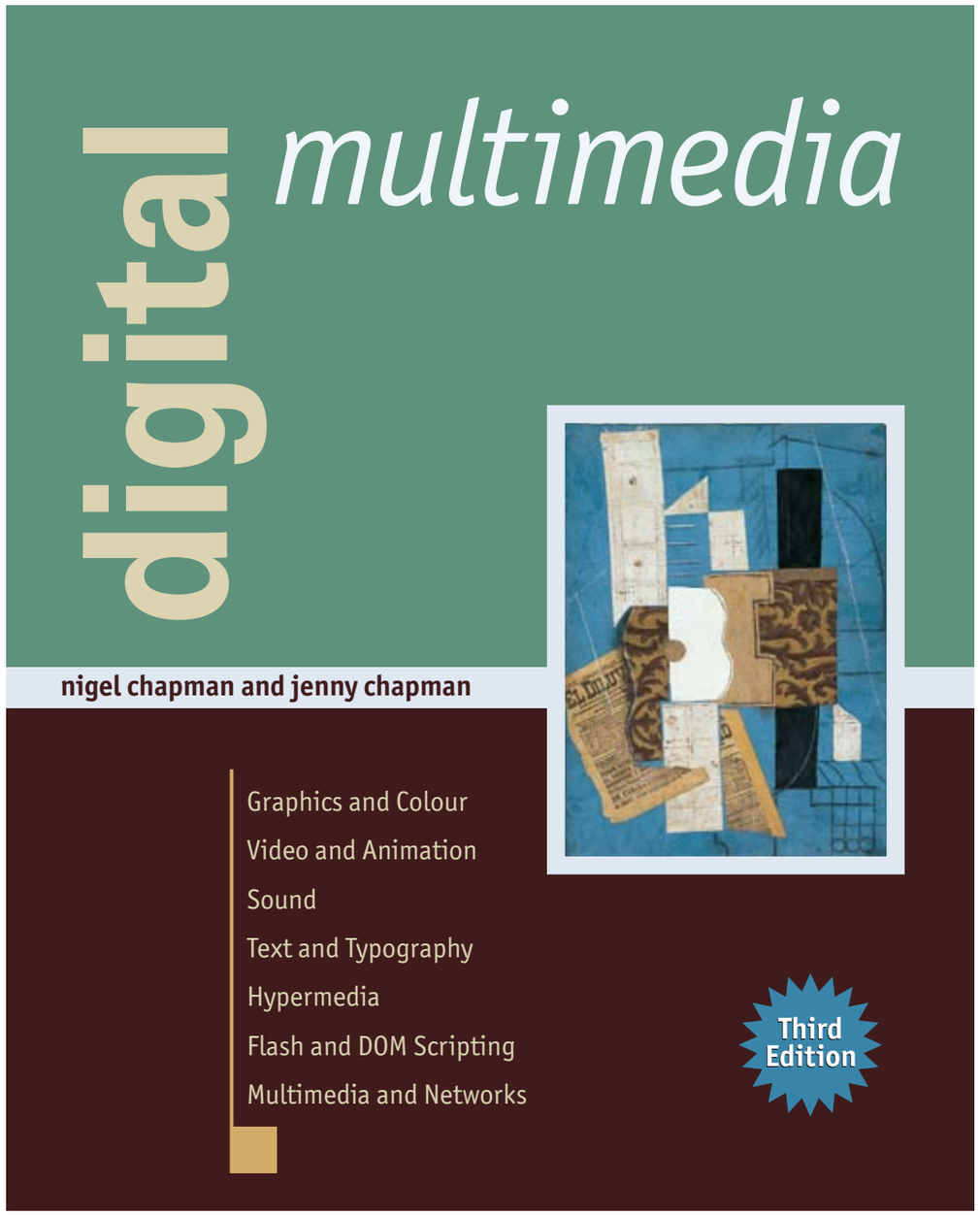


2

Fundamentals

Digital Data

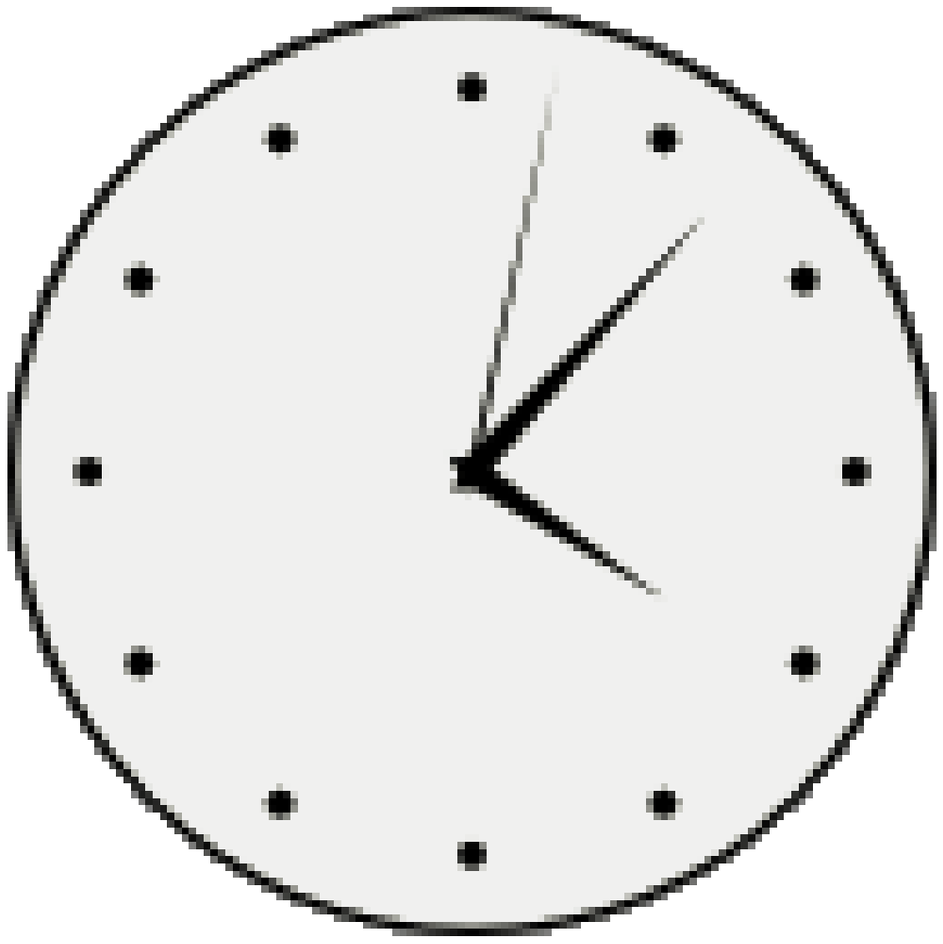
Bits are units of data that can only have one of two values.

A byte is eight bits.

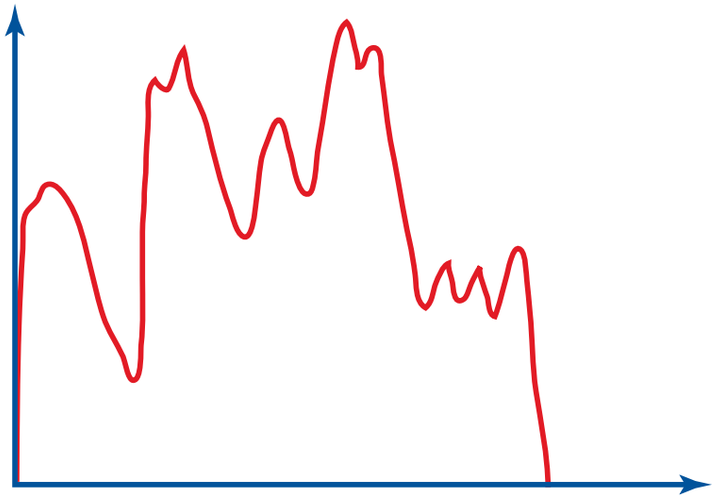
Groups of bits can be interpreted as numbers to base 2, but can also be treated as characters, colours, etc.

Analogue data must be converted to digital form before it can be manipulated by a computer program.

