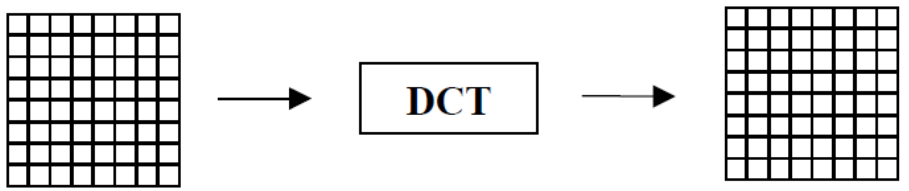
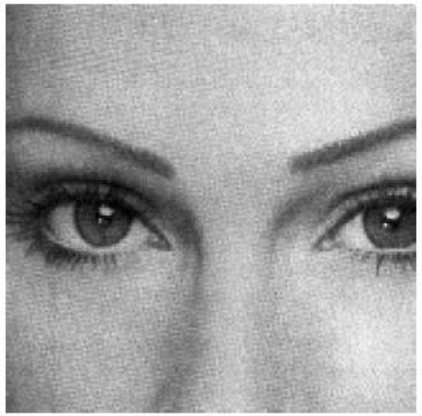
# DCT & Quantizer

# DCT

- The DCT transform of an image brings out a set of numbers called coefficients.
- A coefficient's usefulness is determined by its variance over a set of images as in video's case.
- If a coefficient has a lot of variance over a set, then it cannot be removed without affecting the picture quality.

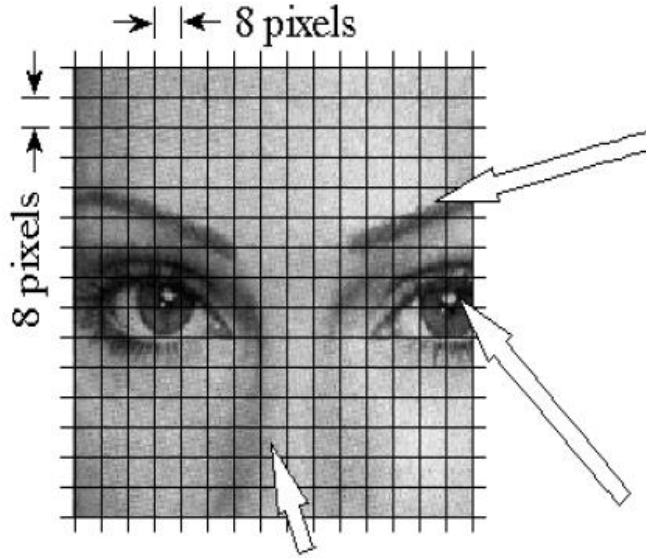




Original Image

Recovered Image

(Notice Lesser Image Quality)




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 154 | 154 | 175 | 182 | 189 | 168 | 217 | 175 |
| 154 | 147 | 168 | 154 | 168 | 168 | 196 | 175 |
| 175 | 154 | 203 | 175 | 189 | 182 | 196 | 182 |
| 175 | 168 | 168 | 168 | 140 | 175 | 168 | 203 |
| 133 | 168 | 154 | 196 | 175 | 189 | 203 | 154 |
| 168 | 161 | 161 | 168 | 154 | 154 | 189 | 189 |
| 147 | 161 | 175 | 182 | 189 | 175 | 217 | 175 |
| 175 | 175 | 203 | 175 | 189 | 175 | 175 | 182 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 231 | 224 | 224 | 217 | 217 | 203 | 189 | 196 |
| 210 | 217 | 203 | 189 | 203 | 224 | 217 | 224 |
| 196 | 217 | 210 | 224 | 203 | 203 | 196 | 189 |
| 210 | 203 | 196 | 203 | 182 | 203 | 182 | 189 |
| 203 | 224 | 203 | 217 | 196 | 175 | 154 | 140 |
| 182 | 189 | 168 | 161 | 154 | 126 | 119 | 112 |
| 175 | 154 | 126 | 105 | 140 | 105 | 119 | 84 |
| 154 | 98 | 105 | 98 | 105 | 63 | 112 | 84 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 42 | 28 | 35 | 28 | 42 | 49 | 35 | 42 |
| 49 | 49 | 35 | 28 | 35 | 35 | 35 | 42 |
| 42 | 21 | 21 | 28 | 42 | 35 | 42 | 28 |
| 21 | 35 | 35 | 42 | 42 | 28 | 28 | 14 |
| 56 | 70 | 77 | 84 | 91 | 28 | 28 | 21 |
| 70 | 126 | 133 | 147 | 161 | 91 | 35 | 14 |
| 126 | 203 | 189 | 182 | 175 | 175 | 35 | 21 |
| 49 | 189 | 245 | 210 | 182 | 84 | 21 | 35 |

The image is broken into 8x8 groups, each containing 64 pixels. Three of these 8x8 groups are enlarged in this figure, showing the values of the individual pixels, a single byte value between 0 and 255.

