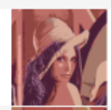
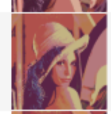
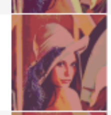
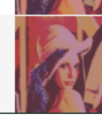
# Method

I quantize either in RGB (C=1) or YUV (C=2) and always evaluate quality back in RGB. The error metric follows the assignment: AbsErr = $\Sigma|orig - out|$ over all pixels & channels. For context I also report MSE and PSNR. A round-trip RGB→YUV→RGB with 8/8/8 yields MSE ≈ 0 in my implementation.

# Lowest AbsErr settings

For each (N, C, M) I list the lowest-error tuple from my sweep. For N=4, I include the output images; for N=6 and N=8, only numbers are required by the spec. The tables below list the top four configurations by AbsErr (lowest first) for each N. Complete per-tuple results are included at the end. N=4 shows images; N=6/8 show metrics only.

Winners

| N | C | M | Q1 | Q2 | Q3 | AbsErr | MSE | PSNR | Out |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 2 | 2 | 4 | 2 | 2 | 3803049 | 38.895255 | 32.232 | |
| 8 | 2 | 2 | 4 | 3 | 1 | 4324774 | 51.933606 | 30.976 | |
| 8 | 2 | 2 | 5 | 2 | 1 | 4505464 | 54.544266 | 30.763 | |
| 8 | 2 | 2 | 4 | 1 | 3 | 4620292 | 71.365888 | 29.596 | |
| 6 | 2 | 2 | 3 | 2 | 1 | 5949618 | 91.002986 | 28.54 | |
| 6 | 2 | 2 | 4 | 1 | 1 | 6118439 | 102.102444 | 28.04 | |
| 6 | 2 | 2 | 3 | 1 | 2 | 6260240 | 106.124987 | 27.873 | |
| 6 | 1 | 2 | 2 | 2 | 2 | 7665772 | 140.898376 | 26.642 | |
| 4 | 2 | 2 | 2 | 1 | 1 | 9645316 | 233.614253 | 24.446 |  |
| 4 | 1 | 2 | 1 | 2 | 1 | 12446175 | 366.224829 | 22.493 |  |
| 4 | 1 | 2 | 2 | 1 | 1 | 13357974 | 463.186328 | 21.473 |  |
| 4 | 1 | 2 | 1 | 1 | 2 | 13685675 | 495.759991 | 21.178 |  |

# Discussion of Results

## Case 1: C=1, M=1 (RGB + Uniform)

Uniform bins don't adapt to the data, so starving any channel hurts. As the budget grows, balanced splits minimize error: at N=6 the winner is (2,2,2), and at N=8 it's (2,3,3). With the very tight N=4 budget, (1,2,1) edges out the other RGB uniform splits, but the general trend remains: balance helps once you have a few more bits to spread.

### Case 2: C=1, M=2 (RGB + Smart)

Data-adaptive quantization consistently improves over uniform at the same N. Balanced allocations remain best: (2,2,2) wins at N=6 and (3,3,2) at N=8, both with clearly lower AbsErr and higher PSNR than uniform. Even at N=4, (1,2,1) leads the RGB smart group.

### Case 3: C=2, M=1 (YUV + Uniform)

The best rows bias bits toward Y: (2,1,1) at N=4, (3,2,1) at N=6, and (4,2,2) at N=8. That matches perception—structure and edges are largely luminance—yet uniform chroma bins still waste bits where U/V are sparse, so errors remain higher than smart.

### Case 4: C=2, M=2 (YUV + Smart)

Luminance-heavy splits are strongest here too: (2,1,1) at N=4, (3,2,1) at N=6, and (4,2,2) at N=8. With enough total bits, this Y-heavy strategy yields the lowest AbsErr overall (e.g., (4,2,2) at N=8), preserving structure while keeping enough chroma precision to avoid hue shifts.

### Overall Conclusion

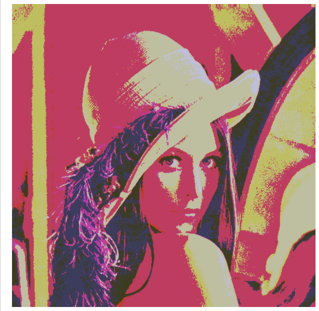
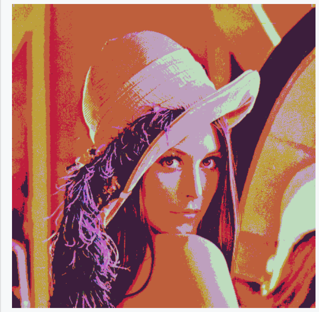
Smart consistently beats uniform at the same N. With very tight budgets, YUV + smart with a Y bias is best by AbsErr. As N increases, YUV + smart with more bits on Y continues to lead on AbsErr (e.g., (3,2,1) at N=6, (4,2,2) at N=8), while RGB + smart (balanced) remains a very strong runner-up and visually neutral. A simple rule that works well: use smart quantization; in YUV, steer extra bits to Y; in RGB, keep bits roughly balanced.