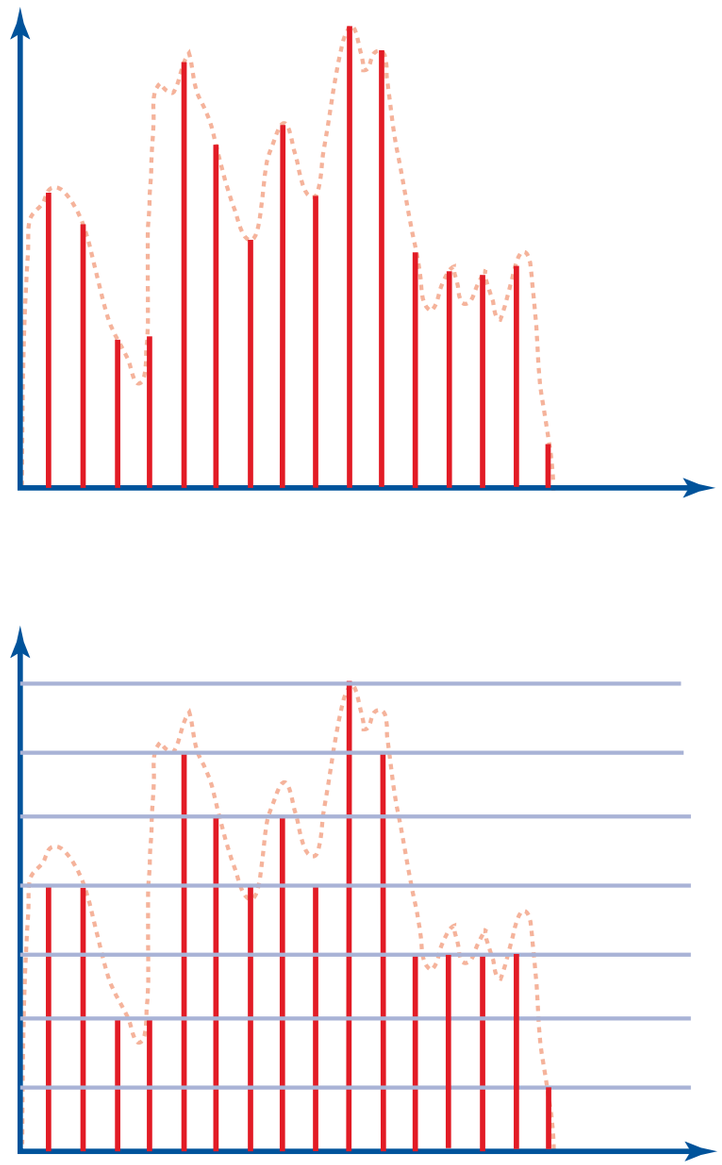
Digitization comprises two operations: sampling and quantization.



