ECE 438 Digital Signal Processing
Week 10: Number Representation and Waveform Quantization

Date 4/1/2020

Section 2

Name		Sign	Time spent outside lab
David Dang	[%]	David Dang	20 hrs
Benedict Lee	[%]	Benedict Lee	20 hrs

Grading Rubric (Spring 2020)

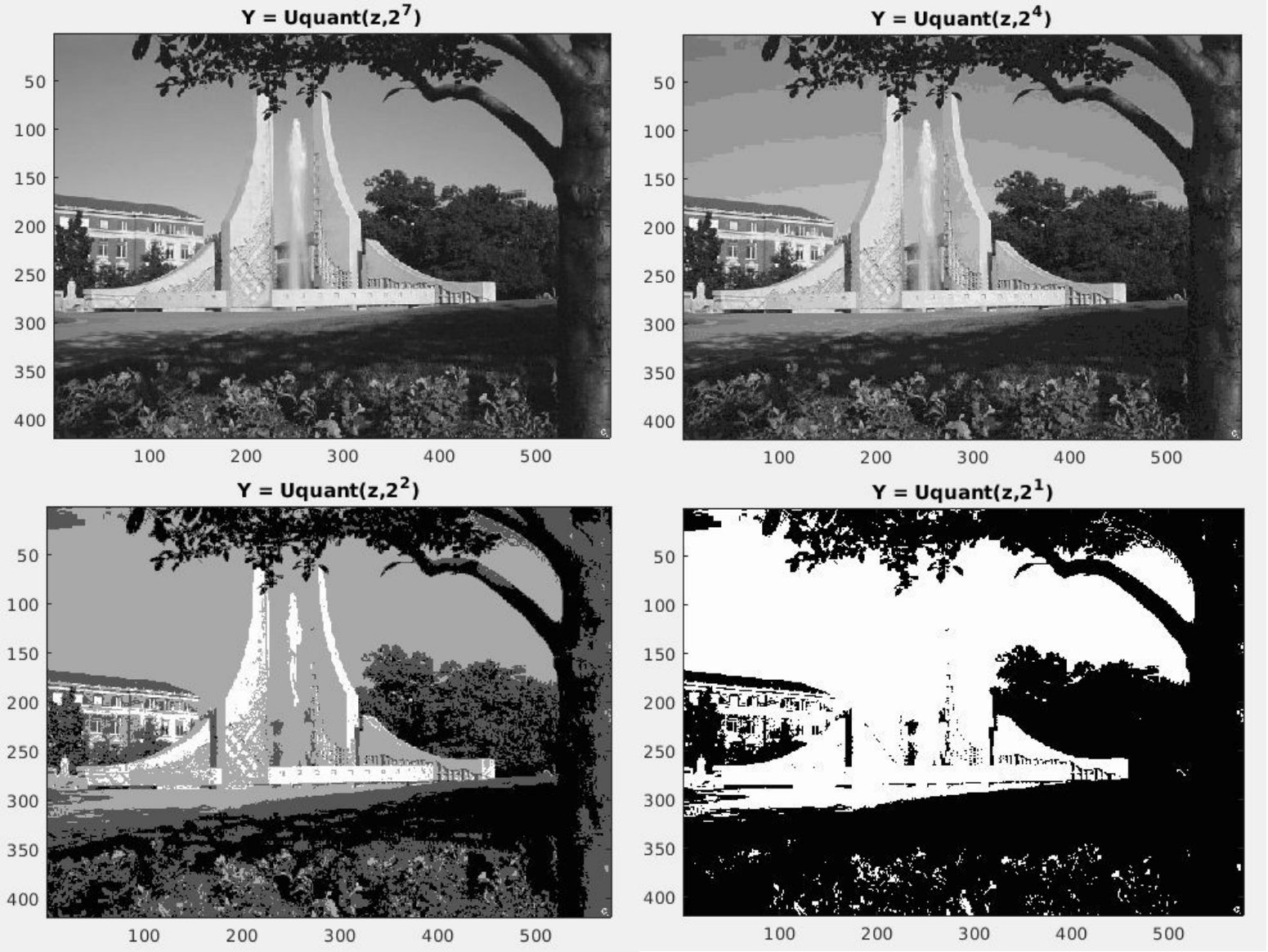
	below expectations	lacks in some respect	meets all expectations
Completeness of the report			
Organization of the report *One-sided, with cover sheet, answers are in the same order as questions in the lab, copies of the questions*			
Quality of figures *Correctly labeled with title, x-axis, y-axis, and name(s)*			
Understanding and implementation of uniform quantizer (45 pts) *Image: original and quantized images, comparison, questions* *Audio: matlab figures, questions*			
Understanding of error analysis (35 pts) *Error histograms, correlation, PSNR, rate-distortion curve, questions*			
Understanding of max quantizer (20 pts) *Histograms, PSNR, comparison with uniform quantizer*			