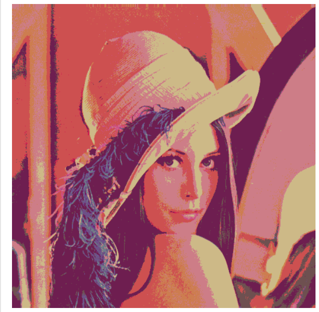
## What I’m submitting

- N=4 table with images and N=6/N=8 tables with error numbers, all directly from analysis.csv (sorted by AbsErr ascending per N).
- This narrative section referencing the lowest-error tuples above.
- Reproducibility: the CSV was generated by my Analysis target; N=4 PNGs are named as shown in the table.
- Link to spreadsheet with all analysis and images
- Link to Google doc of this analysis which contains image embeds

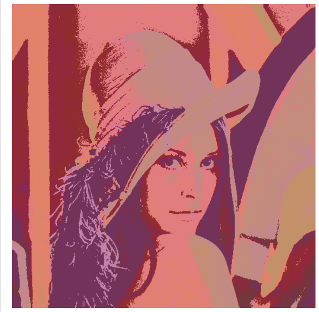
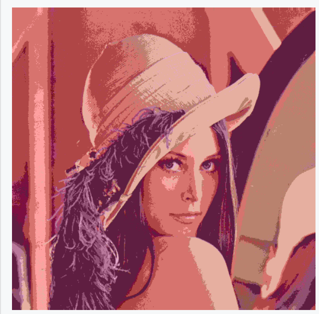
N = 4

| N | C | M | Q1 | Q2 | Q3 | AbsErr | MSE | PSNR | Out |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 1 | 1 | 1 | 2 | 20155030 | 921.748866 | 18.485 |  |
| 4 | 1 | 1 | 1 | 2 | 1 | 19402808 | 881.191981 | 18.68 |  |
| 4 | 1 | 1 | 2 | 1 | 1 | 19664322 | 964.654627 | 18.287 |  |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 2 | 1 | 1 | 2 | 13685675 | 495.759991 | 21.178 |  |
| 4 | 1 | 2 | 1 | 2 | 1 | 12446175 | 366.224829 | 22.493 |  |
| 4 | 1 | 2 | 2 | 1 | 1 | 13357974 | 463.186328 | 21.473 |  |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 2 | 1 | 1 | 1 | 2 | 23754460 | 1357.980021 | 16.802 |  |
| 4 | 2 | 1 | 1 | 2 | 1 | 23840711 | 1199.288174 | 17.342 |  |
| 4 | 2 | 1 | 2 | 1 | 1 | 16691323 | 671.646036 | 19.859 |  |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 2 | 2 | 1 | 1 | 2 | 18066996 | 736.881994 | 19.457 |  |
| 4 | 2 | 2 | 1 | 2 | 1 | 17639663 | 709.752603 | 19.62 |  |
| 4 | 2 | 2 | 2 | 1 | 1 | 9645316 | 233.614253 | 24.446 |  |

