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Haar Wavelet Image Compression

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What Does It Accomplish?

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- Storage
 - Local
 - Archiving
- Transmission Rates
 - Mobile Data
 - Long Distance Transfer



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What Can You Compress?

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■ Lossy

■ Video

- Can transmit only changes
- H.264 vs H.265: 180 GB vs 75 GB

■ Audio

- Silent sections can be lower bitrate
- FLAC vs MP3: 300 MB vs 100 MB

■ Lossless

- Text
- General "non consumable" files



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- Consider a $N \times M$ matrix A (N, M even)



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- Consider a $N \times M$ matrix A (N, M even)
- Elements A_{nm} represent pixels in an image



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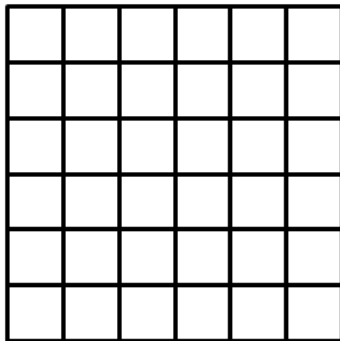
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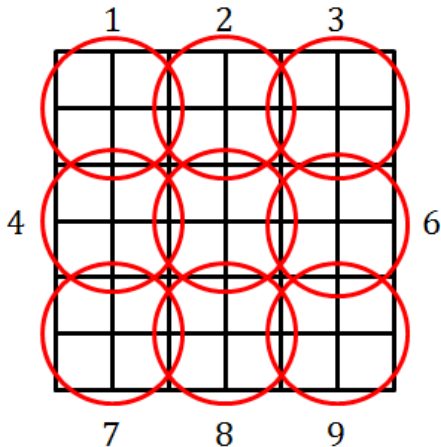
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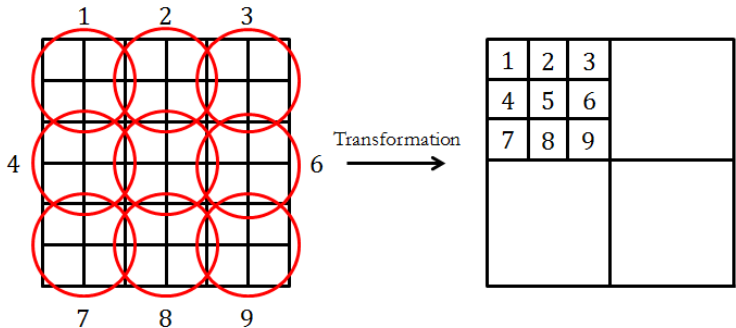
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- How to construct mathematically? Matrix multiplication!



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- How to construct mathematically? Matrix multiplication!

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$



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- How to construct mathematically? Matrix multiplication!

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

- Define a transformation matrix

$$\begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix}$$



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- How to construct mathematically? Matrix multiplication!

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

- Define a transformation matrix

$$\begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix}$$

- Then

$$\begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} \sqrt{2}/2 & -\sqrt{2}/2 \\ \sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix} = 2 \cdot \begin{bmatrix} \frac{a+b+c+d}{4} & \frac{b+d-a-c}{4} \\ \frac{c+d-a-b}{4} & \frac{a+d-b-c}{4} \end{bmatrix}$$



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■ General transformation matrix

$$W_N = \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & \sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & -\sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix}$$



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■ General transformation matrix

$$W_N = \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & \sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & -\sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix}$$

■ W_N orthogonal $\Rightarrow W_N^{-1} = W_N^T$

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■ General transformation matrix

$$W_N = \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & \sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & \sqrt{2}/2 & \sqrt{2}/2 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & -\sqrt{2}/2 & \sqrt{2}/2 & \dots & 0 & 0 \\ \vdots & & & & \ddots & & \vdots \\ 0 & 0 & 0 & 0 & \dots & -\sqrt{2}/2 & \sqrt{2}/2 \end{bmatrix}$$

