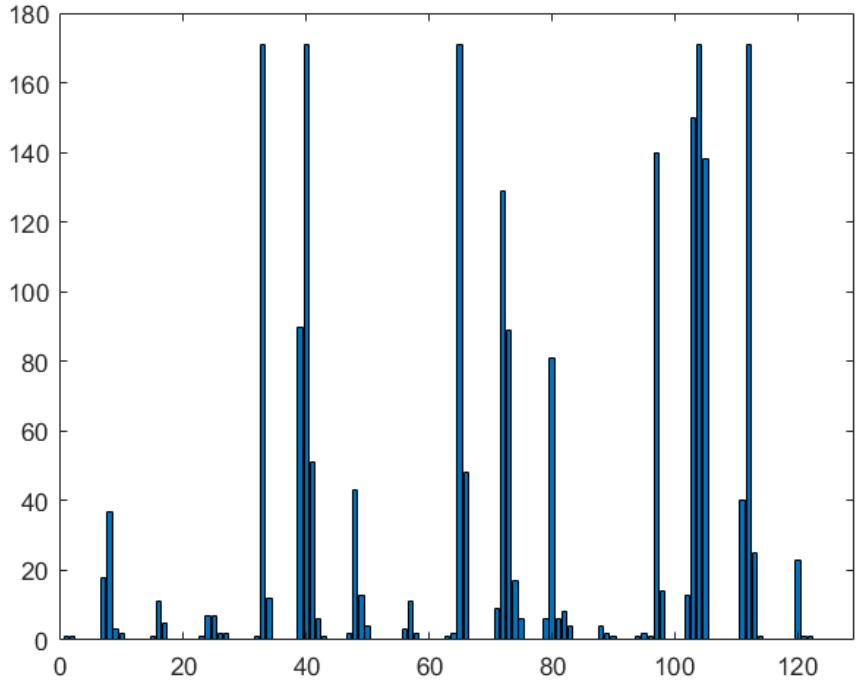

Figure 7: 335.jpg feature 1

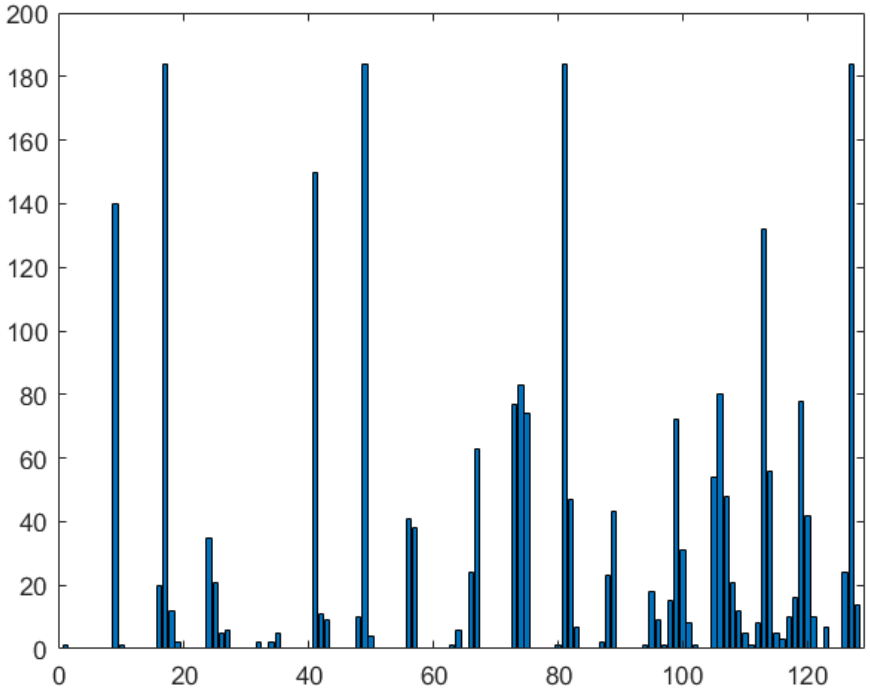

Figure 8: 335.jpg feature 2

1.1.5. Dinosaurs

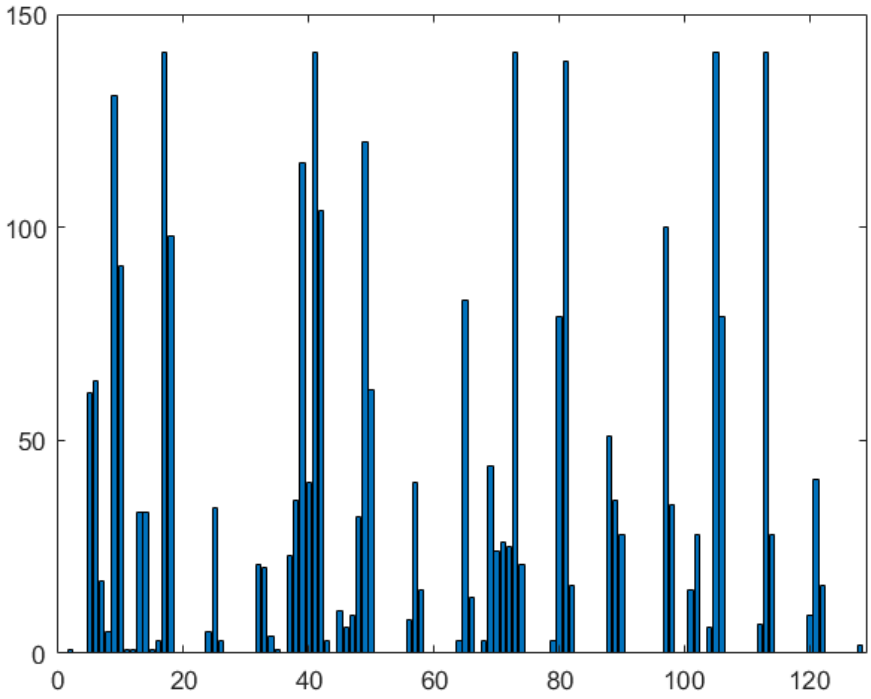

Figure 9: 448.jpg feature 1

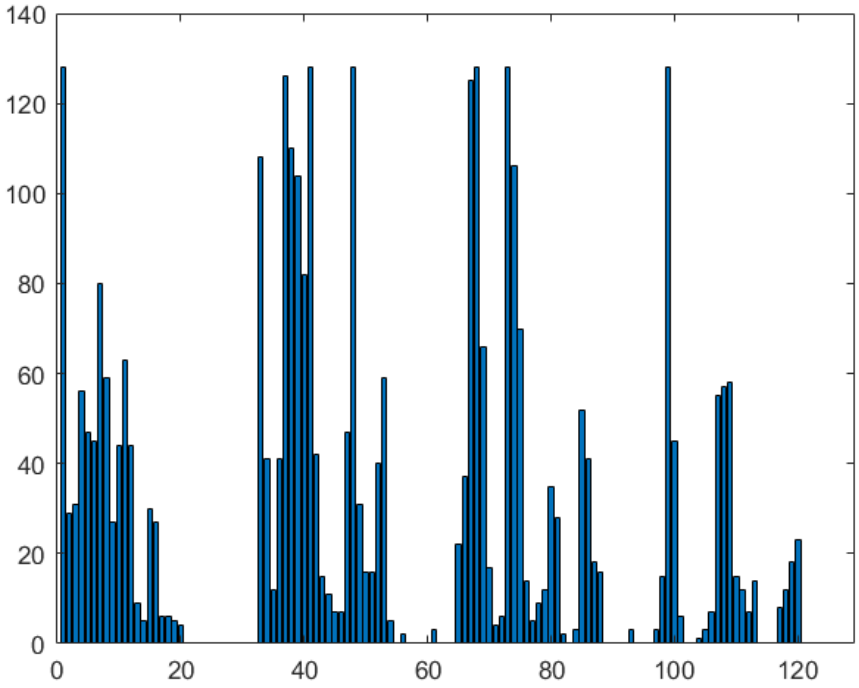

Figure 10: 448.jpg feature 2

1.1.6. Elephants

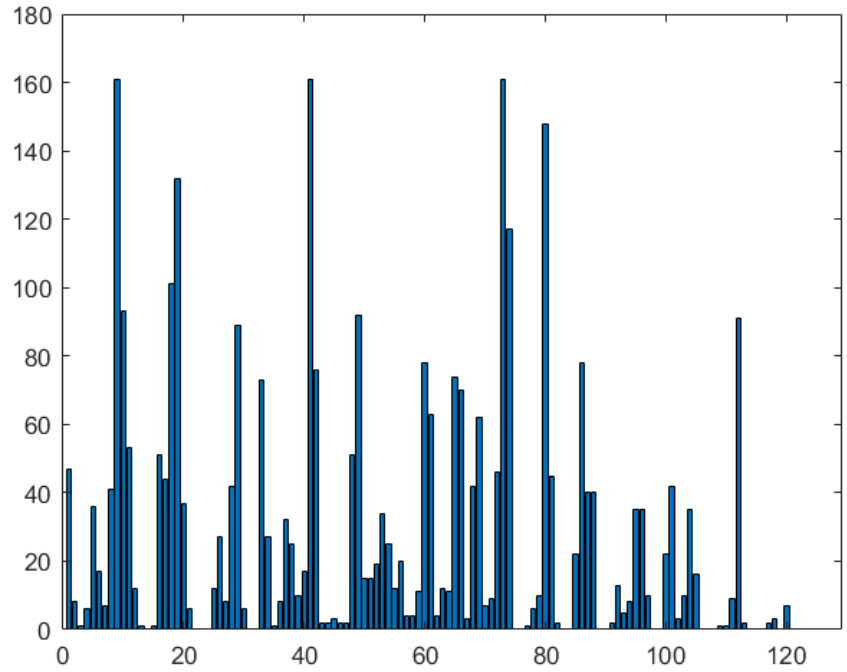

Figure 11: 557.jpg feature 1

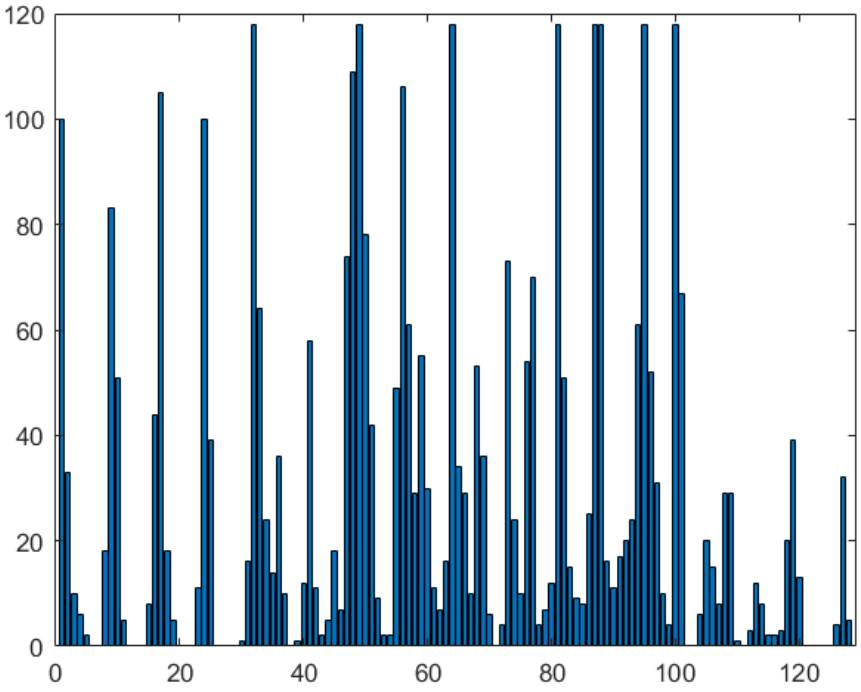

Figure 12: 557.jpg feature 2

1.1.7. Flowers

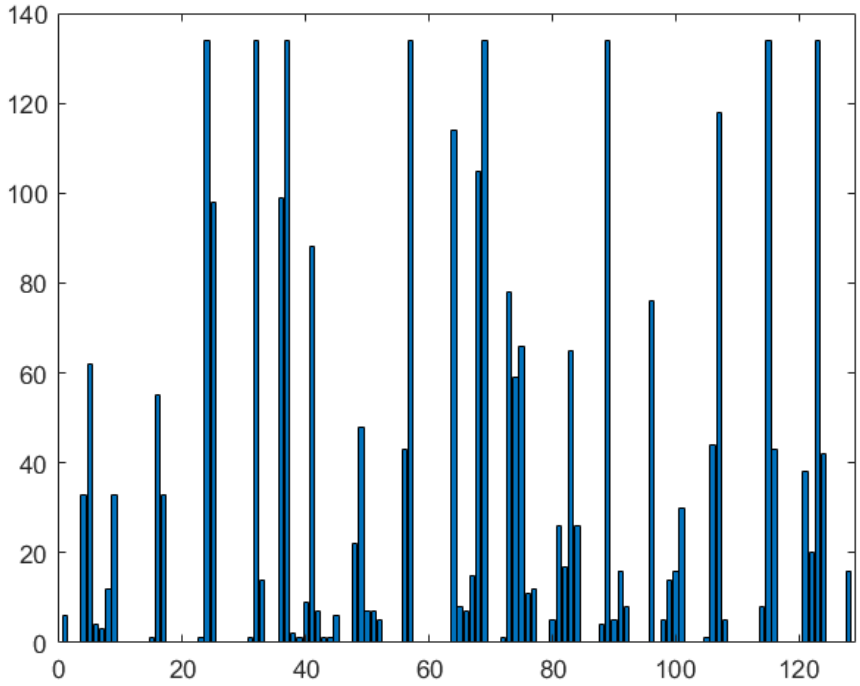

Figure 13: 667.jpg feature 1

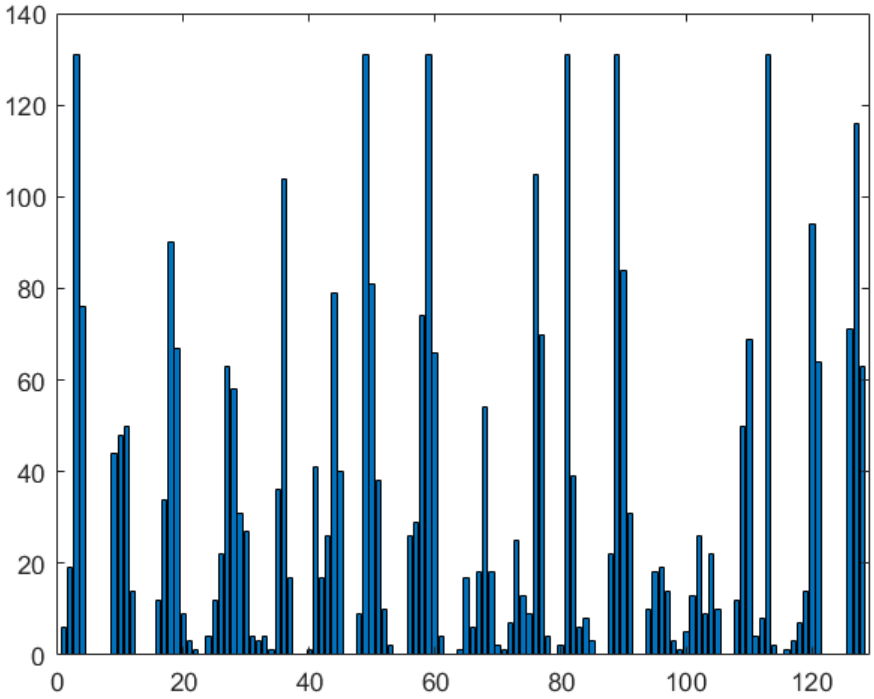

Figure 14: 667.jpg feature 2

1.1.8. Horses