N = 6

| N | C | M | Q1 | Q2 | Q3 | AbsErr | MSE | PSNR |
|---|---|---|---|---|---|---|---|---|
| 6 | 1 | 1 | 1 | 1 | 4 | 16705026 | 800.596624 | 19.097 |
| 6 | 1 | 1 | 1 | 2 | 3 | 13757406 | 486.573939 | 21.259 |
| 6 | 1 | 1 | 1 | 3 | 2 | 13955956 | 496.903488 | 21.168 |
| 6 | 1 | 1 | 1 | 4 | 1 | 16210078 | 771.494553 | 19.257 |
| 6 | 1 | 1 | 2 | 1 | 3 | 14018920 | 570.036585 | 20.572 |
| 6 | 1 | 1 | 2 | 2 | 2 | 12230628 | 330.471603 | 22.939 |
| 6 | 1 | 1 | 2 | 3 | 1 | 13465248 | 539.80925 | 20.808 |
| 6 | 1 | 1 | 3 | 1 | 2 | 14928880 | 611.456426 | 20.267 |
| 6 | 1 | 1 | 3 | 2 | 1 | 14176658 | 570.899541 | 20.565 |
| 6 | 1 | 1 | 4 | 1 | 1 | 17275616 | 887.118963 | 18.651 |
| 6 | 1 | 2 | 1 | 1 | 4 | 12237283 | 468.906254 | 21.42 |
| 6 | 1 | 2 | 1 | 2 | 3 | 9284685 | 248.81201 | 24.172 |
| 6 | 1 | 2 | 1 | 3 | 2 | 8658057 | 221.03749 | 24.686 |
| 6 | 1 | 2 | 1 | 4 | 1 | 10125308 | 305.025625 | 23.287 |
| 6 | 1 | 2 | 2 | 1 | 3 | 10196484 | 345.773509 | 22.743 |
| 6 | 1 | 2 | 2 | 2 | 2 | 7665772 | 140.898376 | 26.642 |
| 6 | 1 | 2 | 2 | 3 | 1 | 8330356 | 188.463826 | 25.379 |
| 6 | 1 | 2 | 3 | 1 | 2 | 9917898 | 334.731829 | 22.884 |
| 6 | 1 | 2 | 3 | 2 | 1 | 8678398 | 205.196668 | 25.009 |
| 6 | 1 | 2 | 4 | 1 | 1 | 11564910 | 422.638964 | 21.871 |
| 6 | 2 | 1 | 1 | 1 | 4 | 23628916 | 1326.677485 | 16.903 |
| 6 | 2 | 1 | 1 | 2 | 3 | 23874581 | 1161.35456 | 17.481 |
| 6 | 2 | 1 | 1 | 3 | 2 | 22531885 | 1073.382964 | 17.823 |
| 6 | 2 | 1 | 1 | 4 | 1 | 22421624 | 1074.703369 | 17.818 |
| 6 | 2 | 1 | 2 | 1 | 3 | 14337241 | 543.46247 | 20.779 |
| 6 | 2 | 1 | 2 | 2 | 2 | 11488631 | 317.909054 | 23.108 |
| 6 | 2 | 1 | 2 | 3 | 1 | 12599283 | 372.56831 | 22.419 |
| 6 | 2 | 1 | 3 | 1 | 2 | 11973879 | 400.309172 | 22.107 |
| 6 | 2 | 1 | 3 | 2 | 1 | 10021168 | 251.333227 | 24.128 |
| 6 | 2 | 1 | 4 | 1 | 1 | 13612608 | 455.30556 | 21.548 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | 2 | 2 | 1 | 1 | 4 | 18039000 | 734.496648 | 19.471 |
| 6 | 2 | 2 | 1 | 2 | 3 | 17680564 | 703.938886 | 19.655 |
| 6 | 2 | 2 | 1 | 3 | 2 | 17621430 | 697.886215 | 19.693 |
| 6 | 2 | 2 | 1 | 4 | 1 | 17493051 | 695.883068 | 19.705 |
| 6 | 2 | 2 | 2 | 1 | 3 | 9252776 | 209.746943 | 24.914 |
| 6 | 2 | 2 | 2 | 2 | 2 | 9002019 | 188.477103 | 25.378 |
| 6 | 2 | 2 | 2 | 3 | 1 | 9037676 | 193.578807 | 25.262 |
| 6 | 2 | 2 | 3 | 1 | 2 | 6260240 | 106.124987 | 27.873 |
| 6 | 2 | 2 | 3 | 2 | 1 | 5949618 | 91.002986 | 28.54 |
| 6 | 2 | 2 | 4 | 1 | 1 | 6118439 | 102.102444 | 28.04 |