■ W_N orthogonal $\Rightarrow W_N^{-1} = W_N^T$

■ A original image then compressed image contained in

$$B = W_N A W_M^T$$

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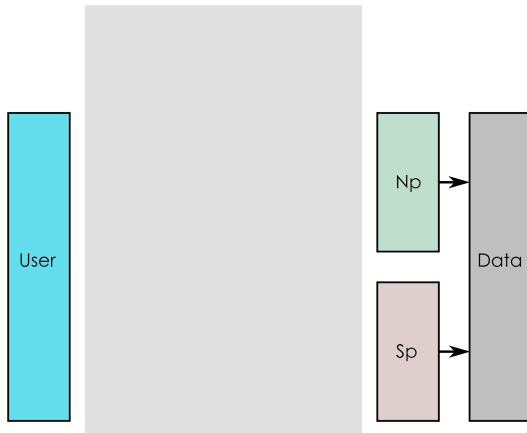
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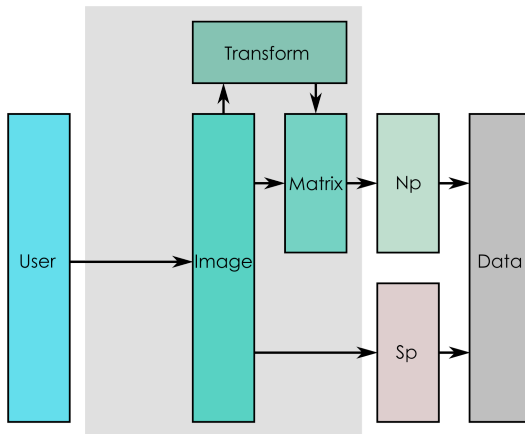
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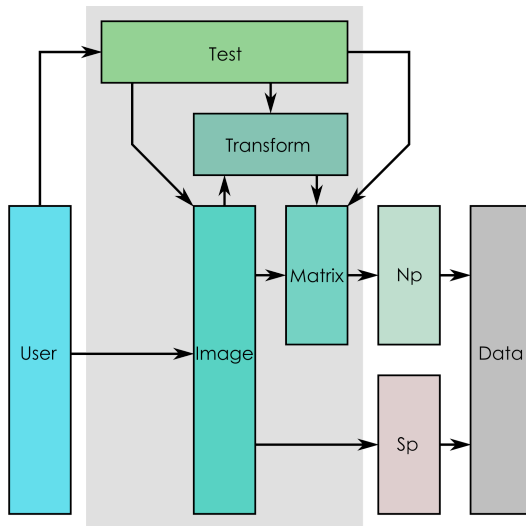
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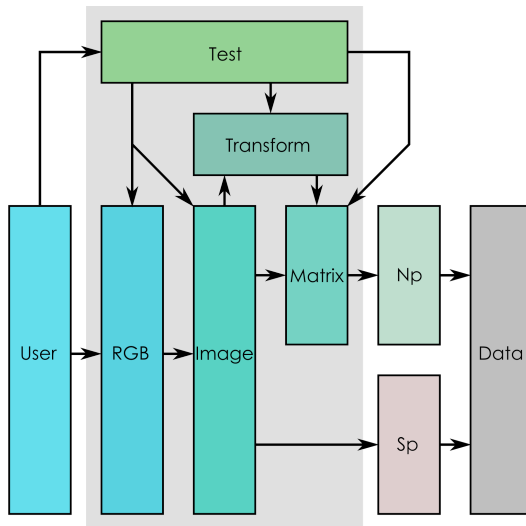
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A problem has been detected and windows has been shut down to prevent damage to your computer.

PFN_LIST_CORRUPT

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

*** STOP: 0x0000004e (0x00000099, 0x00900009, 0x00000900, 0x00000900)

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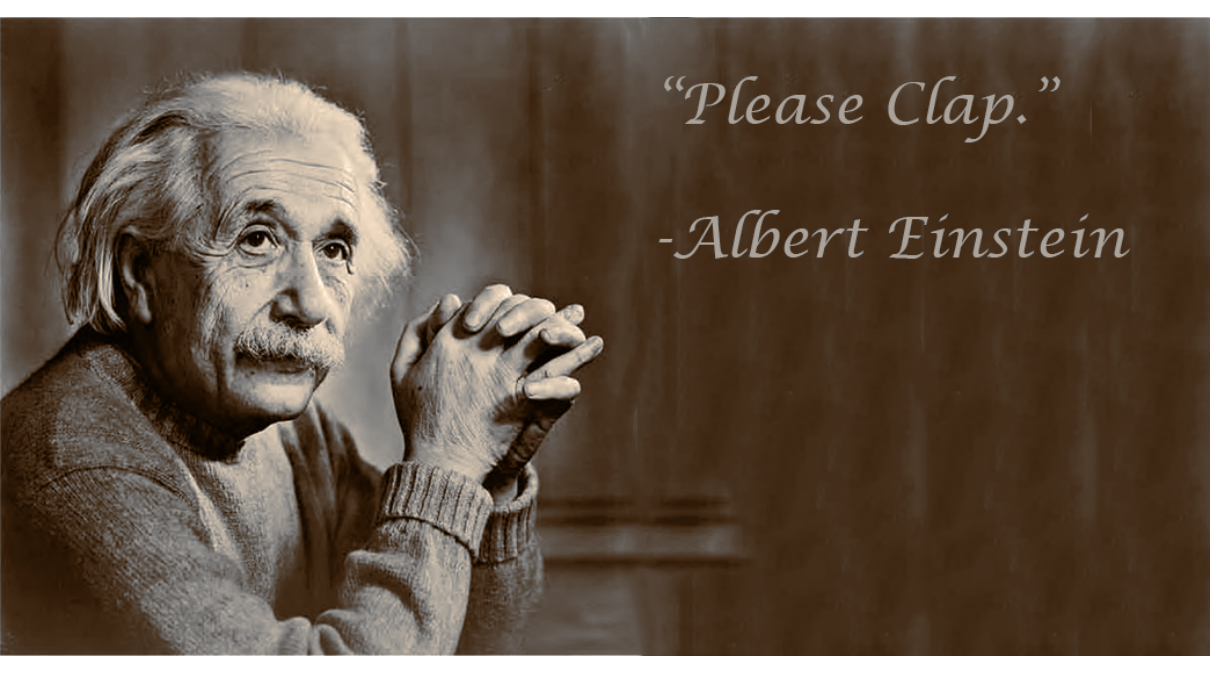
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Summary

- It's quick
- It's easy
- No (longterm) loss of quality



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"Please Clap."

-Albert Einstein