ECE 418 Lab 10

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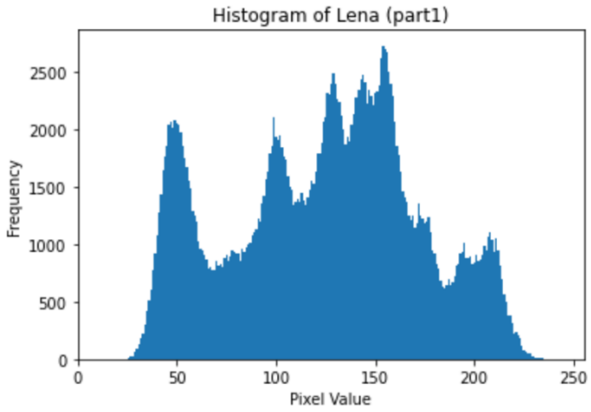
In this lab we examine the lossless compression method called run-length coding. We explore the run length coding of binary images and image bit planes along with exploring predictive coding. For each of the images provided the entropy, total number of runs, the run length entropy, and the total number of bits per pixel is calculated.

Part 1:
We calculate the entropy (H) of lena and the baboon image using the following formula:

$$H = -\sum_{i=0}^{255} P(i) * \log_2 P(i)$$

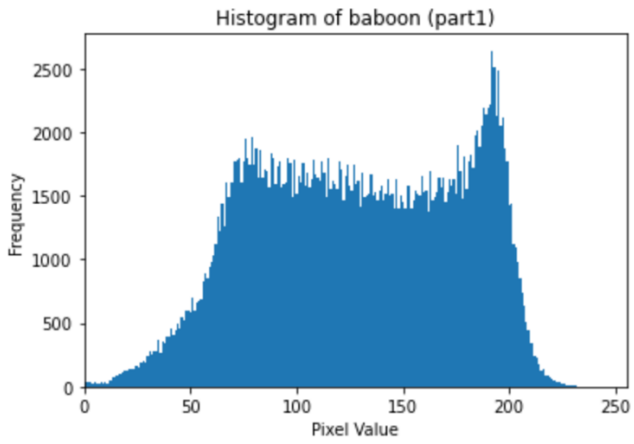
Which results in the following:

Lena:



- Entropy = 7.44551
- Total Bits = 1.95179e+06
- Run-Length Entropy = 0.458987
- Total Runs = 239747
- Average Bits = 0.419772

Baboon:



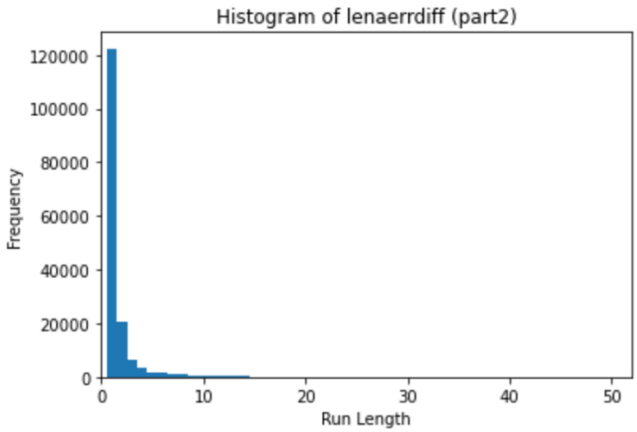
- Entropy = 7.47443
- Total Bits = 1.95938e+06
- Run-Length Entropy = 0.191862
- Total Runs = 254661
- Average Bits = 0.186385

Q2. The entropies of both the images are similar however the resulting histogram is considerably different therefore I couldn't deduce a correlation between the entropy and the histogram shape. I think this conclusion is generally true.

Part 2:

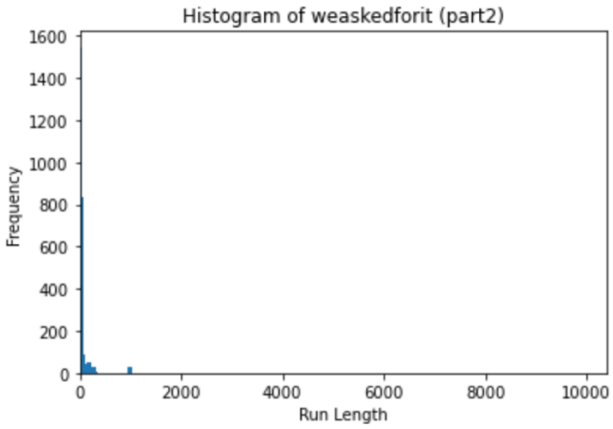
In this part, we examine the run length coding technique on lenaerrdiff and weaskedforit. The image is scanned using "raster-snake" order, the consecutive scanned pixel with the same pixel intensity are consider in the same run. The run length for each run are stored and the frequency of occurrence of each possible run length are displayed as histogram. This results in the following:

Lenaerrdiff:



- Entropy = 0.963907
- Run-Length Entropy = 1.35382
- Total Runs = 159928
- Total Bits = 216514
- Average Bits = 0.825936

Weaskedforit:



- Entropy = 0.985514
- Run-Length Entropy = 5.17203
- Total Runs = 10224
- Total Bits = 52878.9
- Average Bits = 0.201717

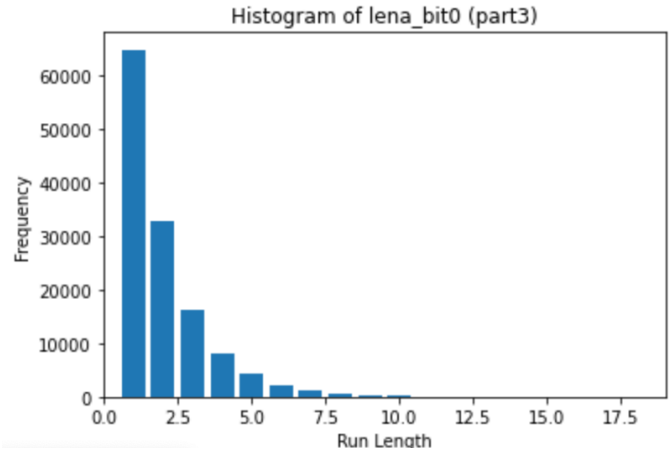
Q3. The "weaskedforit" image compresses better because it requires fewer bits than the "lenaerrdiff" image after run length coding. In general, images with many sections of consecutive pixels with similar pixel intensity values, such as the "weaskedforit" image, have lower entropy than images with more varied pixel intensities, like "lenaerrdiff". "Weaskedforit"

is easier to compress since it has more repeated data than "lenaerrdiff", with large chunks of black and white constant pixel intensity regions. The histogram of the "lena" image has fewer possible run lengths, and they are mostly smaller than those of "weaskedforit".

Part 3:

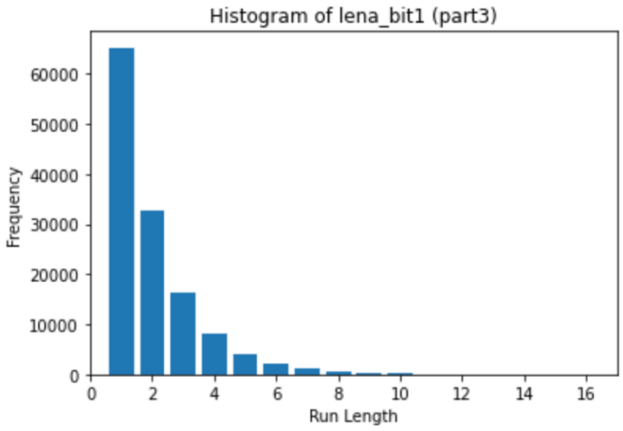
In this part 8 bitplane images of lena are created and each image is examined using methods in the previous parts resulting in the following:

Lena_bit0:



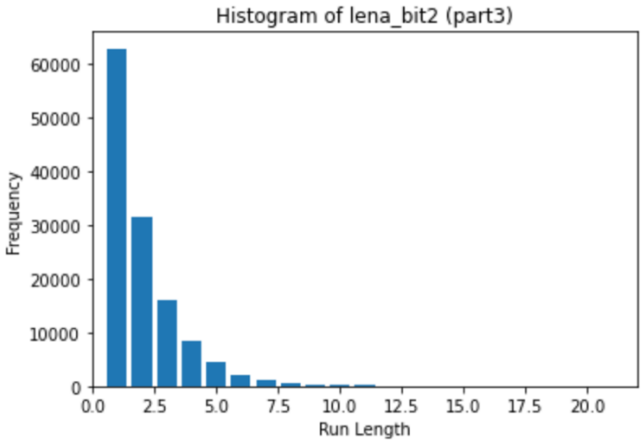
- Run-Length Entropy is 2.01302
- Total Runs = 130213
- Average Bits = 0.999914
- Entropy = 0.999998
- Total Bits = 262143

Lena_bit1:



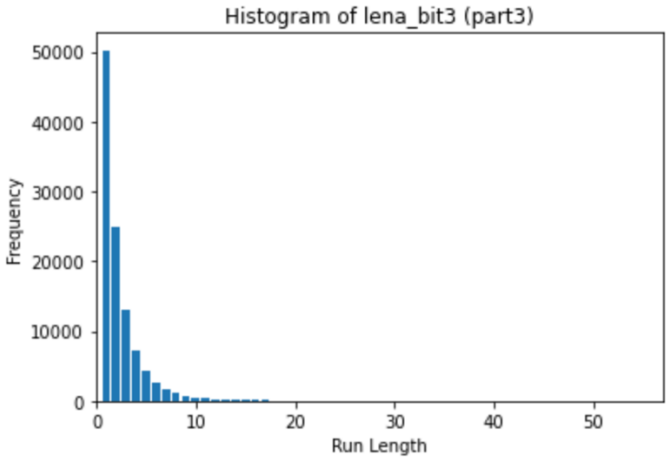
- Run-Length Entropy = 2.00556
- Total Runs = 130700
- Average Bits = 0.999932
- Entropy = 0.999999
- Total Bits = 262144

Lena_bit2:



- Run-Length Entropy = 2.05427
- Total Runs = 127512
- Total Bits = 261944
- Average Bits = 0.999237
- Entropy = 0.999993

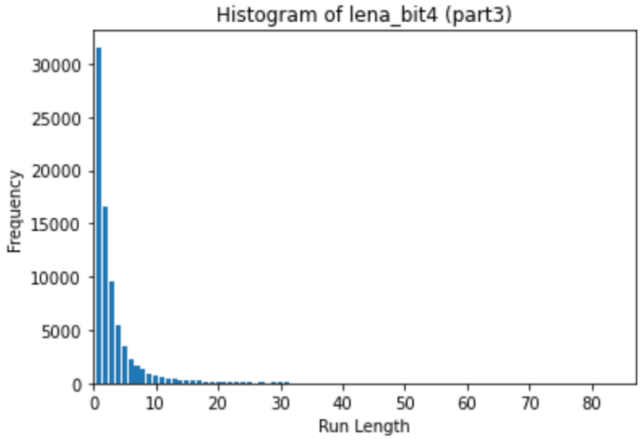
Lena_bit3:



- Run-Length Entropy = 2.34021

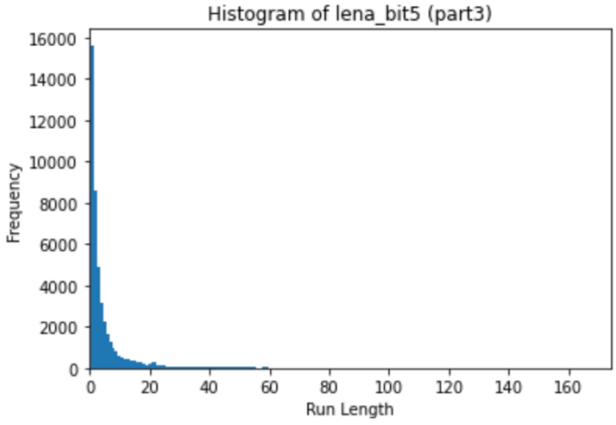
- Total Runs = 107856
- Total Bits = 252405
- Average Bits = 0.96285
- Entropy = 0.999996

Lena_bit4:



- Run-Length Entropy = 2.8132
- Total Runs = 77499
- Total Bits = 218020
- Average Bits = 0.83168
- Entropy = 0.999978

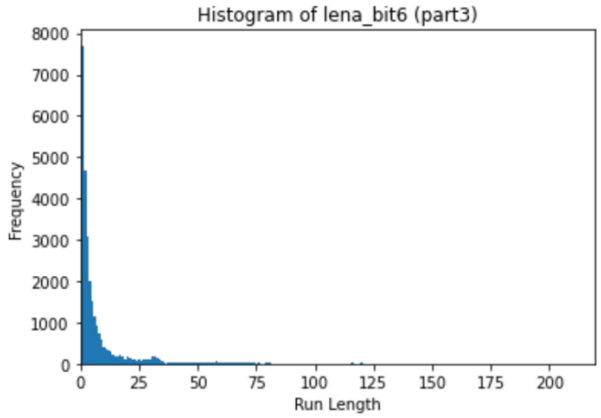
Lena_bit5:



- Run-Length Entropy = 3.49383
- Total Runs = 45667
- Total Bits = 159553

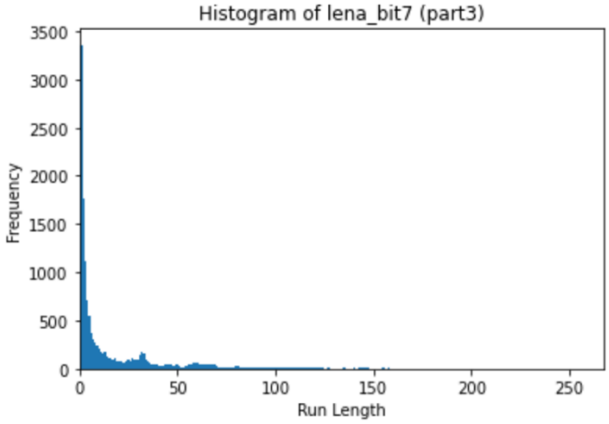
- Average Bits = 0.608645
- Entropy = 0.999882