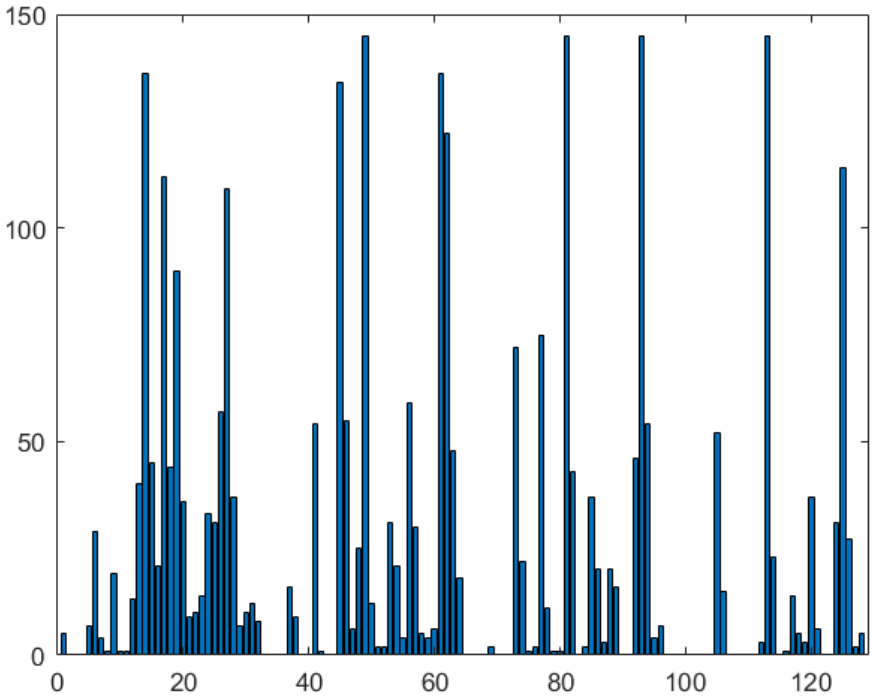

Figure 15: 733.jpg feature 1

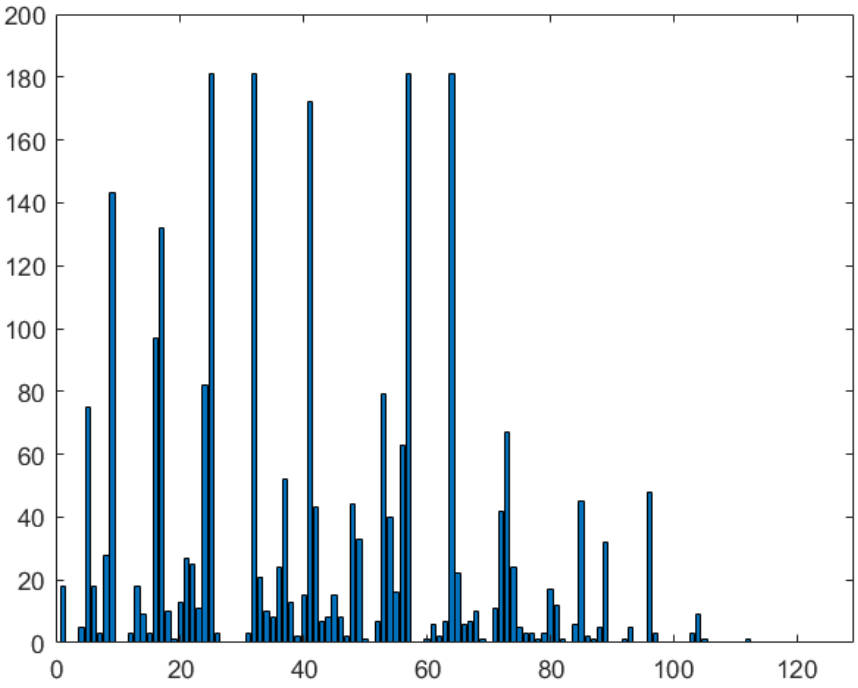

Figure 16: 733.jpg feature 2

1.1.9. Mountains

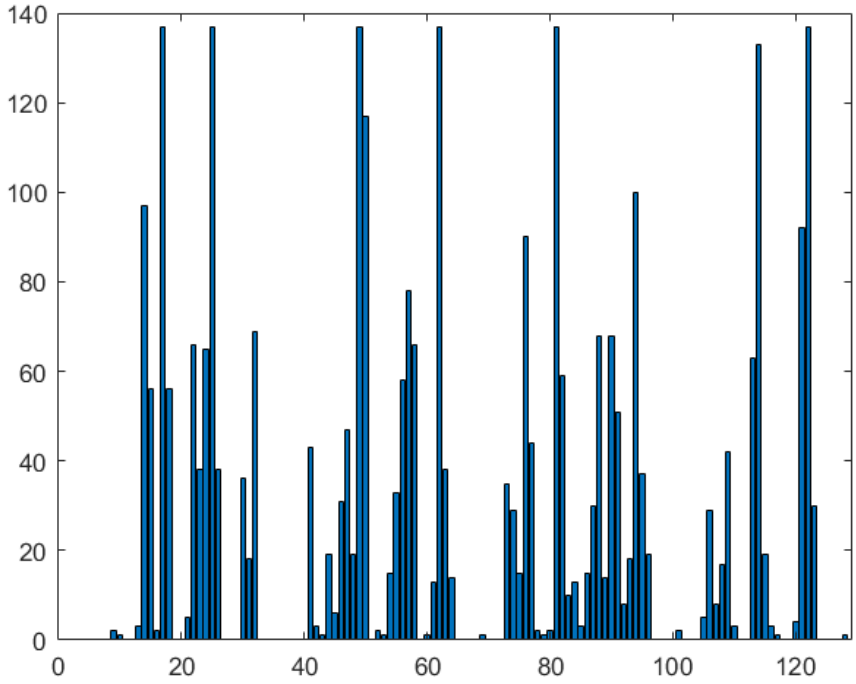

Figure 17: 804.jpg feature 1

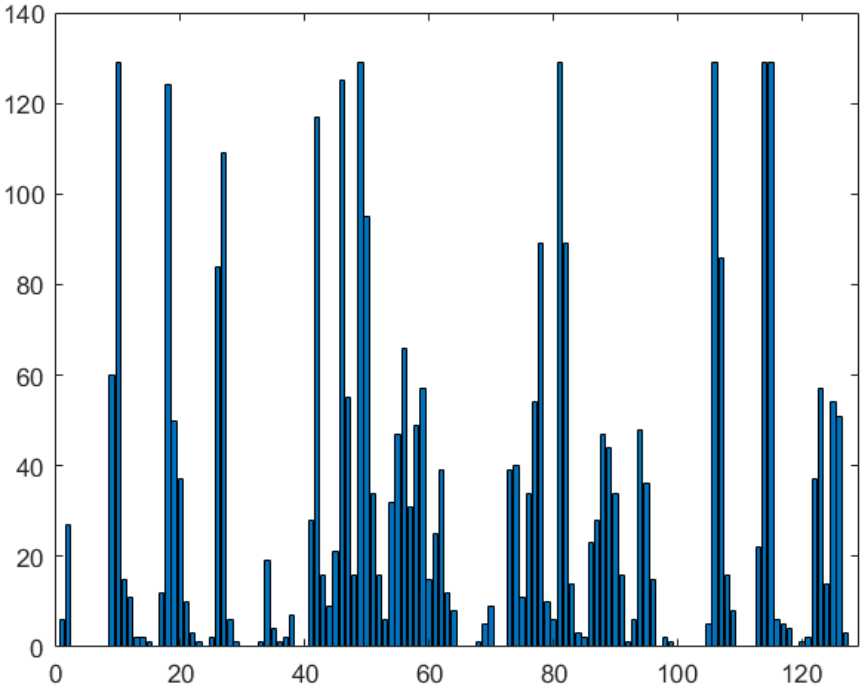

Figure 18: 804.jpg feature 2

1.1.10. Food

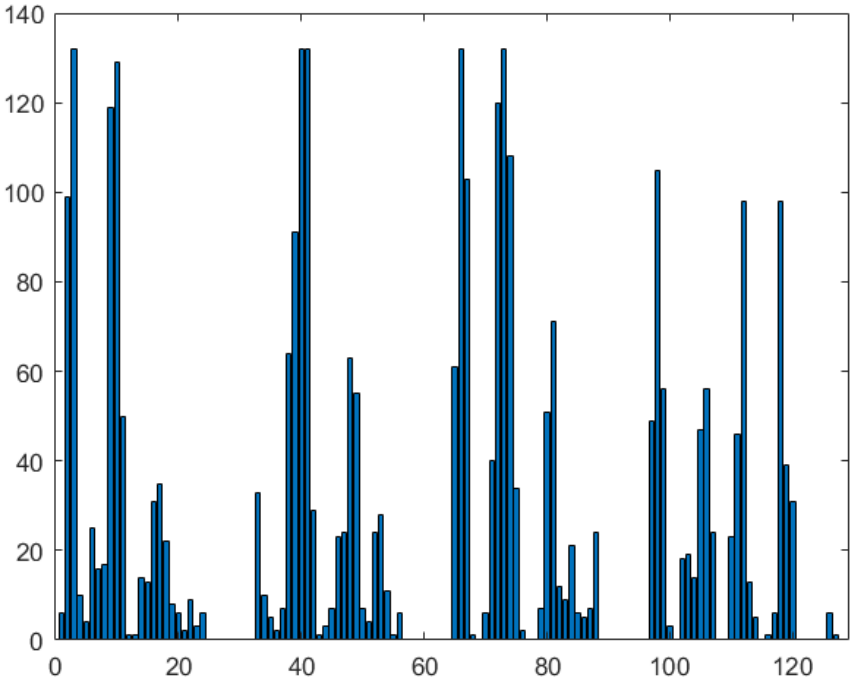

Figure 19: 923.jpg feature 1

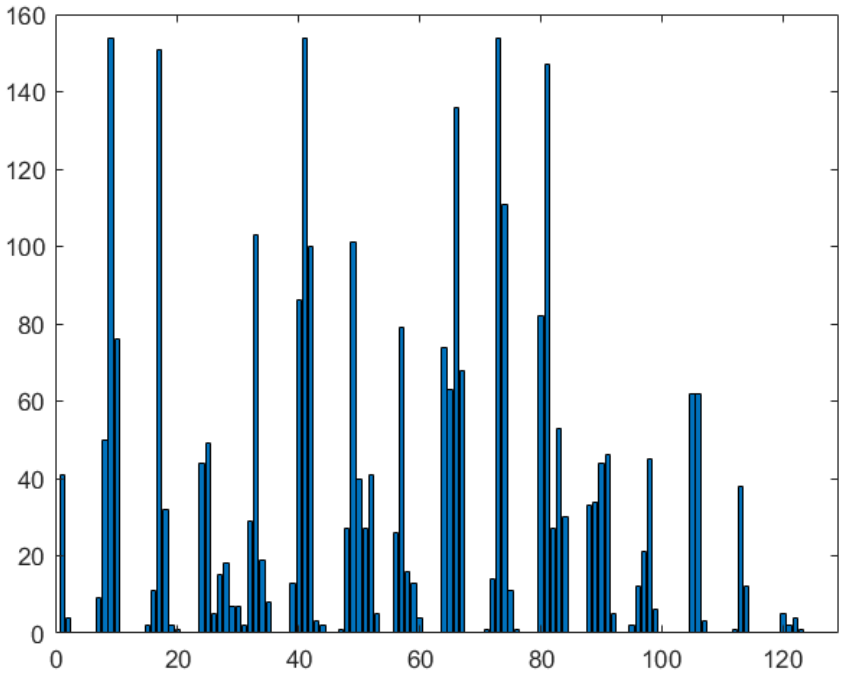

Figure 20: 923.jpg feature 2

1.2 Color Based Descriptors

1.2.1. Africa

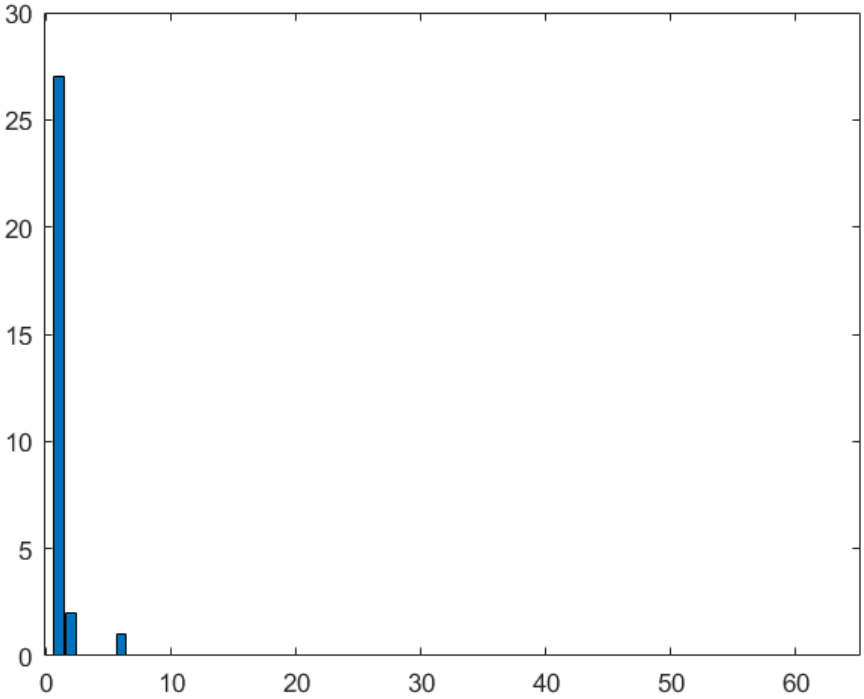

Figure 21: 0.jpg feature 1

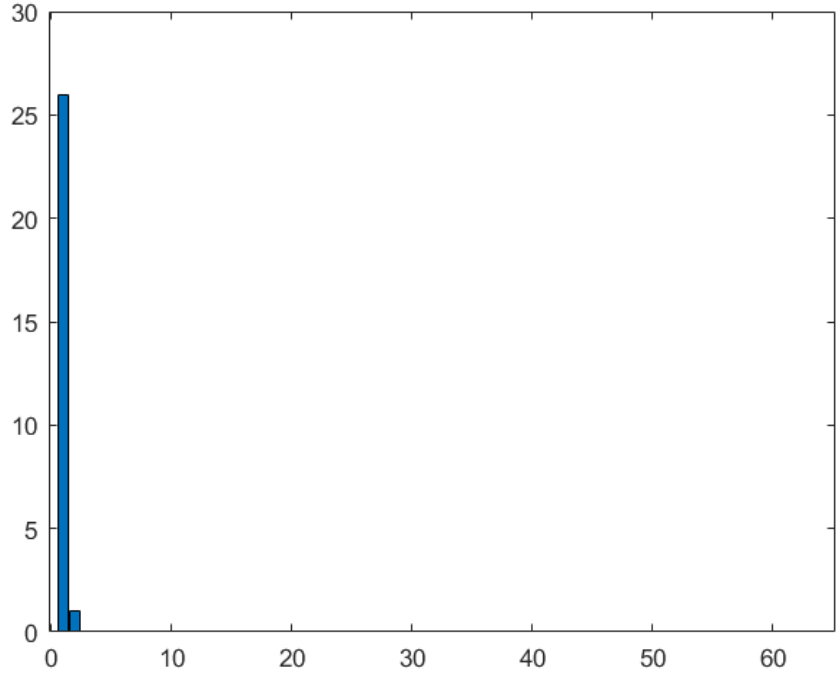

Figure 22: 0.jpg feature 2

1.2.2. Beach