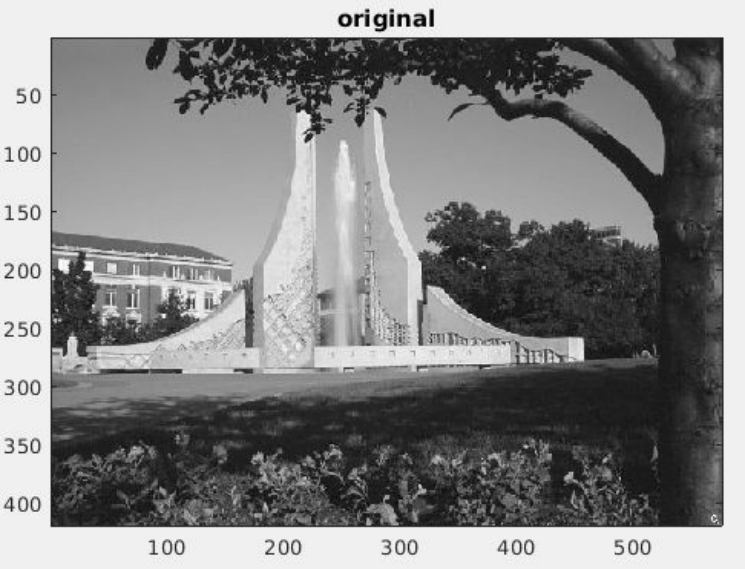
ECE 438 Lab 8
David Dang & Benedict Lee

3.3 Image Quantization

INLAB REPORT:

1. Describe the artifacts (errors) that appear in the image as the number of bits is lowered?
2. Note the number of b/pel at which the image quality noticeably deteriorates.
3. Hand in the printouts of the above four quantized images and the original.
4. Compare each of these four quantized images to the original.

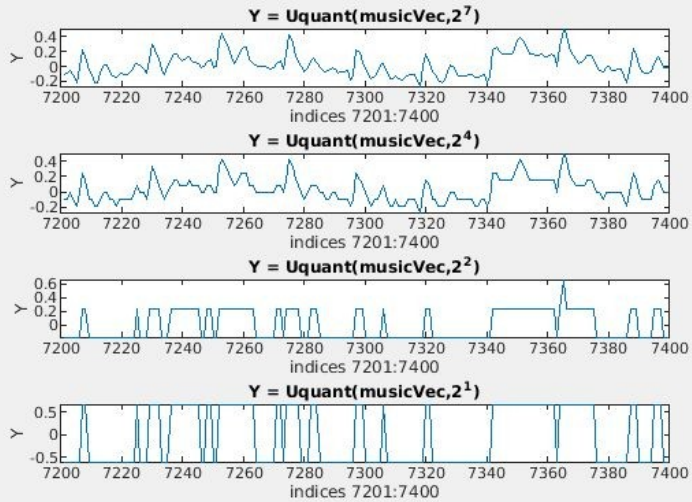


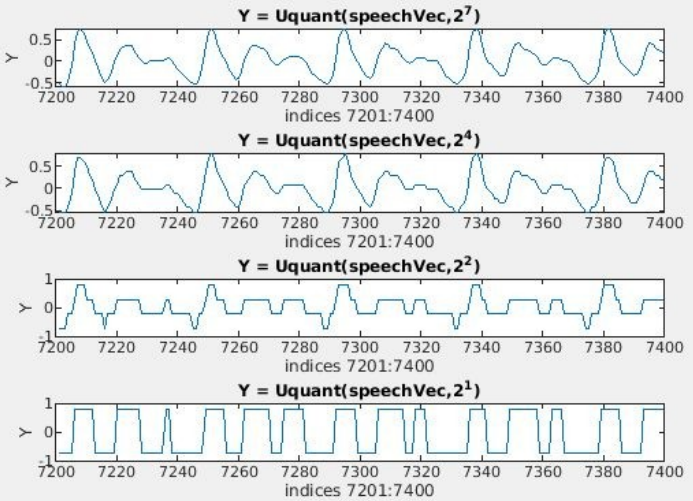


- As the number of bits are lowered, the amount of gray in the image decreases and causes the image to have less detail
- The number of b/pel at which the image noticeably deteriorates is 2 b/pel
- At 7 b/pel, both the quantized and original images look about the same. At 4 and 2 b/pel, the quantized image becomes less detailed. At 1 b/pel, the image becomes black and white since the pixels only take on two values.

3.4 Audio Quantization

INLAB REPORT: Hand in answers to the above questions, and the two Matlab figures.





•For each signal, describe the change in quality as the number of b/sample is reduced?