Lena_bit6:



- Run-Length Entropy = 4.08871
- Total Runs = 28387
- Total Bits = 116066
- Average Bits = 0.442757
- Entropy = 0.981496

Lena_bit7:



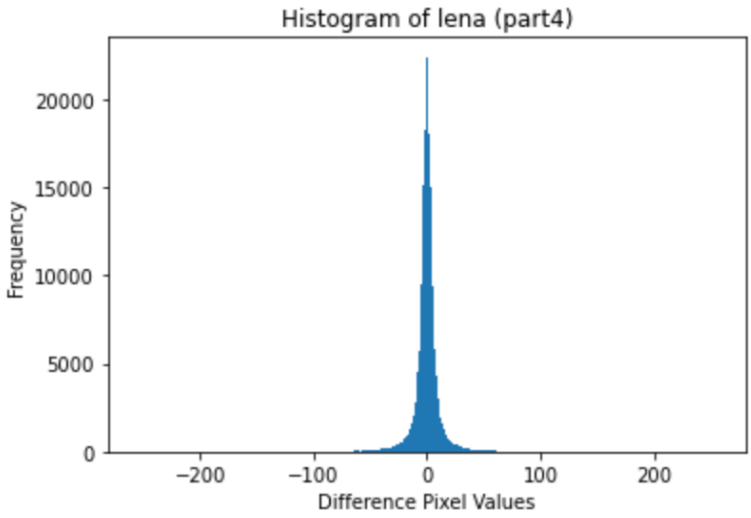
- Run-Length Entropy 5.00165
- Total Runs = 13926
- Total Bits = 69653
- Average Bits = 0.265705
- Entropy = 0.99964

Q4. The most significant bit planes are the most efficient to compress, whereas the least significant planes are the least efficient to compress because the least significant bit planes have way less long runs when compared to the most significant bit plane.

Part 4:

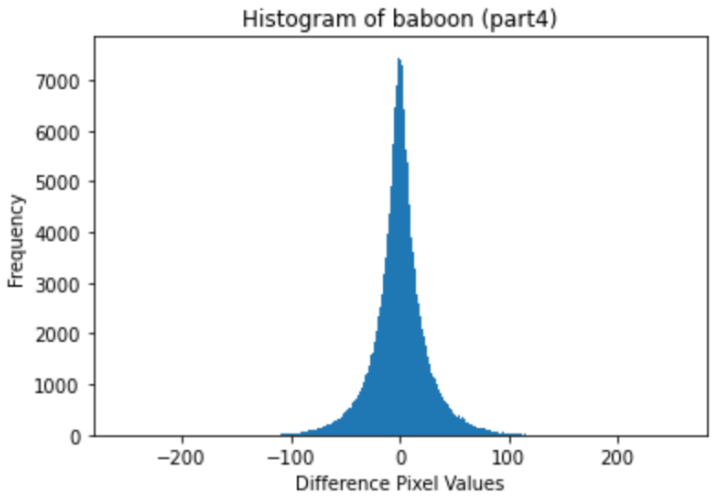
Predictive coding involves assuming that a pixel's intensity value will likely be the same as its previous scanned neighbor's intensity value. By predicting the current pixel's value from its causal neighbor, we can generate a predicted image. The error image is then calculated as the difference between the predicted image and the original image. By using the first pixel value and the error (difference) image pixel values, we can reconstruct the original pixels. This allows us to losslessly compress the difference image in order to compress the original image losslessly. The histogram of difference pixel values is generated, and the bits required and entropy are calculated to assess the effectiveness of the compression. This results in the following:

Lena:



- Entropy = 5.055012
- The total number of bits required = 1325136.125 bits

Baboon:



- Entropy = 6.547993
- The total number of bits required = 1716510.5 bits

Q5. Both baboon and lena image has lower entropy in part 4 than part 1. Predictive coding performs better because each pixel's value can be similar to its causal neighbouring pixel resulting in difference pixel (prediction error) values that are low, thus the entropy value will be low.

Q6. Run length coding of a bi-level image can result in an expansion of the image in terms of bits per pixel if the image has mostly very short runs which means that the image has very few consecutive scanned pixels with same intensity value.

Q7. There are no 8-bit images for which run-length encoding each bit planes separately takes as many or more bits than Huffman coding done on 256-level image in part 1. The total number of bits required for lena image in part 1 which use Huffman coding is larger than for 8 bit planes combined in part 3.

In this lab, the lossless coding method and the run length coding method is examined. The run length coding is most efficient in compressing the image that has more long runs. The lossless predictive coding is more efficient due to its assumption that each pixel's value is similar to its causal pixel so that the entropy is lowered.