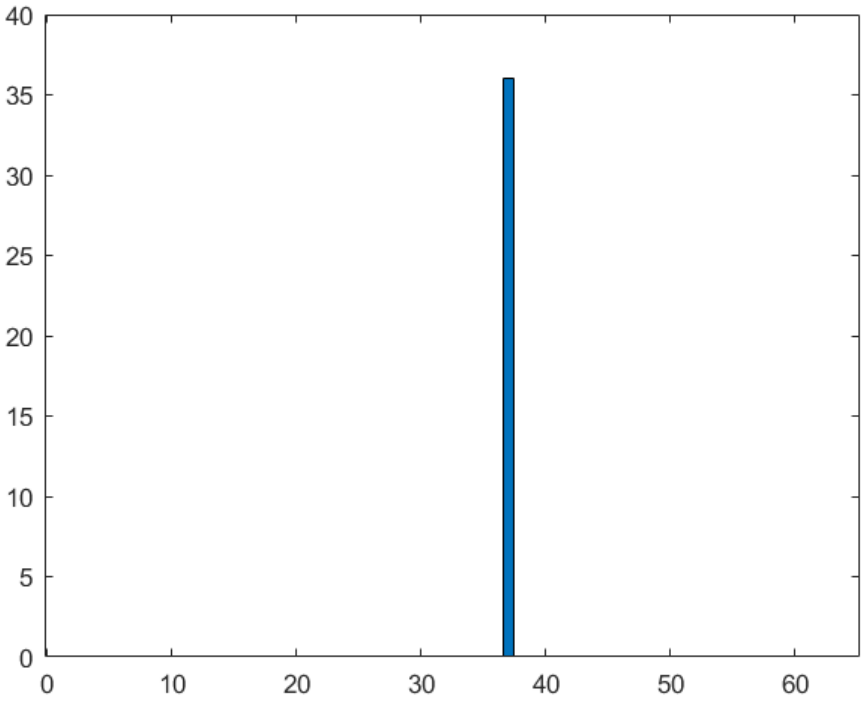

Figure 23: 111.jpg feature 1

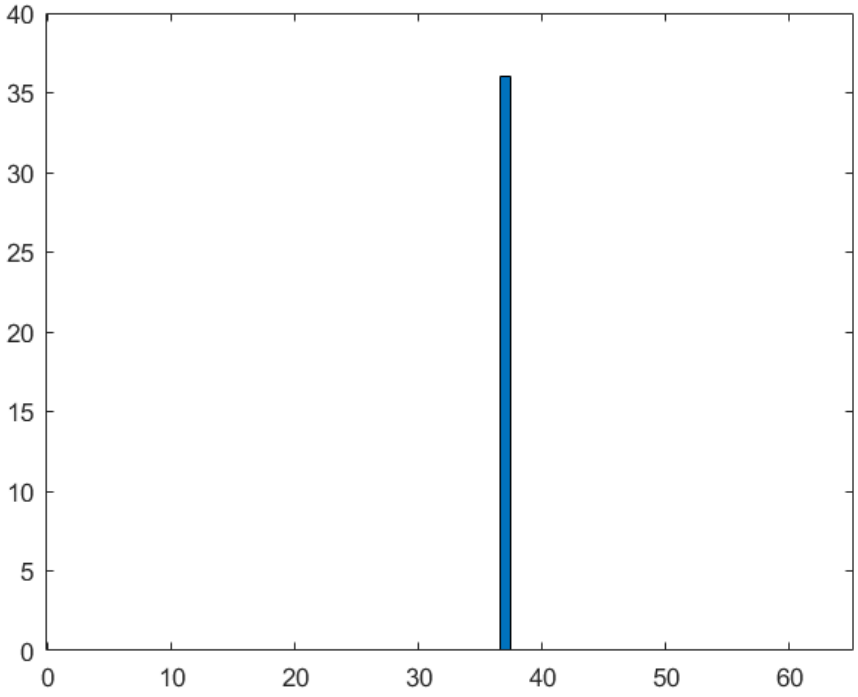

Figure 24: 111.jpg feature 2

1.2.3. Buildings

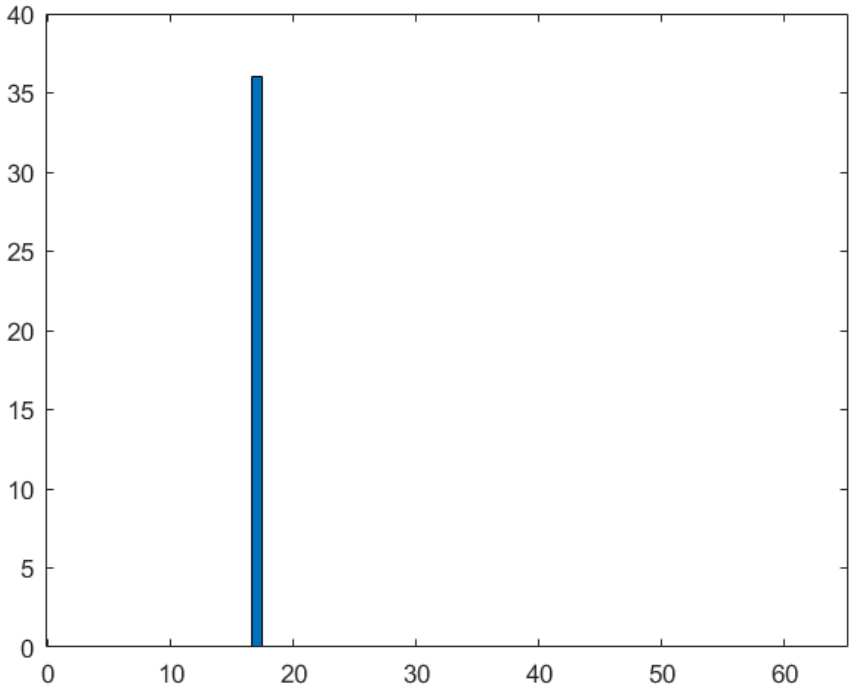

Figure 25: 224.jpg feature 1

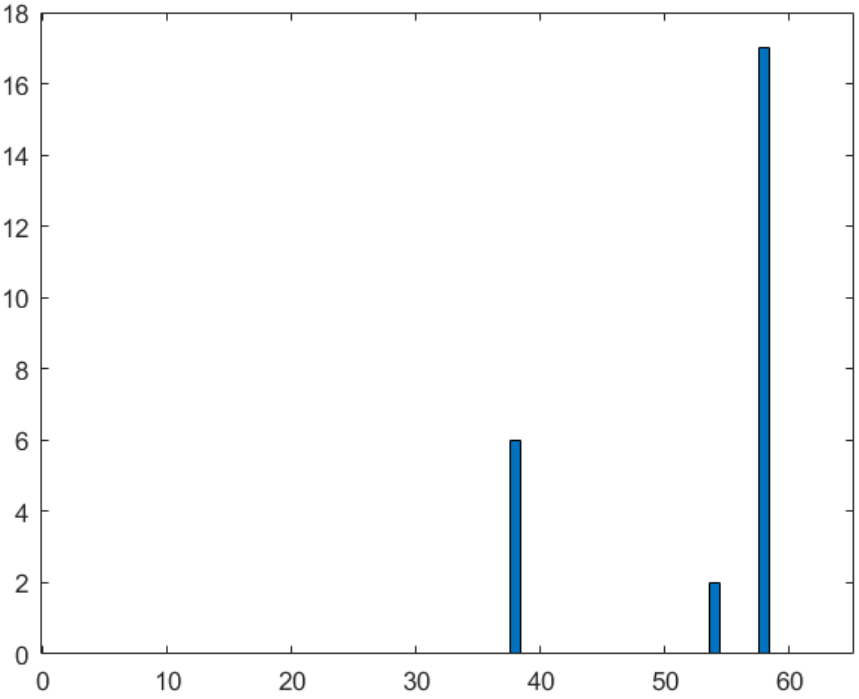

Figure 26: 224.jpg feature 2

1.2.4. Buses

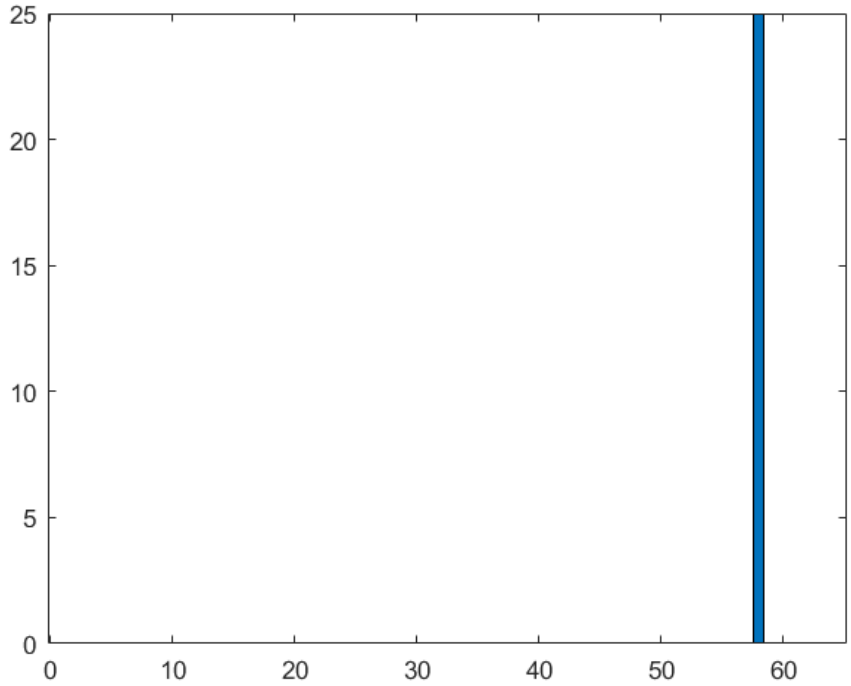

Figure 27: 335.jpg feature 1

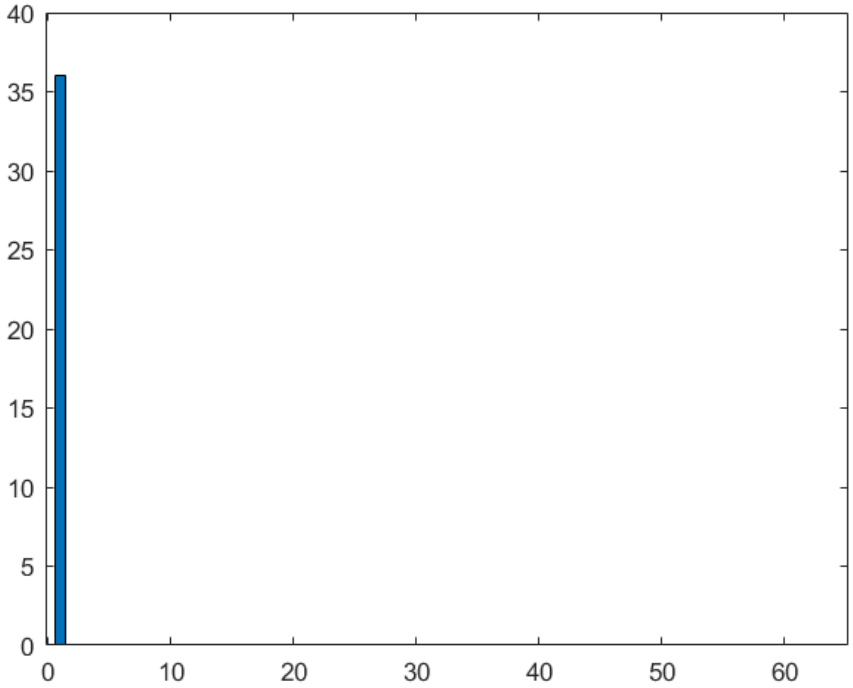

Figure 28: 335.jpg feature 2

1.2.5. Dinosaurs

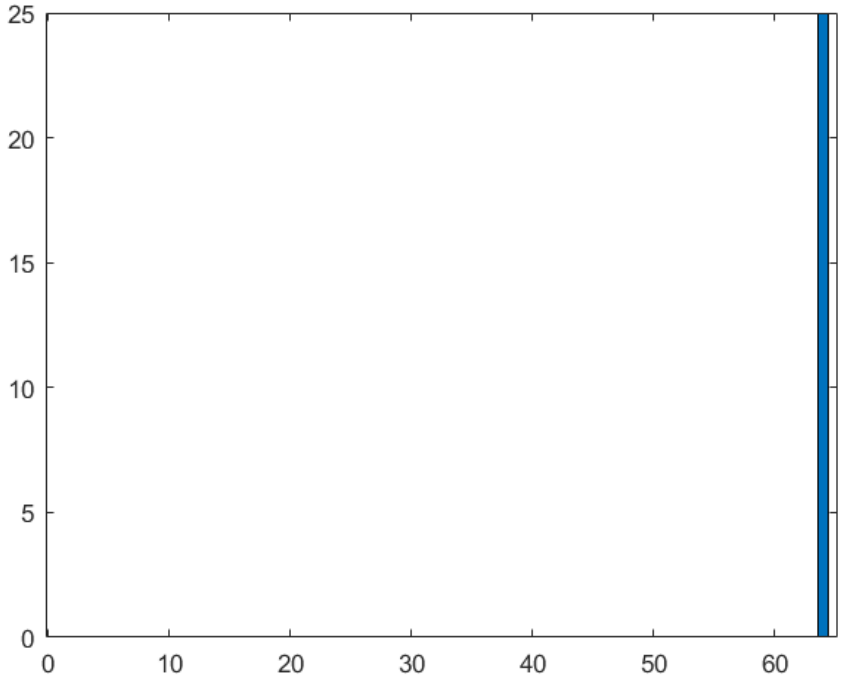

Figure 29: 448.jpg feature 1

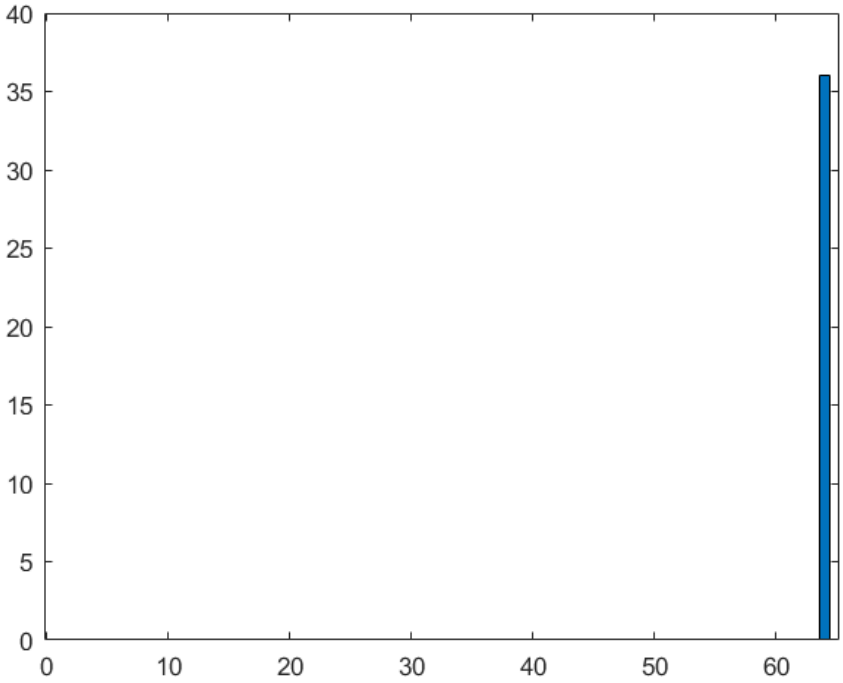

Figure 30: 448.jpg feature 2

1.2.6. Elephants