N = 8

| N | C | M | Q1 | Q2 | Q3 | AbsErr | MSE | PSNR |
|---|---|---|---|---|---|---|---|---|
| 8 | 1 | 1 | 1 | 1 | 6 | 15915842 | 793.908529 | 19.133 |
| 8 | 1 | 1 | 1 | 2 | 5 | 12085312 | 457.870682 | 21.523 |
| 8 | 1 | 1 | 1 | 3 | 4 | 10505952 | 375.751246 | 22.382 |
| 8 | 1 | 1 | 1 | 4 | 3 | 10564676 | 376.876511 | 22.369 |
| 8 | 1 | 1 | 1 | 5 | 2 | 12343920 | 469.290756 | 21.416 |
| 8 | 1 | 1 | 1 | 6 | 1 | 15422758 | 764.747564 | 19.296 |
| 8 | 1 | 1 | 2 | 1 | 5 | 12346826 | 541.333328 | 20.796 |
| 8 | 1 | 1 | 2 | 2 | 4 | 8780624 | 209.319361 | 24.923 |
| 8 | 1 | 1 | 2 | 3 | 3 | 7819846 | 145.191208 | 26.511 |
| 8 | 1 | 1 | 2 | 4 | 2 | 9037898 | 220.774175 | 24.691 |
| 8 | 1 | 1 | 2 | 5 | 1 | 11853212 | 512.196518 | 21.036 |
| 8 | 1 | 1 | 3 | 1 | 4 | 11478876 | 490.304184 | 21.226 |
| 8 | 1 | 1 | 3 | 2 | 3 | 8531256 | 176.281499 | 25.669 |
| 8 | 1 | 1 | 3 | 3 | 2 | 8729806 | 186.611048 | 25.421 |
| 8 | 1 | 1 | 3 | 4 | 1 | 10983928 | 461.202113 | 21.492 |
| 8 | 1 | 1 | 4 | 1 | 3 | 11630214 | 492.500921 | 21.207 |
| 8 | 1 | 1 | 4 | 2 | 2 | 9841922 | 252.935939 | 24.101 |
| 8 | 1 | 1 | 4 | 3 | 1 | 11076542 | 462.273585 | 21.482 |
| 8 | 1 | 1 | 5 | 1 | 2 | 13367756 | 584.508784 | 20.463 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 1 | 1 | 5 | 2 | 1 | 12615534 | 543.951899 | 20.775 |
| 8 | 1 | 1 | 6 | 1 | 1 | 16445124 | 879.974508 | 18.686 |
| 8 | 1 | 2 | 1 | 1 | 6 | 11816707 | 466.117303 | 21.446 |
| 8 | 1 | 2 | 1 | 2 | 5 | 8503397 | 240.941639 | 24.312 |
| 8 | 1 | 2 | 1 | 3 | 4 | 7209665 | 194.183753 | 25.249 |
| 8 | 1 | 2 | 1 | 4 | 3 | 6963818 | 187.612806 | 25.398 |
| 8 | 1 | 2 | 1 | 5 | 2 | 7505214 | 205.149694 | 25.01 |
| 8 | 1 | 2 | 1 | 6 | 1 | 9521187 | 300.417645 | 23.354 |
| 8 | 1 | 2 | 2 | 1 | 5 | 9415196 | 337.903137 | 22.843 |
| 8 | 1 | 2 | 2 | 2 | 4 | 6217380 | 114.04464 | 27.56 |
| 8 | 1 | 2 | 2 | 3 | 3 | 5168866 | 71.051008 | 29.615 |
| 8 | 1 | 2 | 2 | 4 | 2 | 5344905 | 79.699172 | 29.116 |
| 8 | 1 | 2 | 2 | 5 | 1 | 7177513 | 172.576031 | 25.761 |
| 8 | 1 | 2 | 3 | 1 | 4 | 8469506 | 307.878092 | 23.247 |
| 8 | 1 | 2 | 3 | 2 | 3 | 5516908 | 87.783849 | 28.697 |
| 8 | 1 | 2 | 3 | 3 | 2 | 4890280 | 60.009328 | 30.349 |
| 8 | 1 | 2 | 3 | 4 | 1 | 6357531 | 143.997463 | 26.547 |
| 8 | 1 | 2 | 4 | 1 | 3 | 8403420 | 305.226145 | 23.285 |
| 8 | 1 | 2 | 4 | 2 | 2 | 5872708 | 100.351013 | 28.116 |
| 8 | 1 | 2 | 4 | 3 | 1 | 6537292 | 147.916463 | 26.431 |
| 8 | 1 | 2 | 5 | 1 | 2 | 9003697 | 323.500075 | 23.032 |
| 8 | 1 | 2 | 5 | 2 | 1 | 7764197 | 193.964914 | 25.254 |
