Introduction to Data Compression

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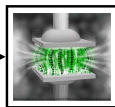
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Compression algorithm

Compressed data,
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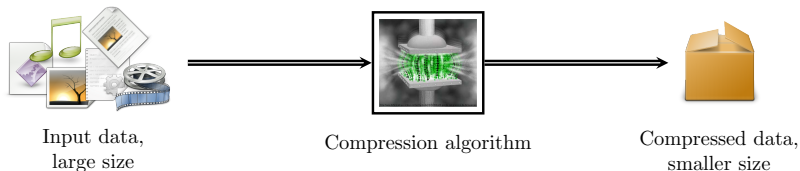

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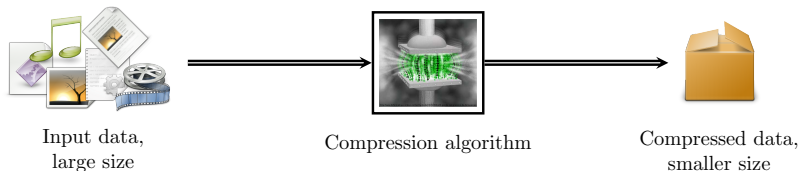
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Talking about data compression ⇔   talking about the compression
and
the decompression algorithm.

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Why does it matter?
An illustrative example

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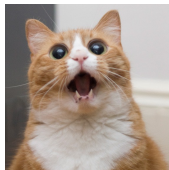
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Leading to a total weight of: $5400 \times 25 \times 1280 \times 720 \times 3 =$ 373 248 Mb.

$\simeq 80$ single-side, single-layer DVDs !

And that is not even considering the sound...

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Data compression is interesting for several reasons:

→ To save space/memory.

++ Particularly true in the early days of computer science, when memory was über costly (it nonetheless remains the case nowadays).

The IBM Model 350 disk file with a storage space of 5MB from 1956 and a Micro SD Card
Source: https://ourworldindata.org/technological-progress

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$\rightarrow$ To increase security.

$++$ Data compression and cryptography are strongly linked: a compressed data is illegible for anyone who does not possess the correct decompression algorithm.

$--$ However, a corrupted compressed file is irremediably lost (can be a problem for some applications).

A brief historical review

1838 Morse code can be considered as the first compression algorithm since frequent letters ('e','t') are given shorter support.

1948 Claude Shannon establishes the Information Theory with its seminal paper *A Mathematical Theory of Communication*, laying the mathematical basis for data compression and transmission.

1952 David Huffman publishes the encoding algorithm that is now named after him.

1977 Abraham Lempel and Jacob Ziv introduce LZ77 as the first adaptive compression algorithm.

1984 Terry Welch improves LZ77 to give birth to the LZW algorithm.

1980s Computing power and storage capacities increase, allowing for the manipulation of sound and images and calling for lossy compression algorithms.

1992 The first JPEG standard is released (still evolving nowadays).

1993 Following JPEG, the first MPEG-1 standard is completed.

Data compression
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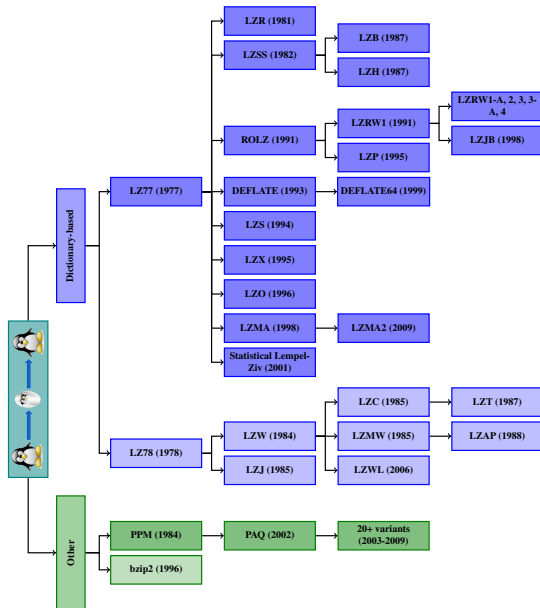

Lossy compression: discard some information during the compression/decompression process. Data after compression is not the same as before compression.

Lossless compression

→ Mature discipline (not so much research going on in the field nowadays).

→ Very efficient on noise-free data (such as text documents, executable files, etc), but performances degrade with noise.

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Lossy compression

→ Lossy compression algorithms assume that some part of the data to compress can be discarded, such that the human user won't notice the difference.

→ But how to evaluate which information is relevant and which one is redundant/useless in some data?

→ Well suited for sound and image compression, but not for text files (you may not want a piece of code to be altered after compression/decompression...).

→ Still an active field of research (wavelets, compressed sensing, etc).

high compression, bad quality   low compression, good quality

```
-rw-r--r-- 1 gtochon lrde 4,2K févr. 17 16:39 lemonhead_cat_highcompression.jpg
-rw-r--r-- 1 gtochon lrde  26K févr. 17 16:39 lemonhead_cat_lowcompression.jpg
```

General outline

1. Introduction

2. A flavor of Information Theory

3. Lossless compression algorithms
    - Run-length encoding algorithm
    - Huffman compression algorithm
    - bzip2 compression algorithm
    - LZW compression algorithm

4. Analog-to-digital conversion

5. Lossy compression algorithms
    - Some mathematical preliminaries to JPEG
    - JPEG compression algorithm for grayscale images
    - JPEG compression algorithm for color images
    - The one and only Principal Component Analysis