**DCT**

**Frequency Coefficients Compared to Magnitude Thresholds Resulting in Compressed Data Streams**

# Quantizer

- this saves a lot of bits, but we no longer have an exact replica of original image block

**DCT**

$$\begin{bmatrix} -415 & -30 & -61 & 27 & 56 & -20 & -2 & 0 \\ 4 & -22 & -61 & 10 & 13 & -7 & -9 & 5 \\ -47 & 7 & 77 & -25 & -29 & 10 & 5 & -6 \\ -49 & 12 & 34 & -15 & -10 & 6 & 2 & 2 \\ 12 & -7 & -13 & -4 & -2 & 2 & -3 & 3 \\ -8 & 3 & 2 & -6 & -2 & 1 & 4 & 2 \\ -1 & 0 & 0 & -2 & -1 & -3 & 4 & -1 \\ 0 & 0 & -1 & -4 & -1 & 0 & 1 & 2 \end{bmatrix}$$

→

**quantized DCT**

$$\begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

**inverse DCT** ←

$$\begin{bmatrix} 60 & 63 & 55 & 58 & 70 & 61 & 58 & 80 \\ 58 & 56 & 56 & 83 & 108 & 88 & 63 & 71 \\ 60 & 52 & 62 & 113 & 150 & 116 & 70 & 67 \\ 66 & 56 & 68 & 122 & 156 & 116 & 69 & 72 \\ 69 & 62 & 65 & 100 & 120 & 86 & 59 & 76 \\ 68 & 68 & 61 & 68 & 78 & 60 & 53 & 78 \\ 74 & 82 & 67 & 54 & 63 & 64 & 65 & 83 \\ 83 & 96 & 77 & 56 & 70 & 83 & 83 & 89 \end{bmatrix}$$

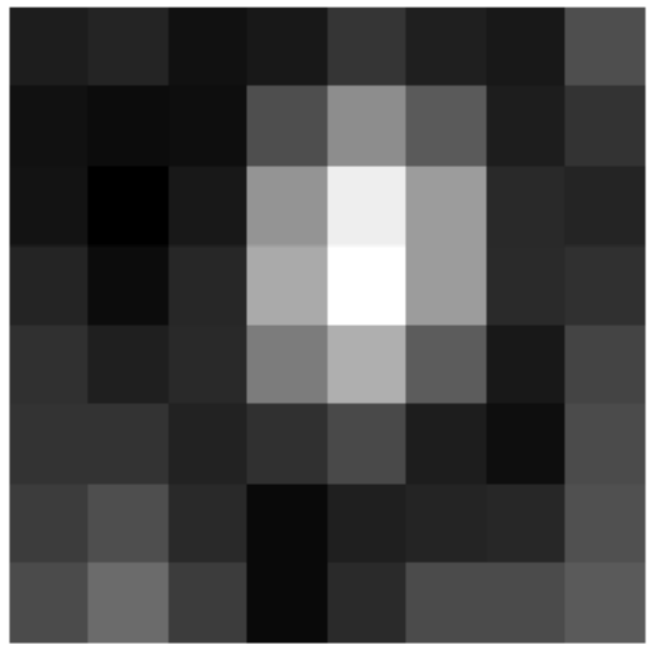
$\neq$

**original pixels**

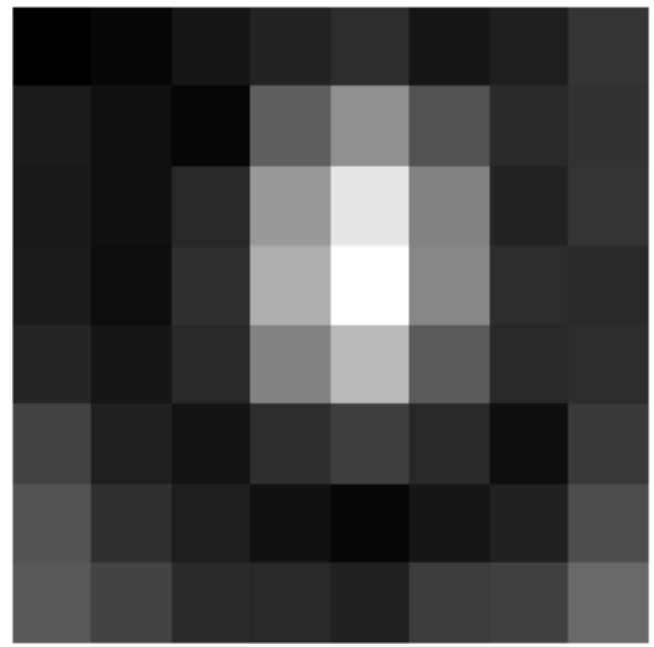
$$\begin{bmatrix} 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\ 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\ 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\ 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\ 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\ 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\ 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \end{bmatrix}$$

note, however, that visually the blocks are not very different

**original**



**decompressed**

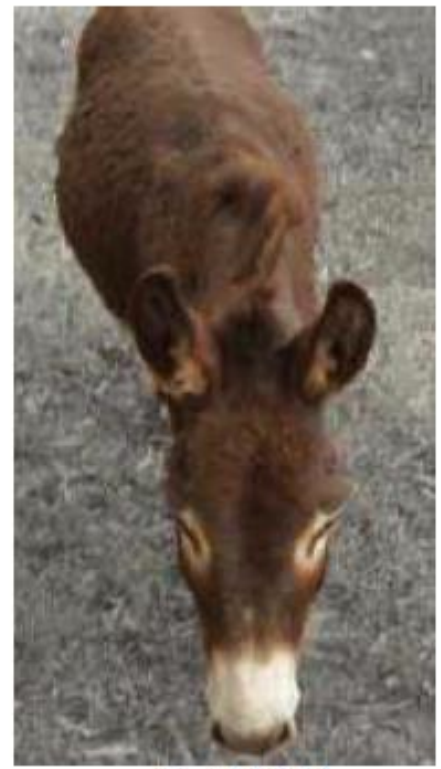


- we have saved lots of bits without much “perceptual” loss
- this is the reason why JPEG and MPEG work

# Image compression

- three JPEG examples

36KB



5.7KB

1.7KB

  - note that the blockiness is more visible in the torso