As the number of b/sample is reduced, each signal gradually loses clarity until eventually the signal takes on two values at 1 b/sample

•For each signal, is there a point at which the signal quality deteriorates drastically?At what point (if any) does it become incomprehensible?

The signal quality deteriorates drastically at 2 b/sample. It becomes incomprehensible at 1 b/sample

•Which signal's quality deteriorates faster as the number of levels decreases?

The music signal's quality deteriorates faster.

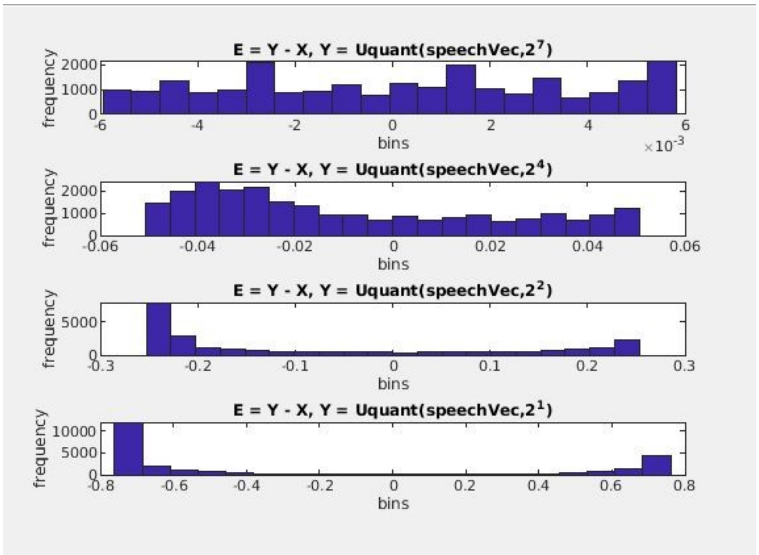
•Do you think 4 b/sample is acceptable for telephone systems? ... 2b/sample?

4 b/sample is somewhat acceptable. 2 b/sample is not acceptable.

3.4.1 Error Analysis

INLAB REPORT:

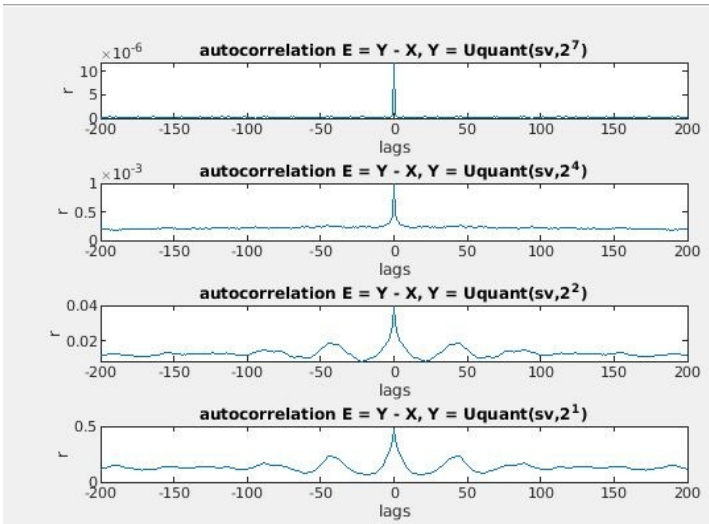
1. Hand in the histogram figure.
2. How does the number of quantization levels seem to affect the shape of the distribution?
3. Explain why the error histograms you obtain might not be uniform?

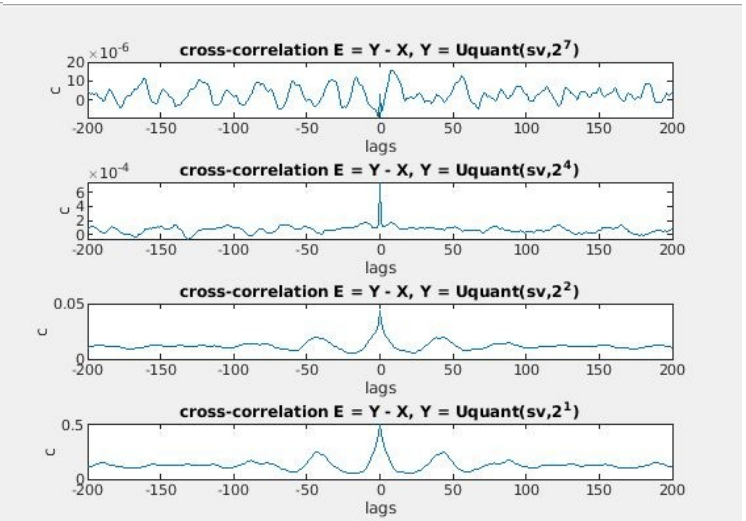


- As the number of quantization levels decreases, the error becomes worse and causes the histogram to have higher frequencies at larger error values
- The error histograms aren't uniform because the error differs from point to point between the actual and quantized signals

INLAB REPORT:

1. Hand in the autocorrelation and cross-correlation estimates.
2. Is the autocorrelation influenced by the number of quantization levels? Do samples in the error signal appear to be correlated with each other?
3. Does the number of quantization levels influence the cross-correlation?