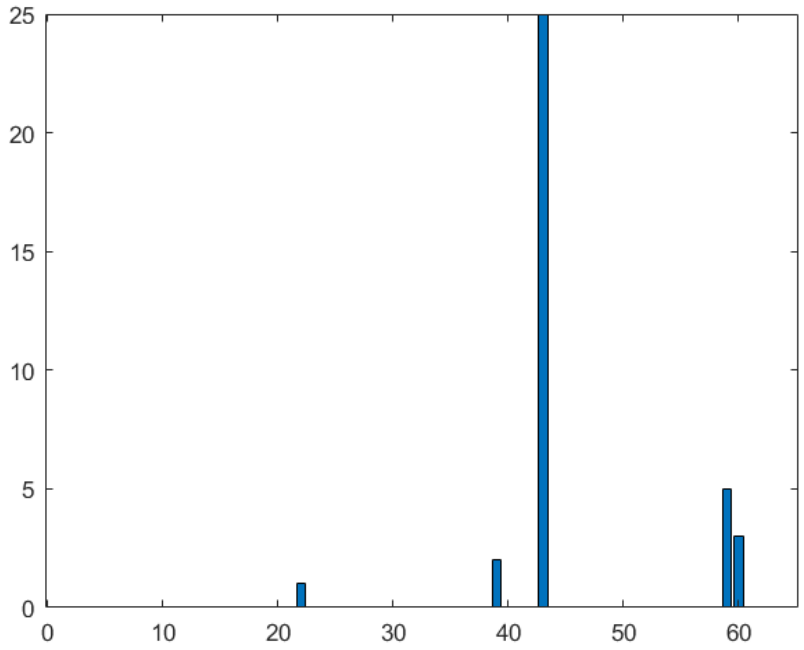

Figure 31: 557.jpg feature 1

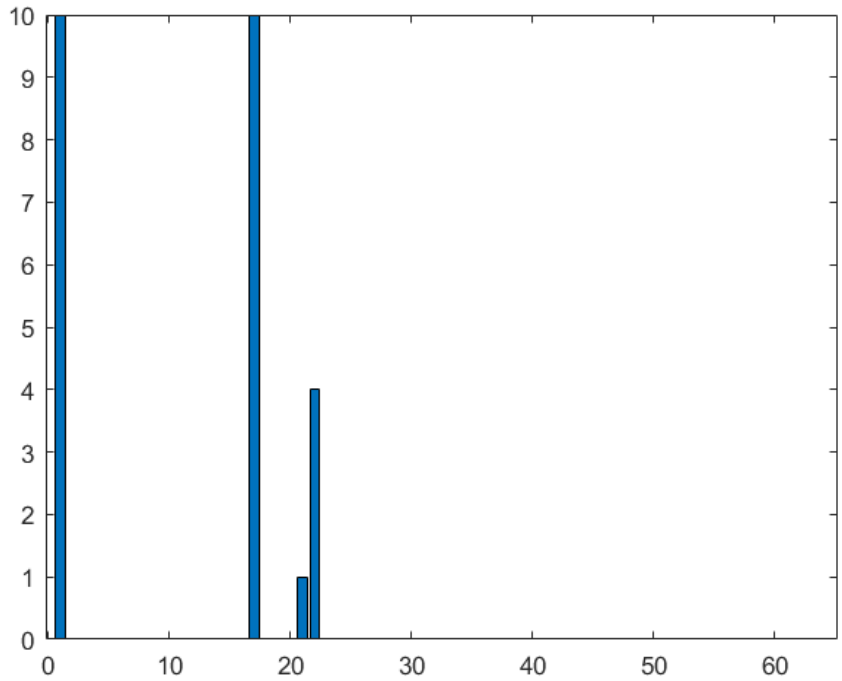

Figure 32: 557.jpg feature 2

1.2.7. Flowers

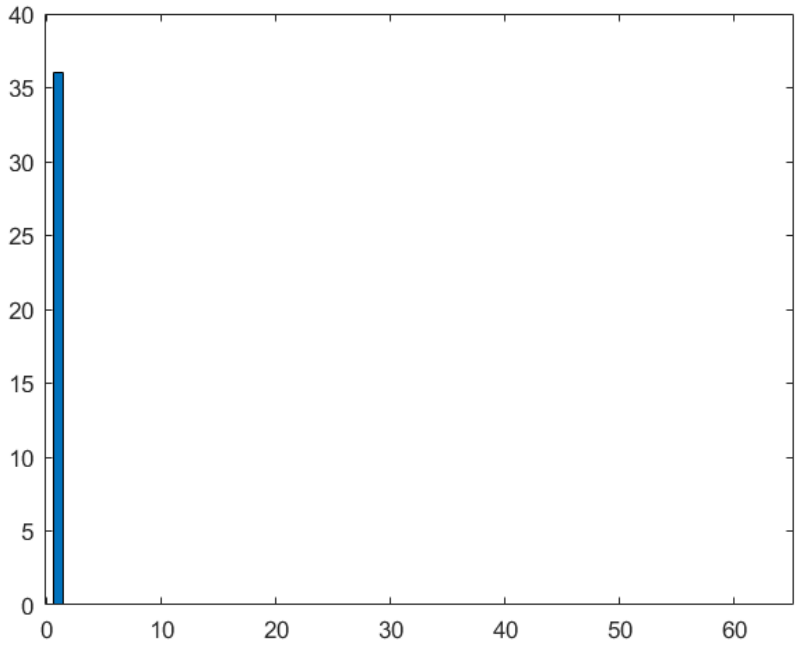

Figure 33: 667.jpg feature 1

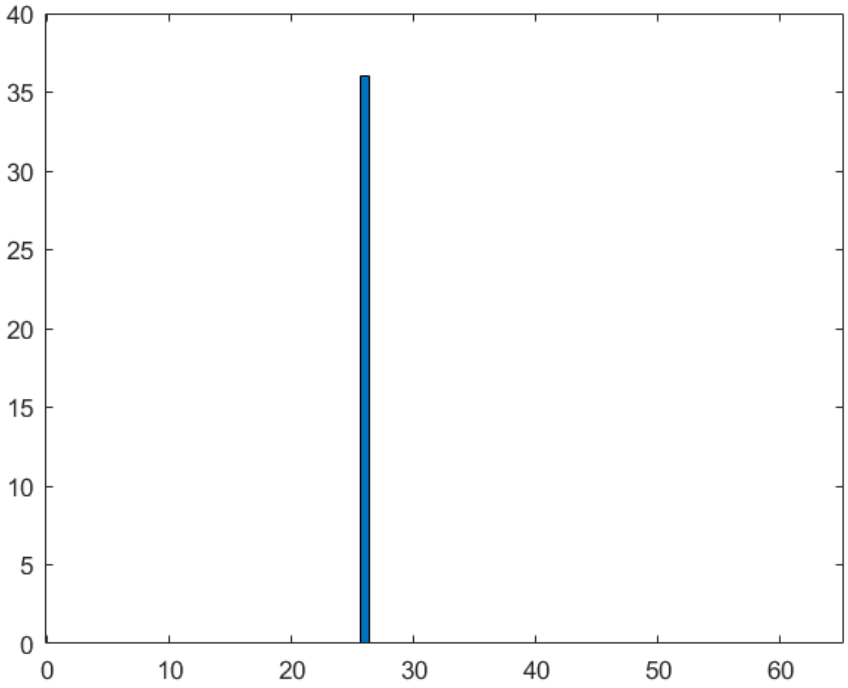

Figure 34: 667.jpg feature 2

1.2.8. Horses

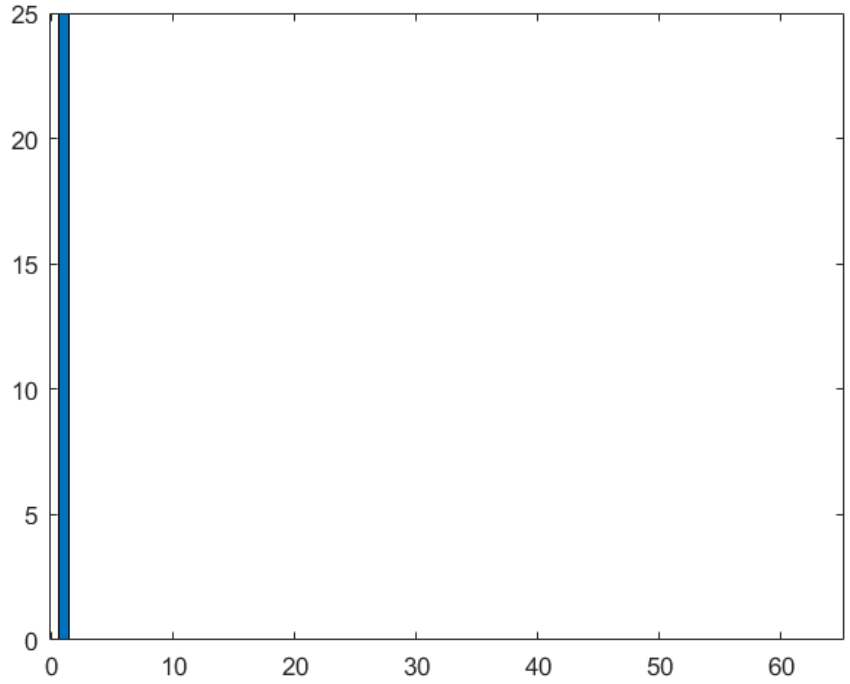

Figure 35: 733.jpg feature 1

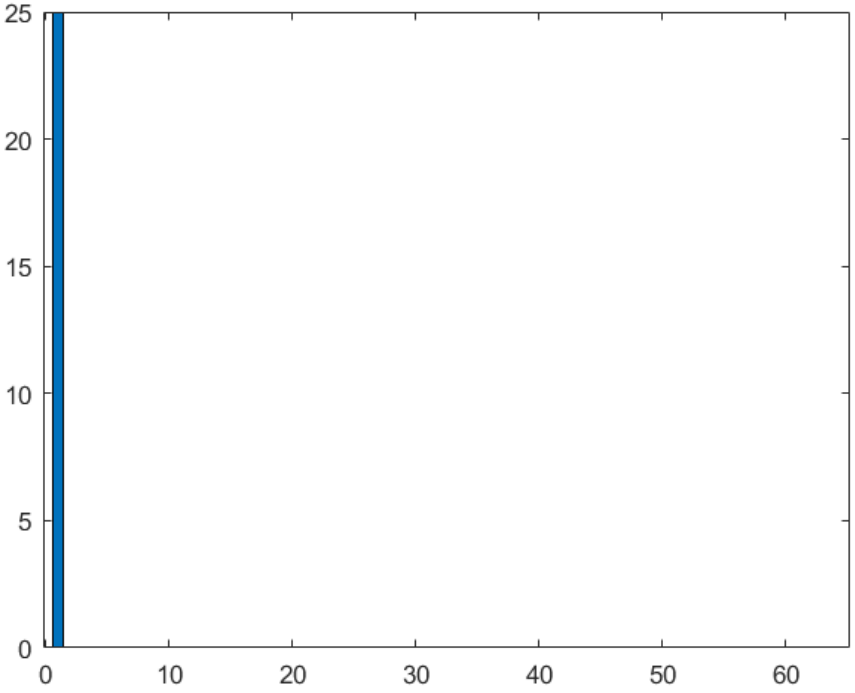

Figure 36: 733.jpg feature 2

1.2.9. Mountains

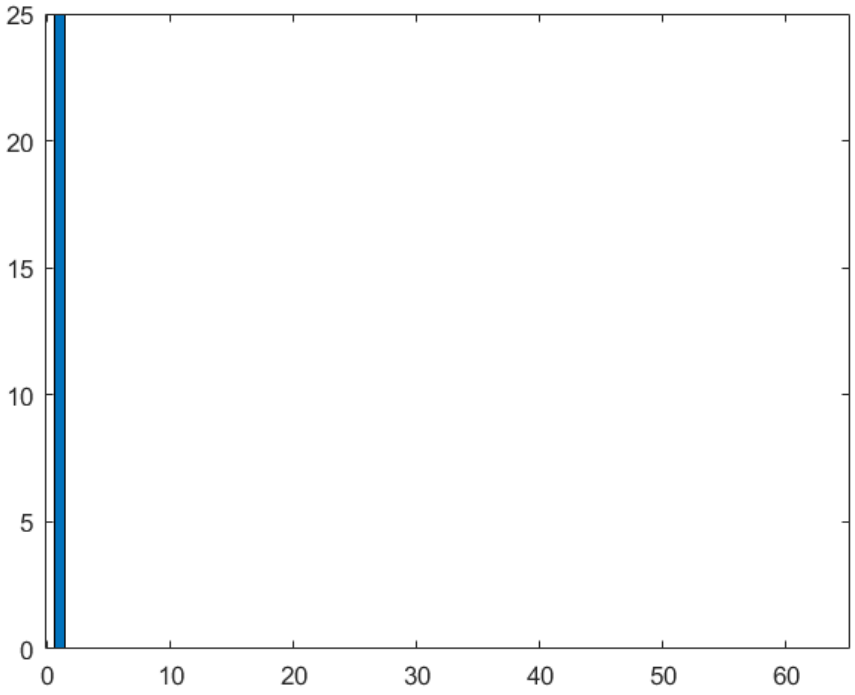

Figure 37: 804.jpg feature 1

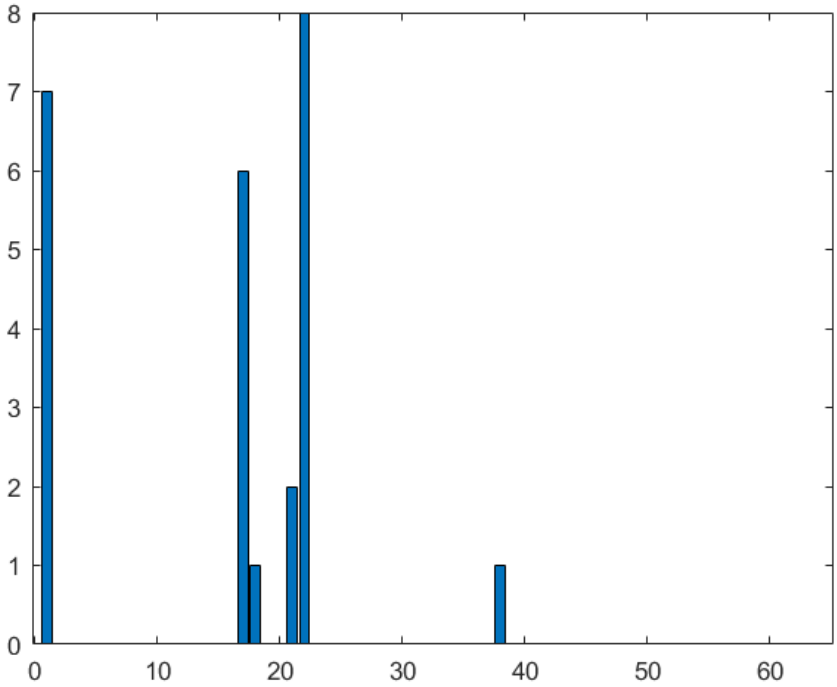

Figure 38: 804.jpg feature 2

1.2.10. Food

