Lossy compression methods

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Overview

Overview

Generally on lossy compression

Lossy compression provides better compression rate than lossless methods, but the original data cannot be fully reconstructed from compressed. The reconstructed data will contain less information than the original. Biological and physical aspects will decide which and how much information to drop.
There are two basic types:

- Lossy transform codecs : samples are taken, transformed into a new basis space, and quantized. The resulting quantized values are then entropy coded. (e.g. Huffman algorithm)
- Lossy predictive codecs : every datapoint is estimated as the linear combination of the others. Error is stored in some way.

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What's the difference?

When we compress human voice (like in the case of phones), the point is to keep the speech understandable . Enjoying it is not important. But when we compress music, or sound layers of a movie, we have to maintain the sound quality .
Some types of speech compression (just by name):

- CELP
- G.711
- G.726
- AMR
- Speex

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Music compression

Some types of music compression (just by name):

- AAC
- ADPCM
- ATRAC
- Dolby AC-3
- MP2
- MP3
- Musepack (based on Musicam)
- Ogg Vorbis (noted for its lack of patent restrictions)
- WMA (Microsoft)

MP3

MP3 is the common name of MPEG-1 and MPEG-2 Audio Layer III . MPEG is a standard which has 3 layers. Each of them is a lossy audio compression with same quality but different compress rate. The most commonly used one is Layer 3, which is abbreviated as MP3. It provides the compress rate about 1:10.
The uncompressed data rate is 2 channels * 44100 samples/s * 16 bit = 1,41Mbit/s. Most commonly used bit rate by MP3 is 128 kbit/s. 4 kbit/s is the minimum for recognizable human speech, and 256-320 kbit/s is near to Audio CD quality.
MP3 uses psychoacoustic models to discard or reduce precision of components less audible to human hearing, and then records the remaining information in an efficient manner. It's basics:

- We cannot hear sounds below the frequency dependent hearing threshold .
- We cannot hear sounds out of our hearing range .
- Due to masking in frequency space we cannot hear the quieter of the two close sounds in frequency space .
- Similarly, due to masking in time we cannot hear the quieter of the two close sounds in time .

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Image compression

Some types of image compression (just by name):

- JPEG
- Wawelet
- JPEG2000
- DjVu (for scanned documents)
- ICER (used by Mars rover
- Fractal compression

JPEG

The term "JPEG" is an acronym for the Joint Photographic Experts Group , which created the standard in 1986. JPEG compression is based on Discrete Cosine Transform.

- In the first step the algorithm transforms the RGB colors to 3 special channels: YUV (one luminance and two color channels).
- Then it splits the image to 8 x 8 blocks . Each block is handled individually. They have 64 coefficients.
- Make Discrete Cosine Transform:

$$DCT(k,l) = \sum_{m=0}^{N-1}\sum_{n=0}^{N-1} q(m,n)\cdot\cos\left((2m+1)\cdot 2\cdot\pi\cdot\frac{k}{4N}\right)\times \\ \times\cos\left((2n+1)\cdot 2\cdot\pi\cdot\frac{l}{4N}\right)$$

Where N is the size of the block, q is the luminance value, and k, l, m, n are coordinates.

JPEG

- The amplitudes of the frequency components are quantized . Human vision is much more sensitive to small variations in color or brightness over large areas than to the strength of high-frequency brightness variations. Therefore, the magnitudes of the high-frequency components are stored with a lower accuracy than the low-frequency components.
- The resulting data for all 8 x 8 blocks is further compressed with a lossless algorithm, a variant of Huffman encoding.