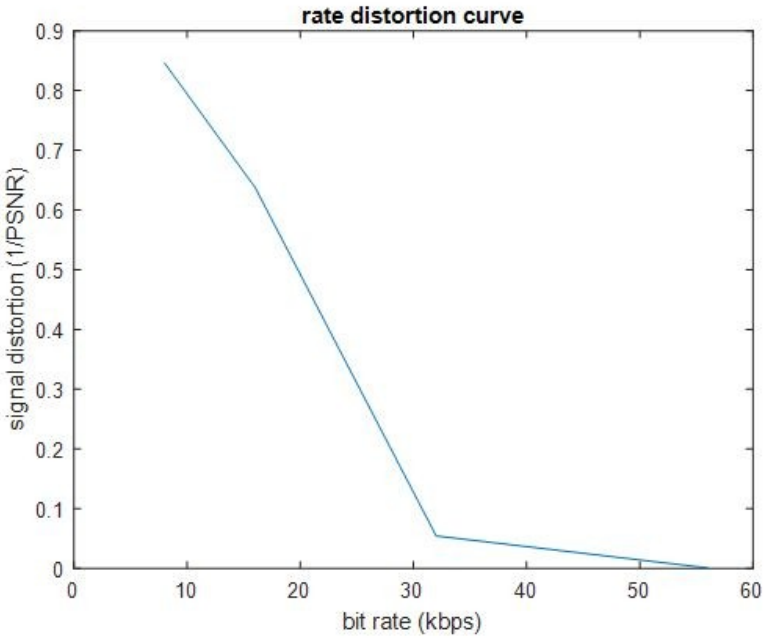


- The autocorrelation is influenced by the number of quantization levels. The samples in the error signal appear to be correlated with each other due to the positive autocorrelation displayed.
- The number of quantization levels influence the cross-correlation.

3.4.2 Signal to Noise Ratio

INLAB REPORT: Hand in a list of the 4 PSNR values, and the rate-distortion curve.

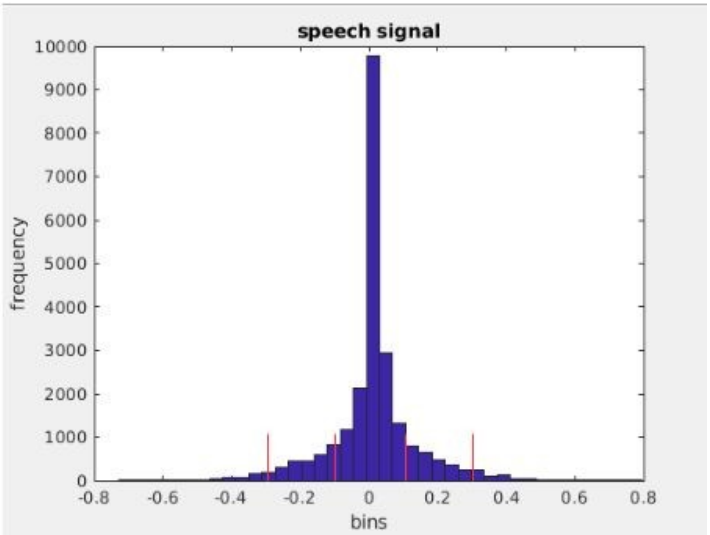
```
PSNR7bs =

    1.4028e+03


PSNR4bs =

    17.1705


PSNR2bs =

     1.5692


PSNR1bs =

     1.1846
```



3.5.2 Implementation, Error Analysis and Comparison

INLAB REPORT:

1. Turn in the histogram plot with the codebook superimposed.
2. Compare the PSNR and sound quality of the uniform- and Max-quantized signals.
3. If the speech signal was uniformly distributed, would the two quantizers be the same? Explain your answer.




```
codebook =

   -0.2738   -0.0817    0.0303    0.2716


PSNR =

    4.5983
```

- The max-quantized signal has a higher PSNR than that for the 2 and 1 b/sample signals, but lower than those of the 7 and 4 b/sample signals. The noise for the uniform signals is more uniform and has a static background-like nature, whereas the noise of the max-quantized signal occurs more in sharp bursts, accentuated with every syllable uttered.
- The two quantizers would be the same since the codebooks and partitions for both would be the same. This is because the area under the resulting horizontally-flat histogram is now constant for every uniform interval along the horizontal axis.