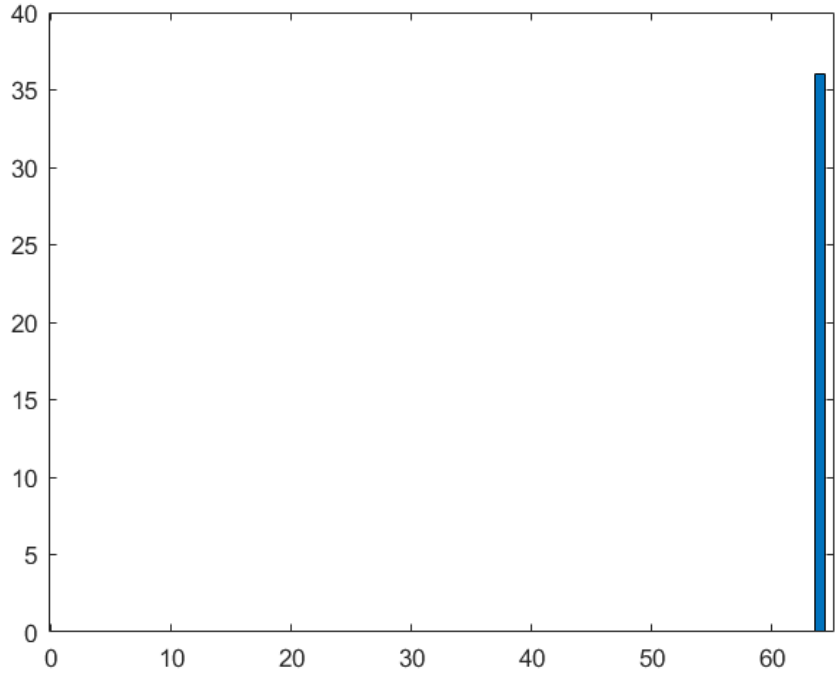

Figure 39: 923.jpg feature 1

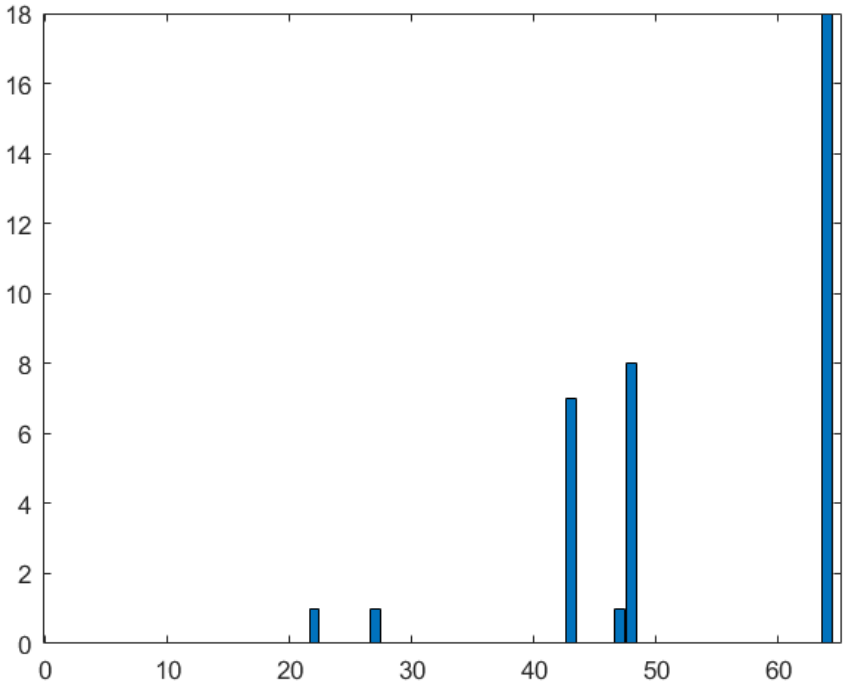

Figure 40: 923.jpg feature 2

2. Bag of Words

2.1. Africa

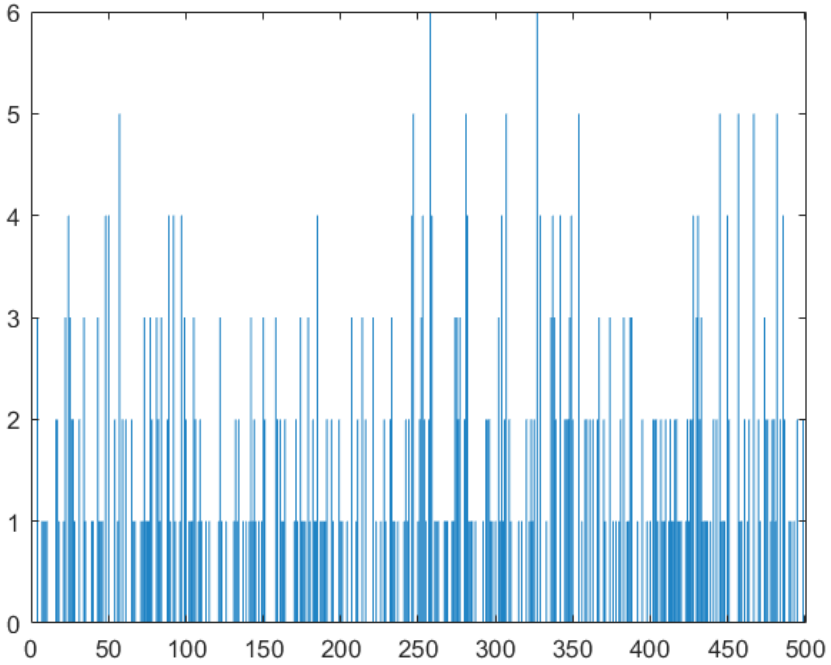

Figure 41: 0.jpg Combined Bag of Words Representation, Codebook Size = 500

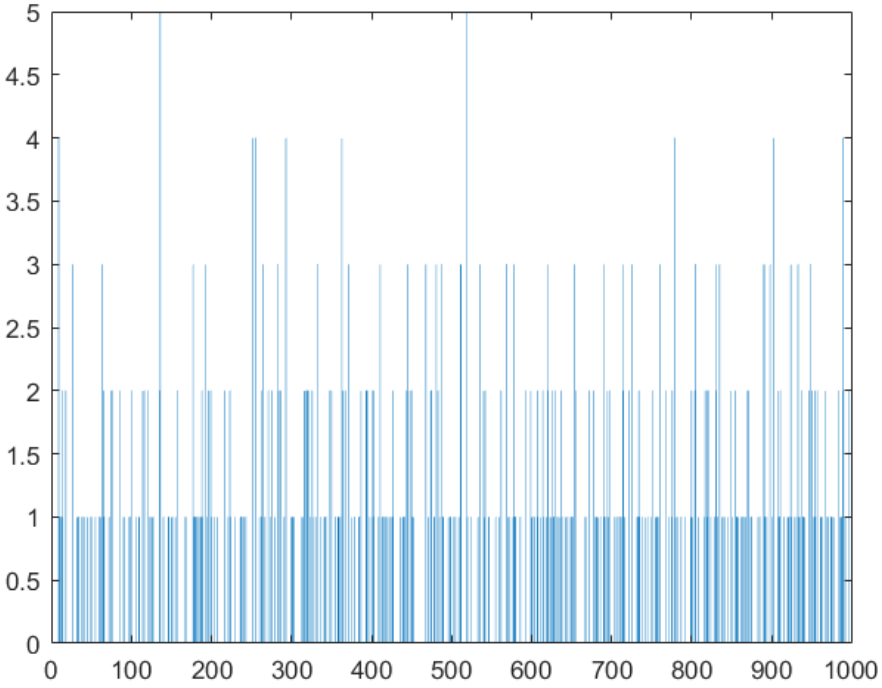

Figure 42: 0.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.2. Beach

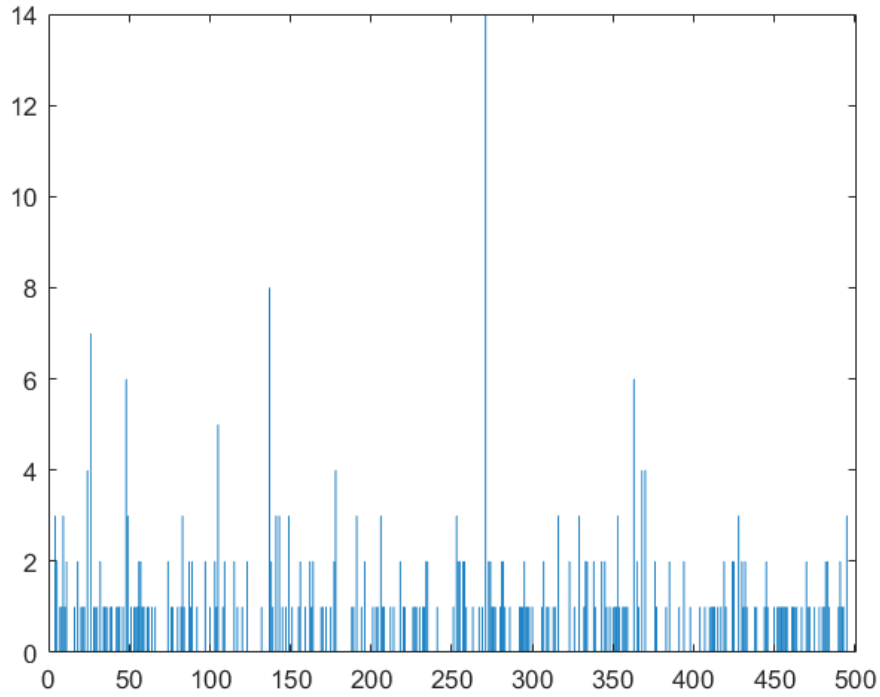

Figure 43: 111.jpg Combined Bag of Words Representation, Codebook Size = 500

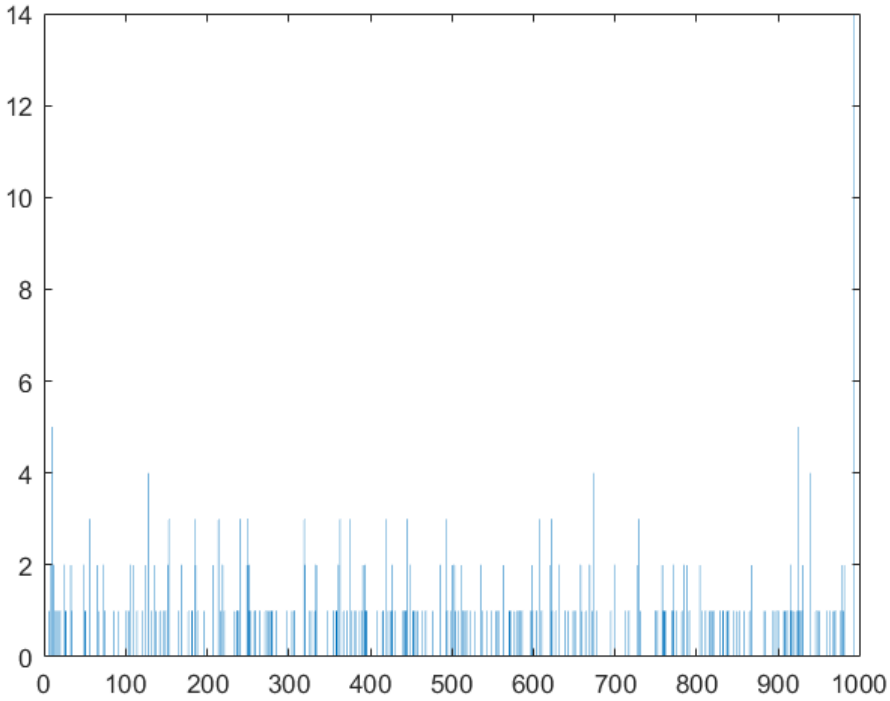

Figure 44: 111.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.3. Buildings