| 8 | 1 | 2 | 6 | 1 | 1 | 11046169 | 419.010985 | 21.909 |
| 8 | 2 | 1 | 1 | 1 | 6 | 23612289 | 1324.552377 | 16.91 |
| 8 | 2 | 1 | 1 | 2 | 5 | 23871742 | 1156.891833 | 17.498 |
| 8 | 2 | 1 | 1 | 3 | 4 | 22380588 | 1040.34152 | 17.959 |
| 8 | 2 | 1 | 1 | 4 | 3 | 22393745 | 1030.146114 | 18.002 |
| 8 | 2 | 1 | 1 | 5 | 2 | 22523220 | 1054.301727 | 17.901 |
| 8 | 2 | 1 | 1 | 6 | 1 | 22377156 | 1067.134201 | 17.849 |
| 8 | 2 | 1 | 2 | 1 | 5 | 14197367 | 535.740103 | 20.841 |
| 8 | 2 | 1 | 2 | 2 | 4 | 10972506 | 285.099584 | 23.581 |
| 8 | 2 | 1 | 2 | 3 | 3 | 10459317 | 254.665844 | 24.071 |
| 8 | 2 | 1 | 2 | 4 | 2 | 10541198 | 259.554688 | 23.989 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 2 | 1 | 2 | 5 | 1 | 12146590 | 344.823285 | 22.755 |
| 8 | 2 | 1 | 3 | 1 | 4 | 10980143 | 364.797586 | 22.51 |
| 8 | 2 | 1 | 3 | 2 | 3 | 7263170 | 136.807755 | 26.77 |
| 8 | 2 | 1 | 3 | 3 | 2 | 7180684 | 124.986186 | 27.162 |
| 8 | 2 | 1 | 3 | 4 | 1 | 8622341 | 193.388872 | 25.266 |
| 8 | 2 | 1 | 4 | 1 | 3 | 9778850 | 330.093984 | 22.944 |
| 8 | 2 | 1 | 4 | 2 | 2 | 6815764 | 119.013583 | 27.375 |
| 8 | 2 | 1 | 4 | 3 | 1 | 8121934 | 165.699028 | 25.938 |
| 8 | 2 | 1 | 5 | 1 | 2 | 10830412 | 347.096865 | 22.726 |
| 8 | 2 | 1 | 5 | 2 | 1 | 8807864 | 193.927625 | 25.254 |
| 8 | 2 | 1 | 6 | 1 | 1 | 13454729 | 440.349072 | 21.693 |
| 8 | 2 | 2 | 1 | 1 | 6 | 18024165 | 732.926177 | 19.48 |
| 8 | 2 | 2 | 1 | 2 | 5 | 17668144 | 702.501007 | 19.664 |
| 8 | 2 | 2 | 1 | 3 | 4 | 17591383 | 694.860124 | 19.712 |
| 8 | 2 | 2 | 1 | 4 | 3 | 17551754 | 692.305023 | 19.728 |
| 8 | 2 | 2 | 1 | 5 | 2 | 17571381 | 693.573243 | 19.72 |
| 8 | 2 | 2 | 1 | 6 | 1 | 17484002 | 695.085869 | 19.71 |
| 8 | 2 | 2 | 2 | 1 | 5 | 9205150 | 207.399437 | 24.963 |
| 8 | 2 | 2 | 2 | 2 | 4 | 8832952 | 178.468877 | 25.615 |
| 8 | 2 | 2 | 2 | 3 | 3 | 8628687 | 169.335954 | 25.843 |
| 8 | 2 | 2 | 2 | 4 | 2 | 8686945 | 173.66177 | 25.734 |
| 8 | 2 | 2 | 2 | 5 | 1 | 8951477 | 188.992596 | 25.366 |
| 8 | 2 | 2 | 3 | 1 | 4 | 5873936 | 96.430478 | 28.289 |
| 8 | 2 | 2 | 3 | 2 | 3 | 4880907 | 60.266689 | 30.33 |
| 8 | 2 | 2 | 3 | 3 | 2 | 4847146 | 57.83239 | 30.509 |
| 8 | 2 | 2 | 3 | 4 | 1 | 5500209 | 78.046678 | 29.207 |
| 8 | 2 | 2 | 4 | 1 | 3 | 4620292 | 71.365888 | 29.596 |
| 8 | 2 | 2 | 4 | 2 | 2 | 3803049 | 38.895255 | 32.232 |
| 8 | 2 | 2 | 4 | 3 | 1 | 4324774 | 51.933606 | 30.976 |
| 8 | 2 | 2 | 5 | 1 | 2 | 4671411 | 70.257348 | 29.664 |
| 8 | 2 | 2 | 5 | 2 | 1 | 4505464 | 54.544266 | 30.763 |
| 8 | 2 | 2 | 6 | 1 | 1 | 5793527 | 92.093876 | 28.488 |