JPEG

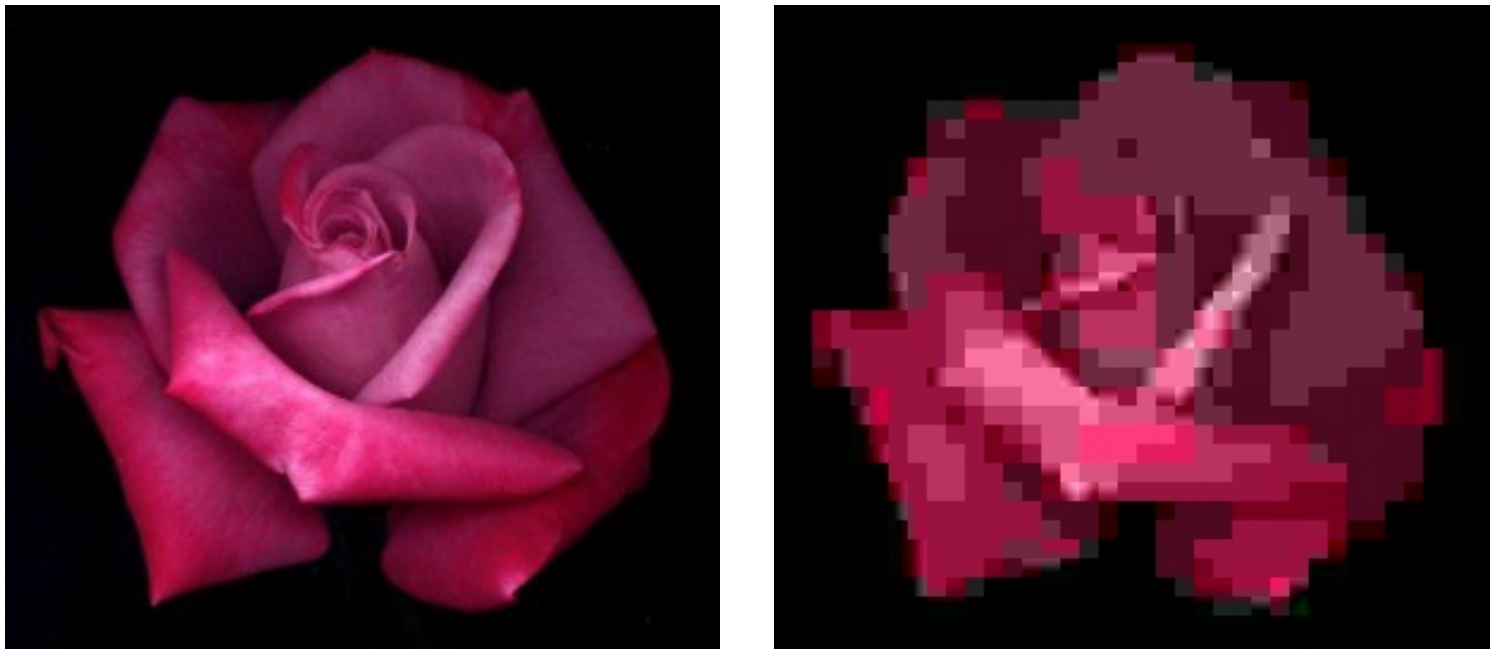

Figure : Examples for JPEG compression. The left picture has a 10% compression rate and is 11.6 kB while the right one has a 90% compression rate and is 1.2 kB. Note that the right picture is totally recognizable so the algorithm kept that 10% of the data which is important for the human brain.

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Video compression

Some types of video compression:

- H.261
- H.263
- H.264/MPEG-4 AVC
- Motion JPEG
- MPEG-1 Part 2
- MPEG-2 Part 2
- MPEG-4 Part 2
- Ogg Theora
- VC-1

Motion compensation

In a typical video the frames following each other are very similar. There is no need to store every one of them separately. We only store the substraction of the pictures, shifted to the same position. The difference image is compressed and stored.

Motion compensation

Figure : Full original frame, as shown on screen.

Motion compensation

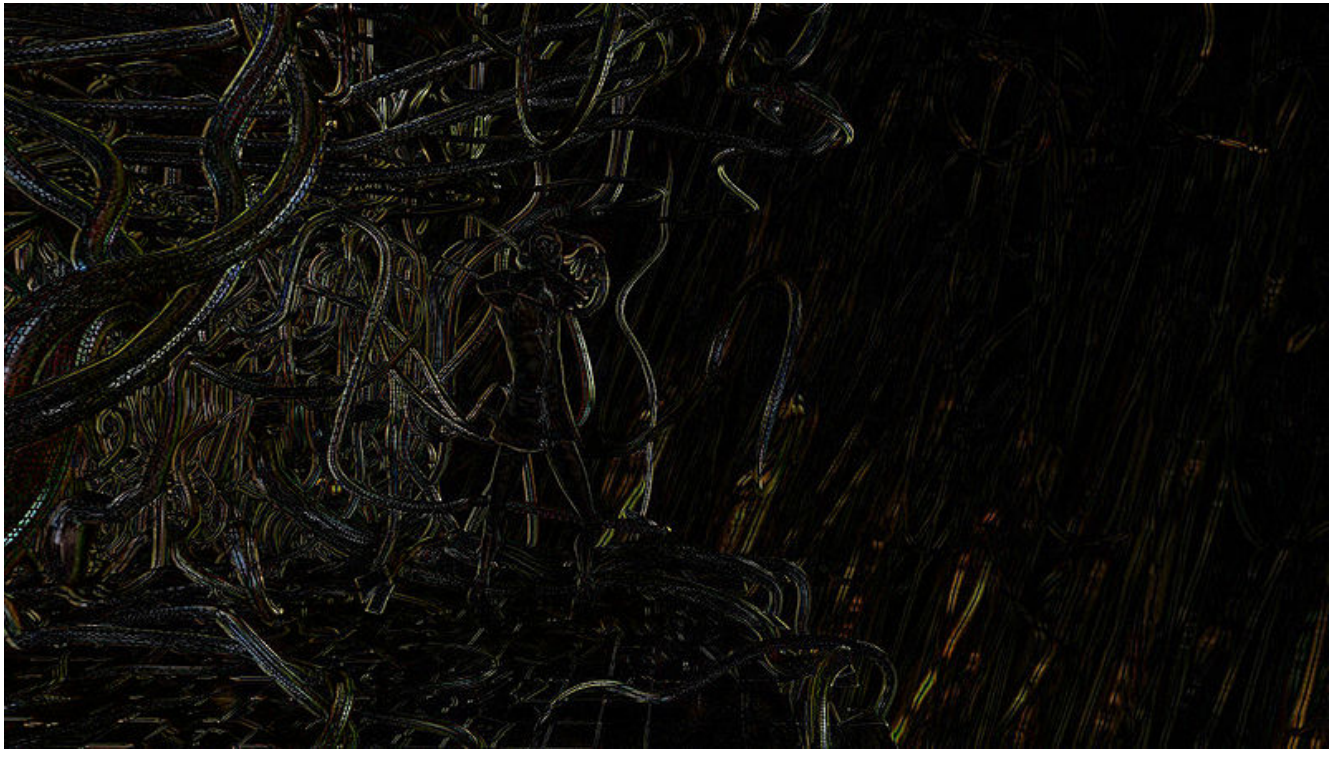

Figure : Differences between the original frame and the next frame.

Motion compensation

Figure : Differences between the original frame and the next frame, shifted right by 2 pixels. Shifting the frame compensates for the panning of the camera, thus there is greater overlap between the two frames.

Any questions?

Thank you for your attention! Credits:

- Tarcai Norbert: Veszteséges tömörítések
- http://en.wikipedia.org/wiki/Lossy_compression
- http://en.wikipedia.org/wiki/JPEG
- http://en.wikipedia.org/wiki/Motion_compensation