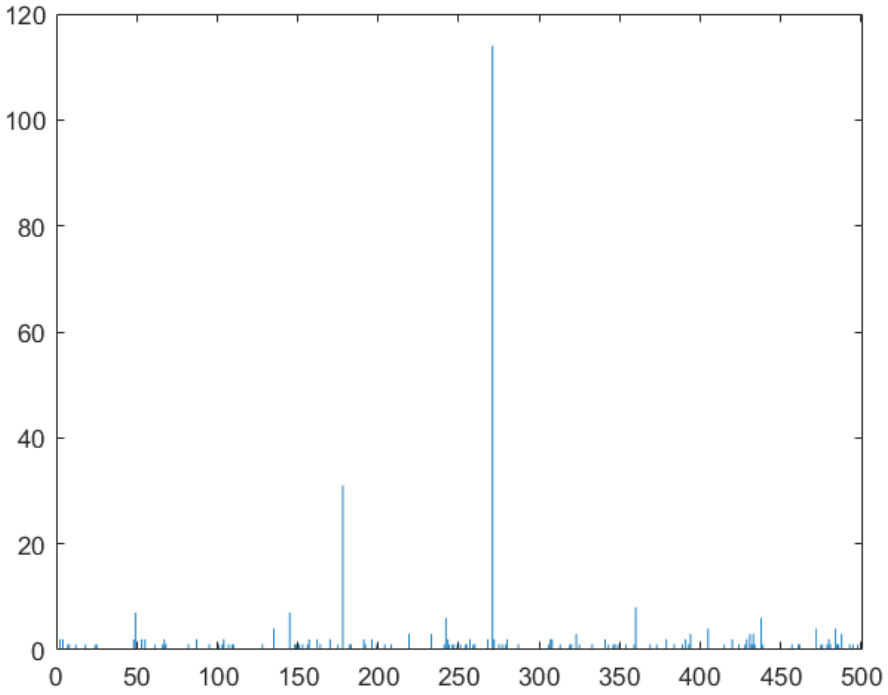

Figure 45: 224.jpg Combined Bag of Words Representation, Codebook Size = 500

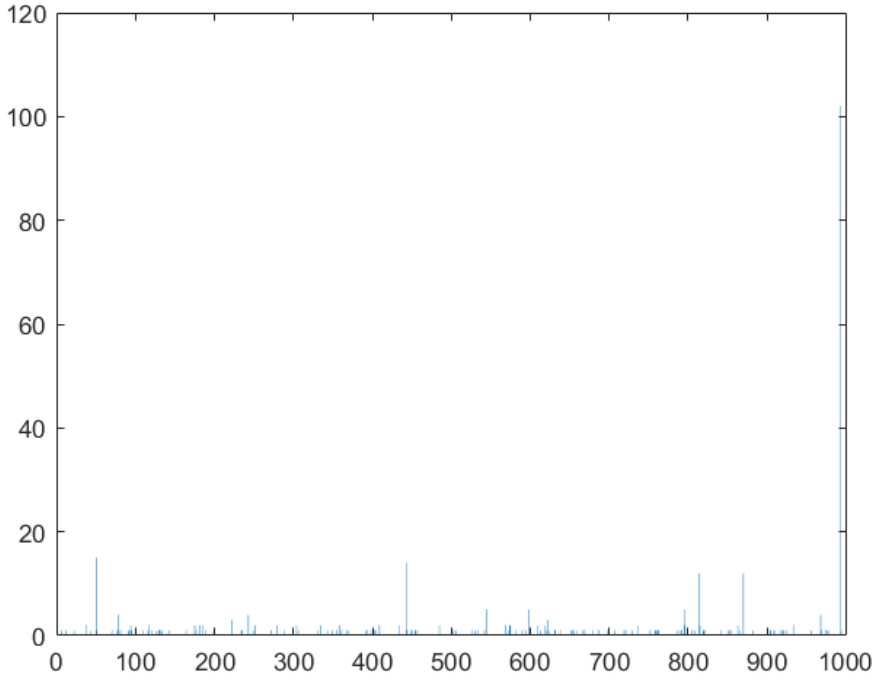

Figure 46: 224.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.4. Buses

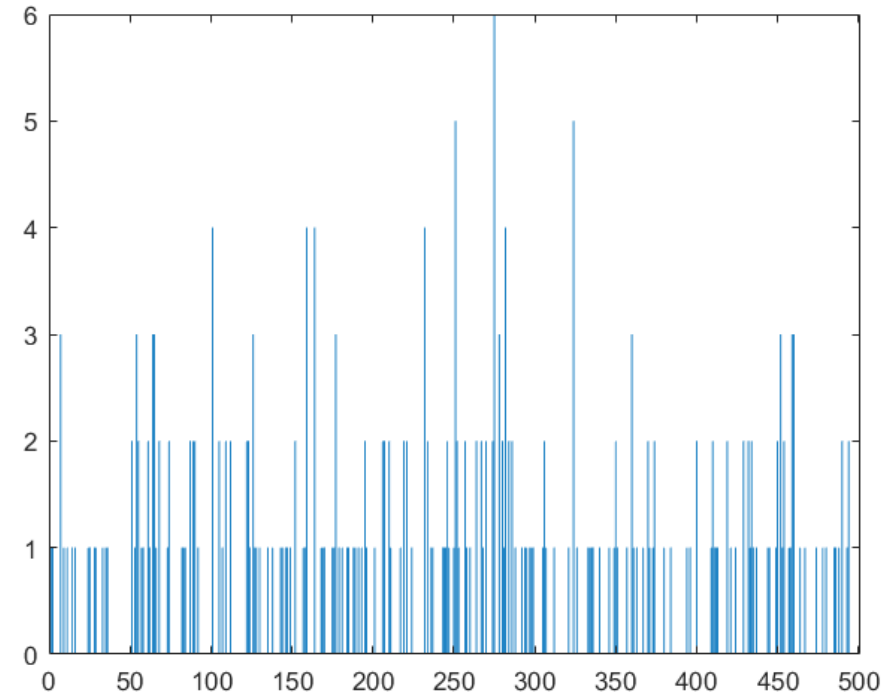

Figure 47: 335.jpg Combined Bag of Words Representation, Codebook Size = 500

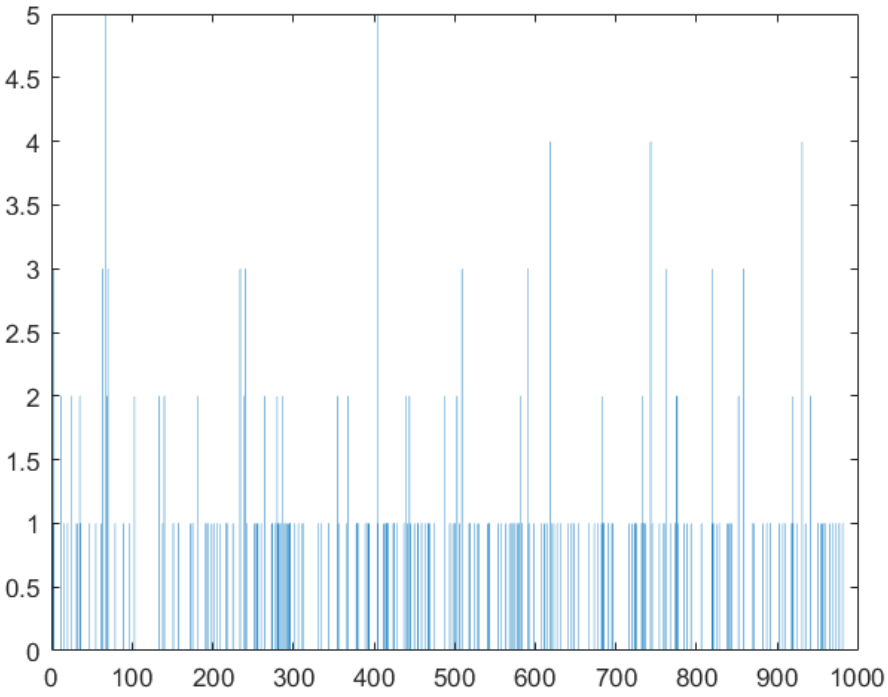

Figure 48: 335.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.5. Dinosaurs

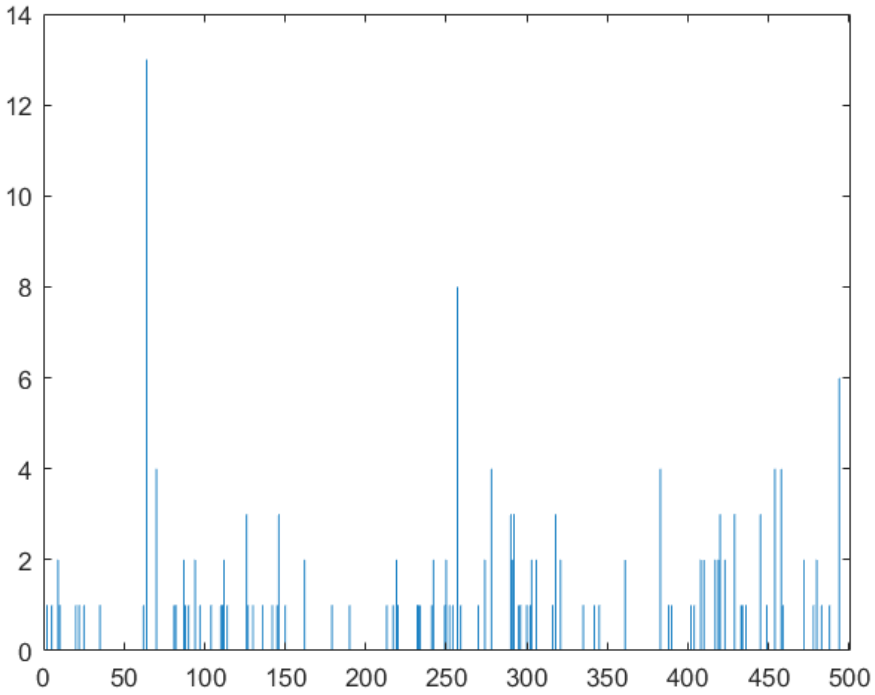

Figure 49: 448.jpg Combined Bag of Words Representation, Codebook Size = 500

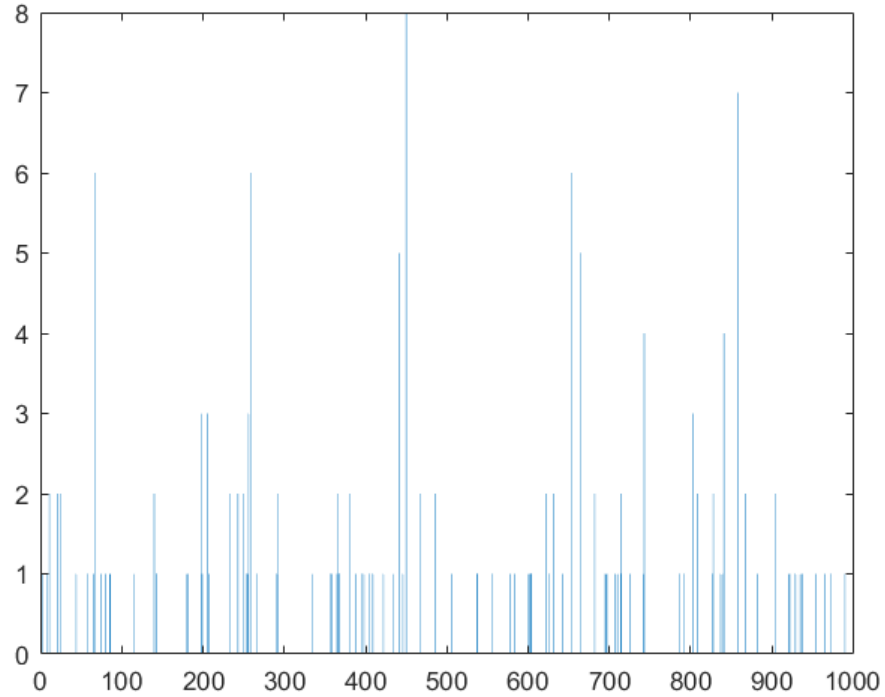

Figure 50: 448.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.6. Elephants

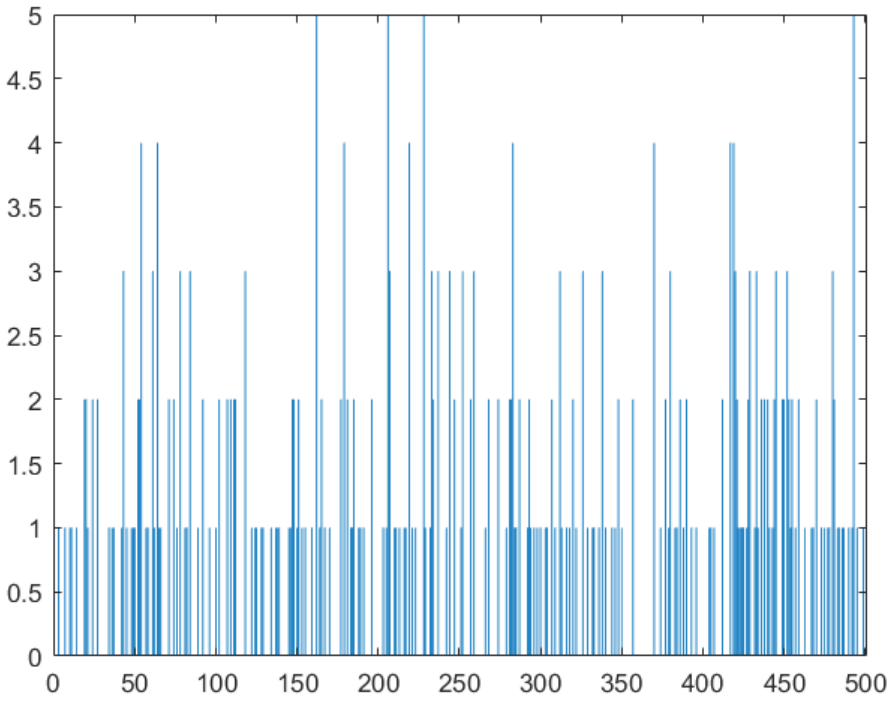

Figure 51: 557.jpg Combined Bag of Words Representation, Codebook Size = 500

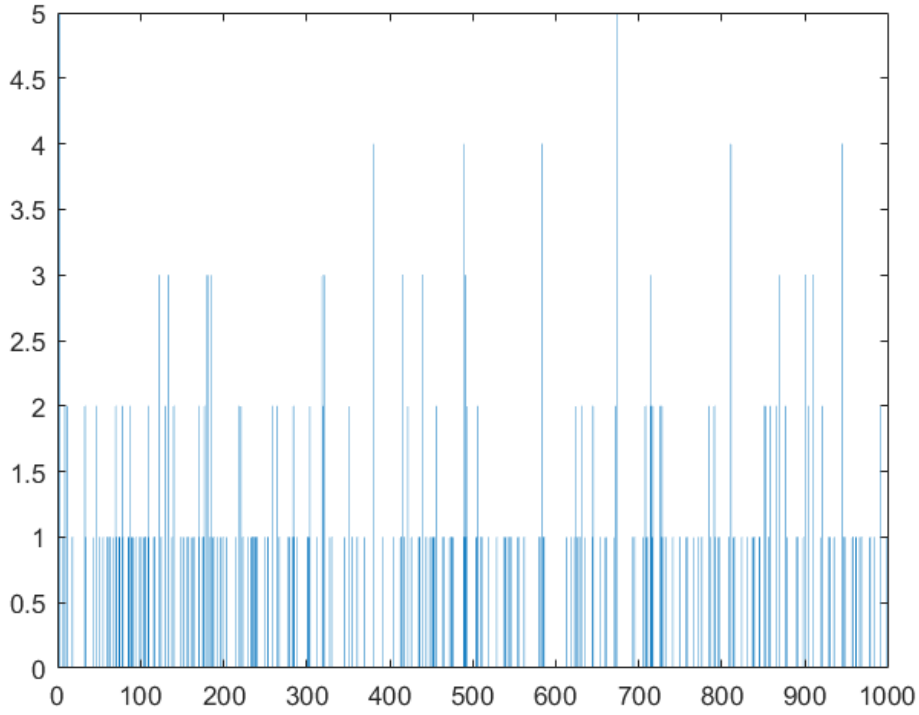

Figure 52: 557.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.7. Flowers

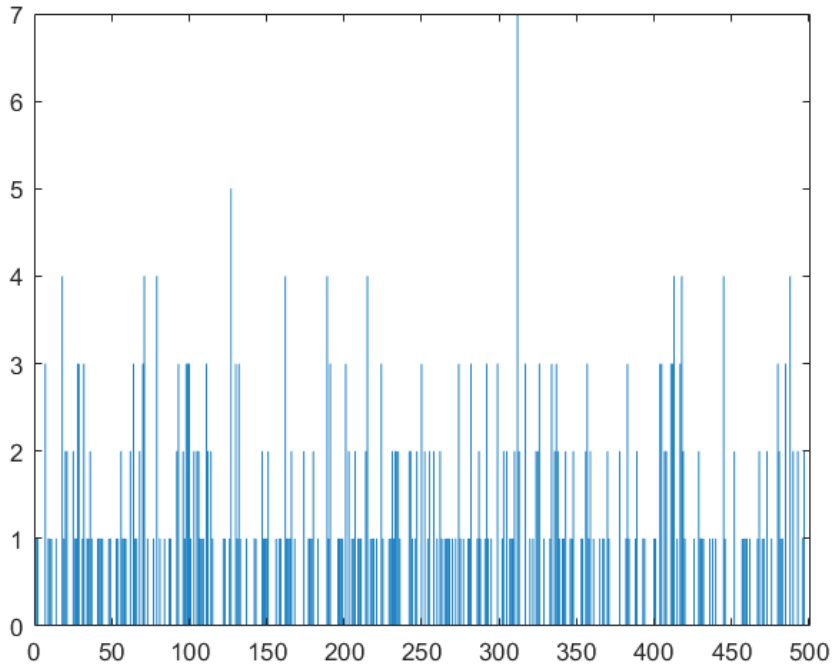

Figure 53: 667.jpg Combined Bag of Words Representation, Codebook Size = 500

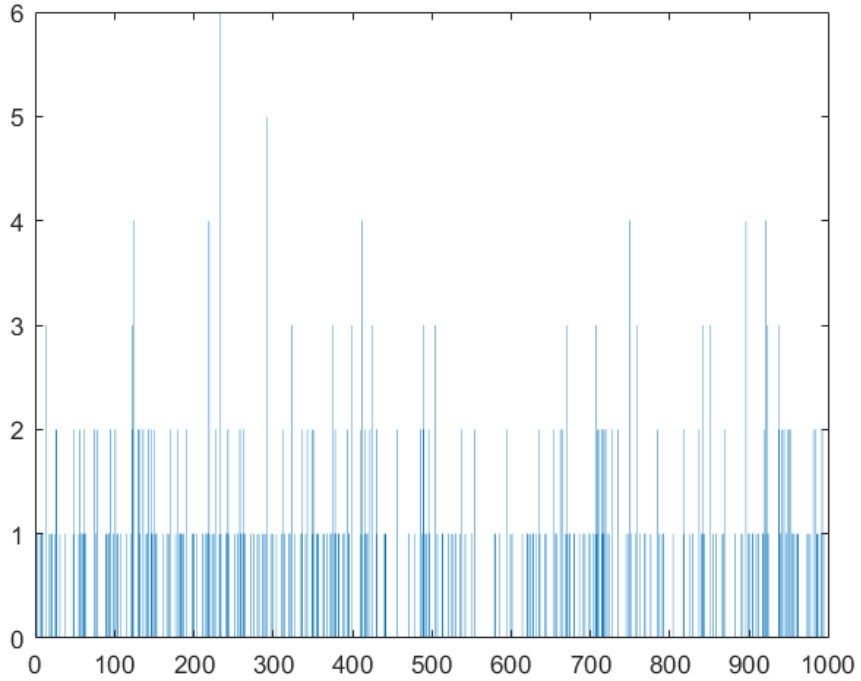

Figure 54: 667.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.8. Horses

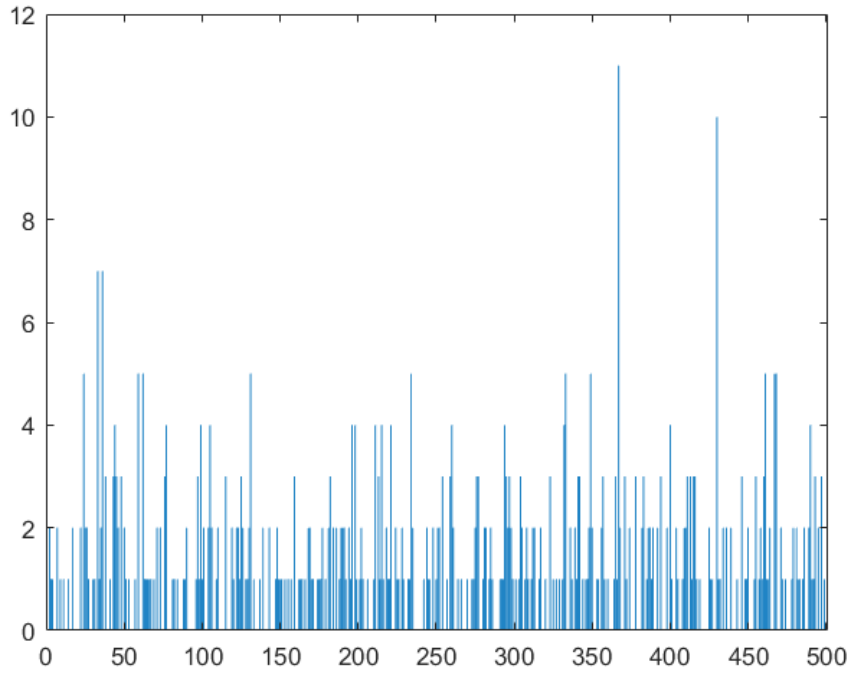

Figure 55: 733.jpg Combined Bag of Words Representation, Codebook Size = 500

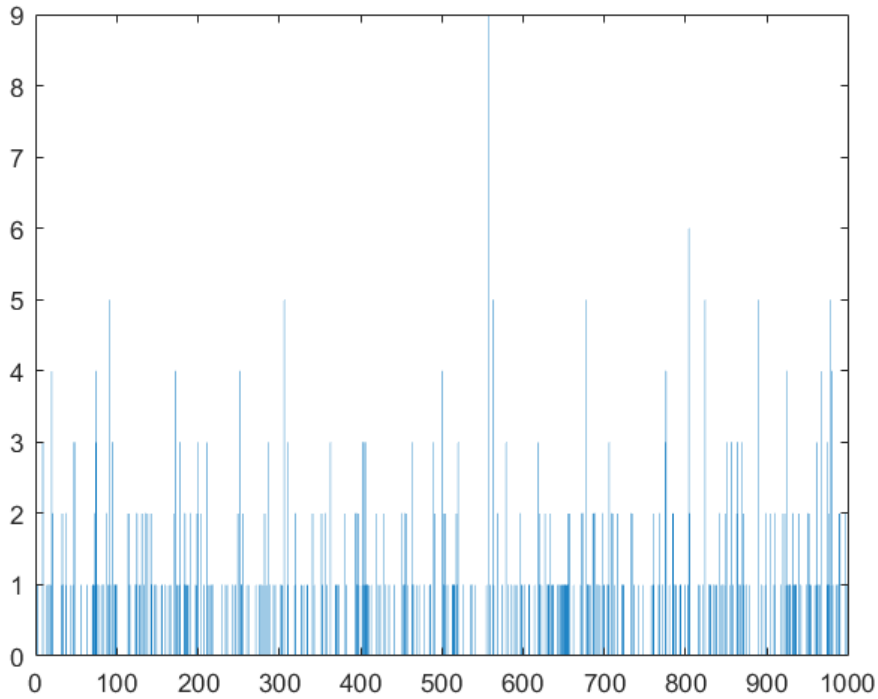

Figure 56: 73.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.9. Mountains

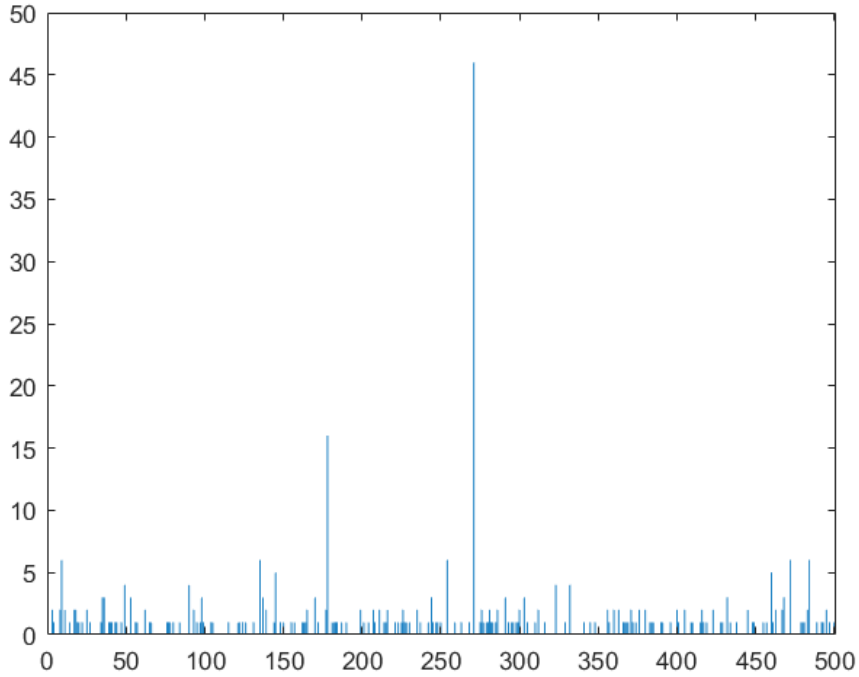

Figure 57: 804.jpg Combined Bag of Words Representation, Codebook Size = 500

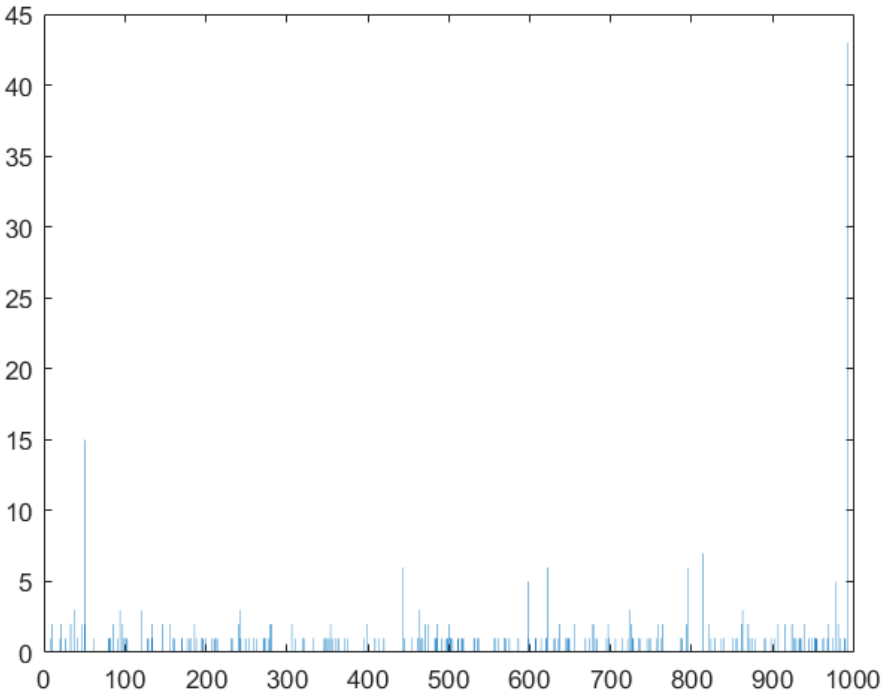

Figure 58: 804.jpg Combined Bag of Words Representation, Codebook Size = 1000

2.10. Food

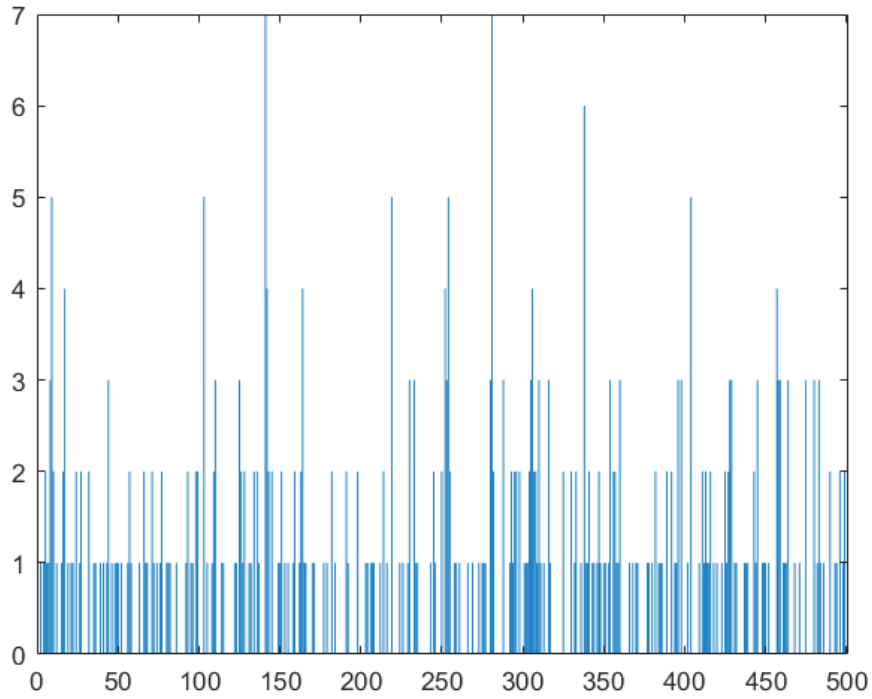

Figure 59: 923.jpg Combined Bag of Words Representation, Codebook Size = 500

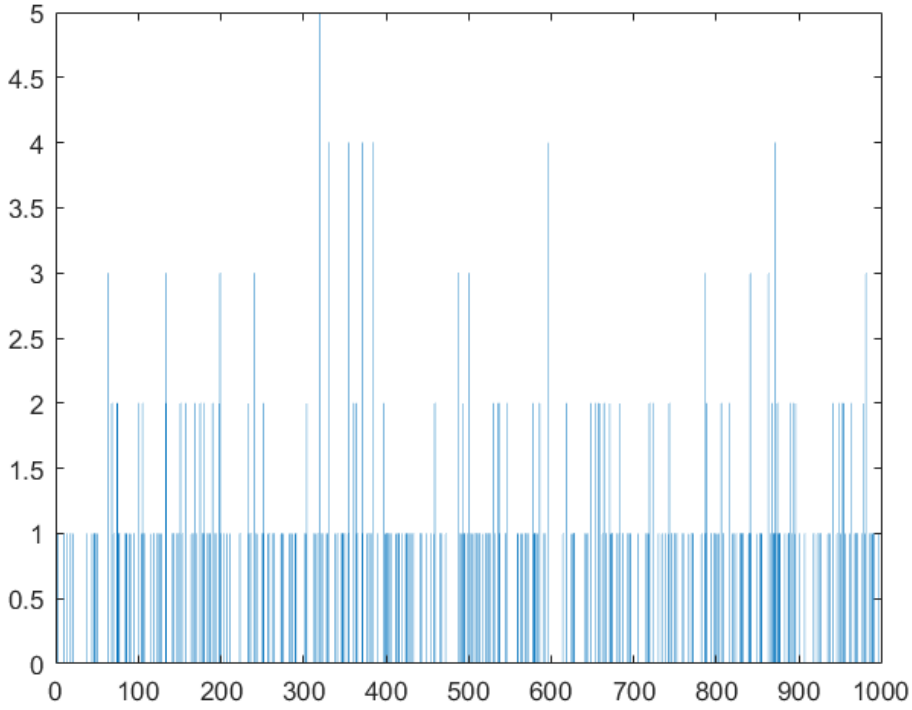

Figure 60: 923.jpg Combined Bag of Words Representation, Codebook Size = 1000

3. Evaluation Results

3.1. Quantitative Evaluation Results

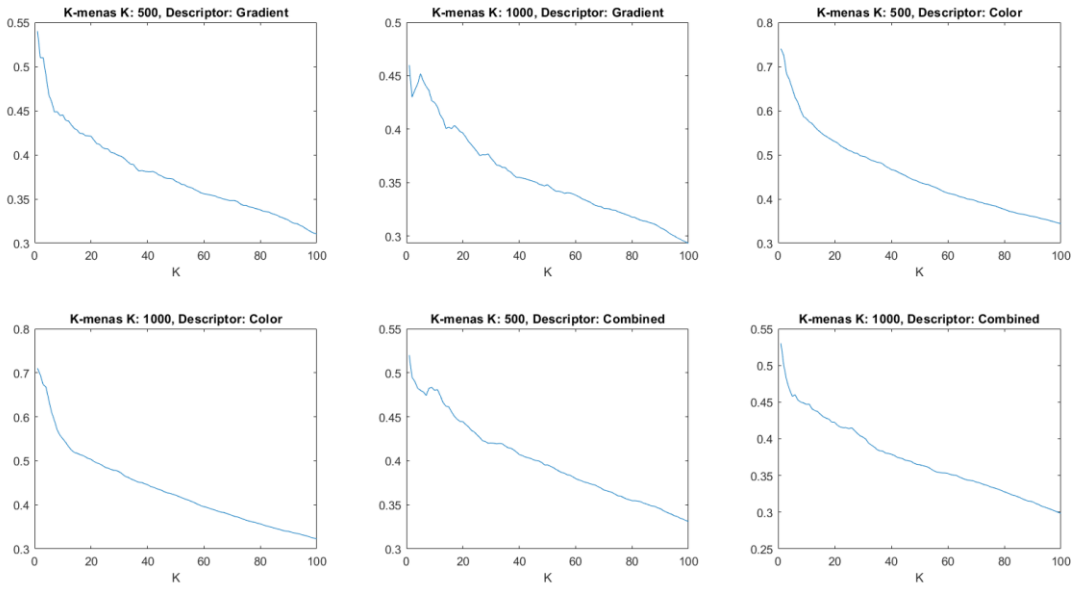

Figure 61: Precision vs K Curves

	africa	beach	buildings	buses	dinosaurs	elephants	flowers	horses	mountains	food	overall
Gradient, Codebook size = 500	0.23	0.25	0.27	0.76	1	0.36	0.63	0.5	0.23	0.22	0.445
Gradient, Codebook size = 1000	0.12	0.31	0.21	0.77	1	0.22	0.69	0.48	0.24	0.21	0.425
Color, Codebook size = 500	0.53	0.36	0.39	0.72	1	0.48	0.63	0.79	0.28	0.64	0.582
Color, Codebook size = 1000	0.48	0.38	0.3	0.71	1	0.43	0.62	0.71	0.28	0.59	0.55
Combined, Codebook size = 500	0.23	0.26	0.33	0.82	1	0.32	0.69	0.64	0.31	0.19	0.48
Combined, Codebook size = 1000	0.18	0.34	0.18	0.86	1	0.28	0.72	0.51	0.21	0.19	0.447

Figure 62: P@10 Score Table

3.2. Retrieval Results

3.2.1. Africa

Figure 63: 55.jpg

Figure 64: Search Result

3.2.2. Beach

Figure 65: 143.jpg

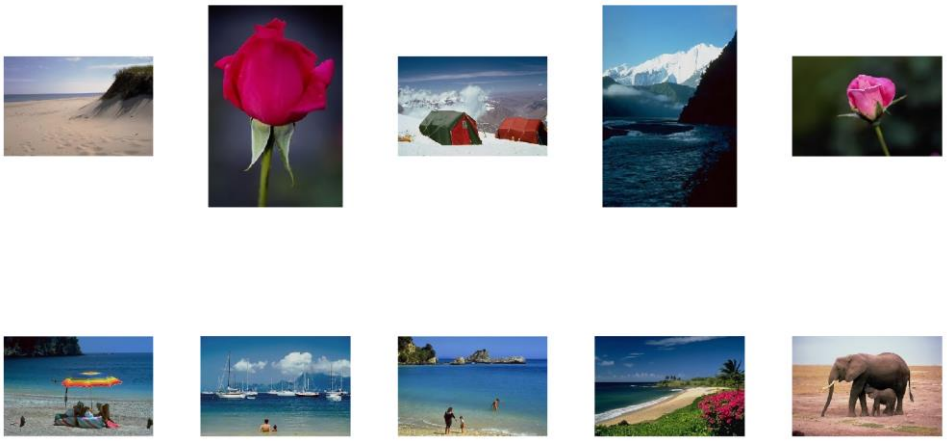

Figure 66: Search Result

3.2.3. Buildings

Figure 67: 205.jpg

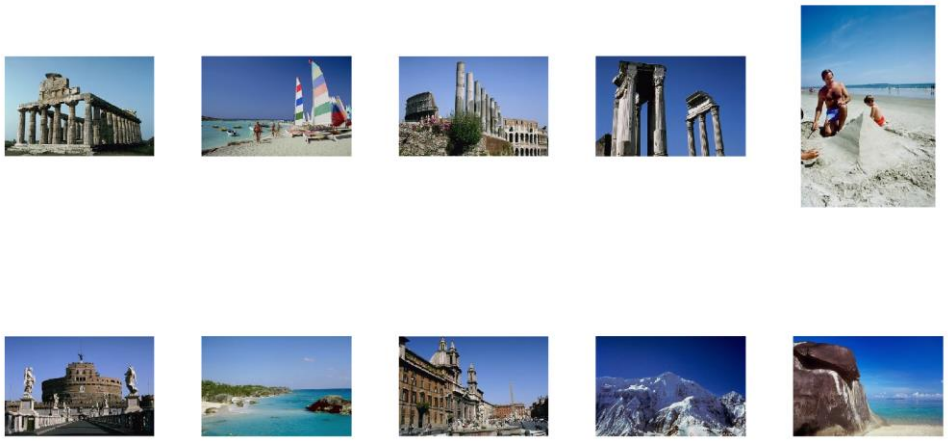

Figure 68: Search Result

3.2.4. Buses

Figure 69: 310.jpg

Figure 70: Search Result

3.2.5. Dinosaurs

Figure 71: 401.jpg

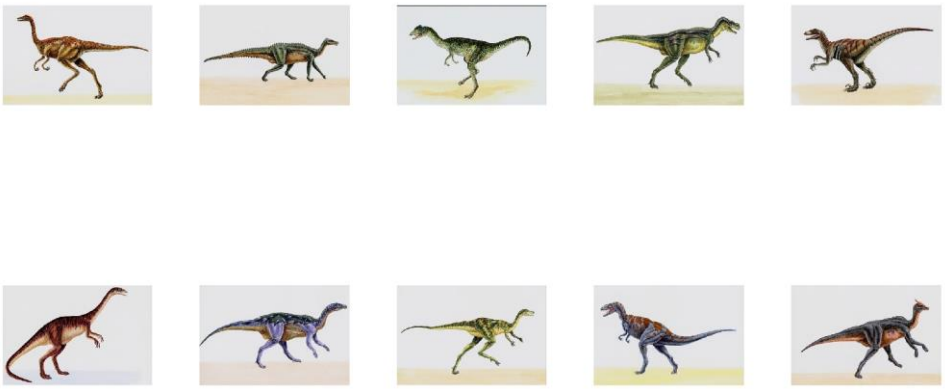

Figure 72: Search Result

3.2.6. Elephants

Figure 73: 545.jpg

Figure 74: Search Result

3.2.7. Flowers

Figure 75: 626.jpg

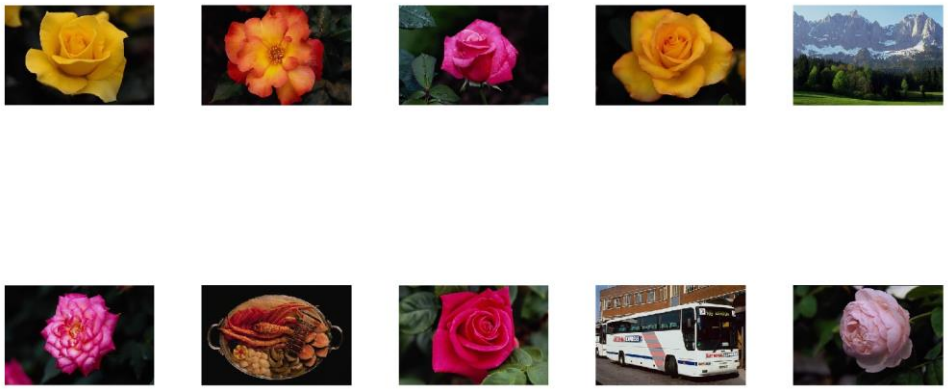

Figure 76: Search Result

3.2.8. Horses

Figure 77: 701.jpg

Figure 78: Search Result

3.2.9. Mountains

Figure 79: 805.jpg

Figure 80: Search Result

3.2.10. Food

Figure 81: 954.jpg

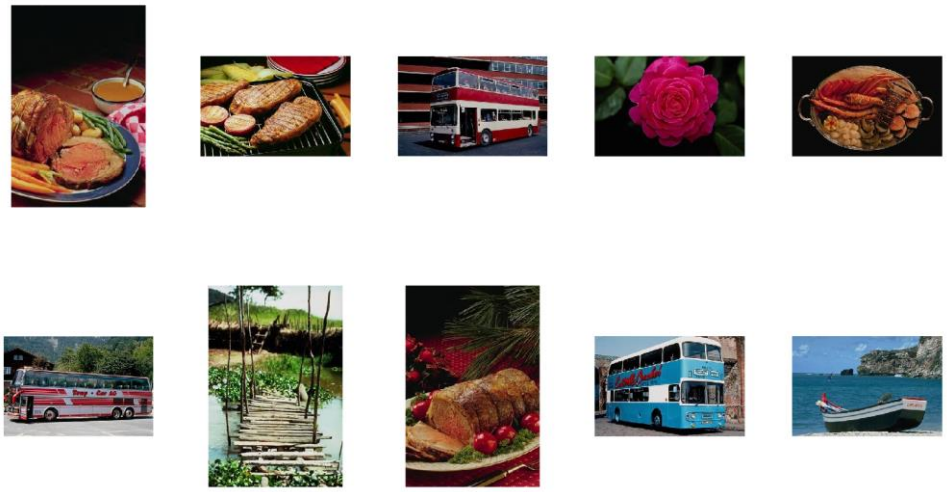

Figure 82: Search Result

4. Discussion

I observed that gradient descriptor generally gives the poorest result with my experiments. Also different categories give different result to each descriptor type. I think there can be written a program that searches with different descriptor depend on bag of visual

words content to optimize search results. About codebook size, I observed that if codebook size gets too big, distance between similar images changes dramatically, and if codebook size gets too small, distance between different images gets shorter. I saw codebook size around 500 gives best result with my experiments, and if codebook size exceeds 1500, search returns a lot of irrelevant images. The easiest category was dinosaurs. Images in that category have very distinct features such as shape and background. Therefore, dinosaur retrieval was the easiest. Buses and flowers were also easy since again they have distinct features. The hardest ones were foods and buildings because they do not very distinct features in its category. I also observed that if image has grass in it, search shows other images that have grass in it very . Evaluation step does not give point to this similarities well. For instance, even evaluation step does not give point to this similarities (e.g. elephants and horses are different categories), there are very similar images.