Analogue and digital representations



An analogue signal



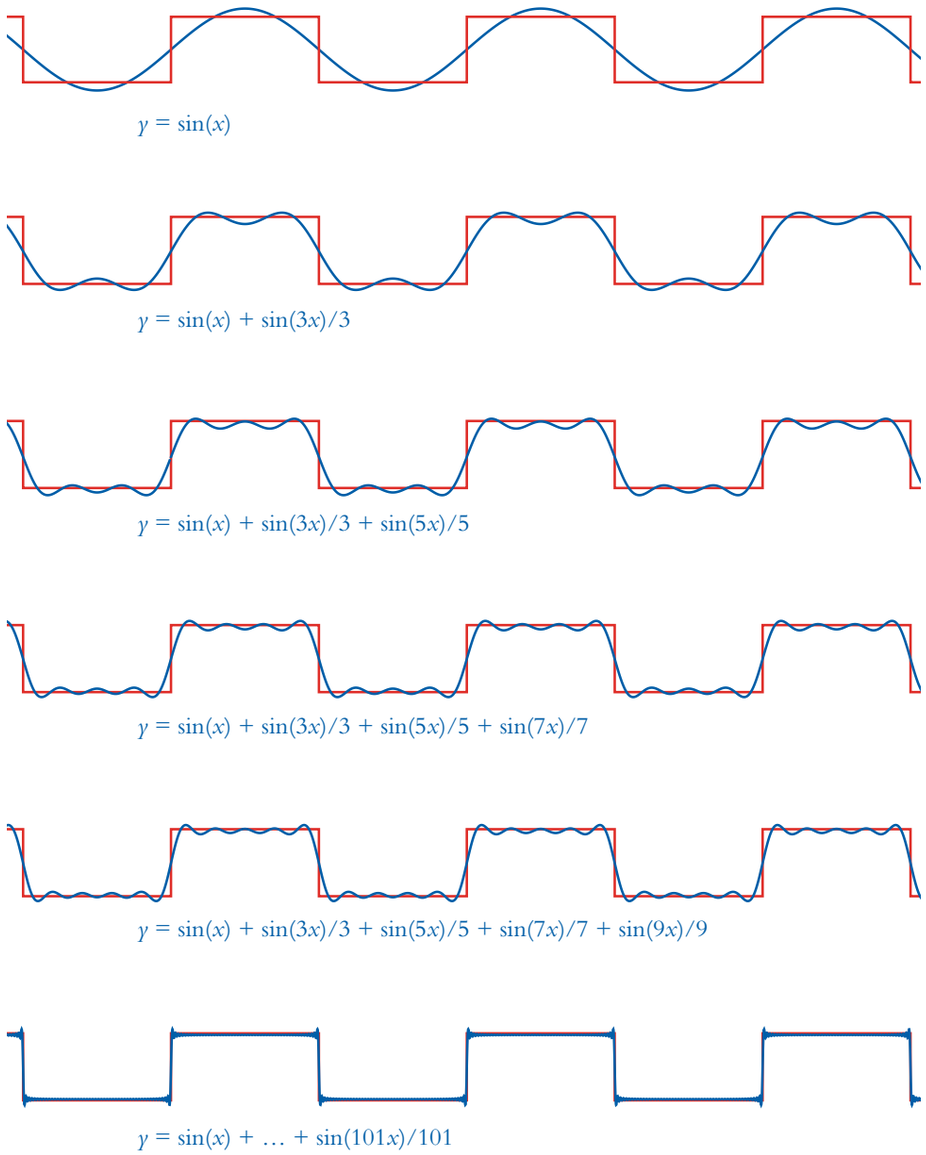
Sampling and quantization

The sampling rate is the number of samples in a fixed amount of time or space.

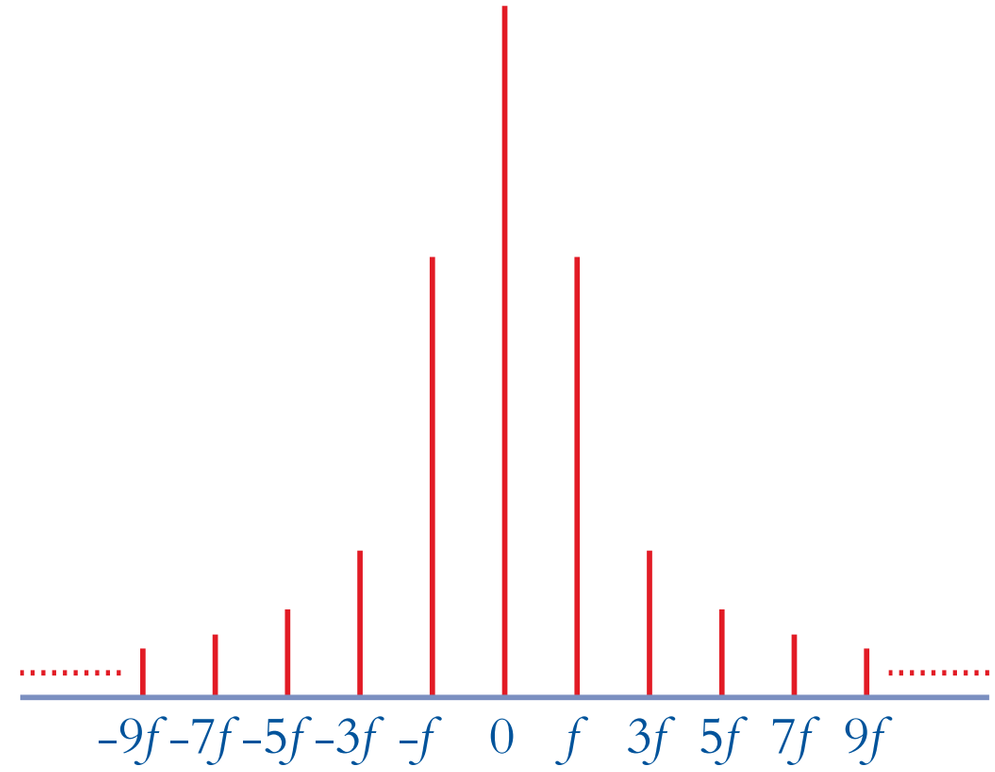
The quantization levels are the set of values to which a signal is quantized.

Spatial and temporal signals are made up of pure sine wave components at different frequencies.

The Fourier Transform operation can be used to compute a signal's representation in the frequency domain.



Frequency components of a square wave

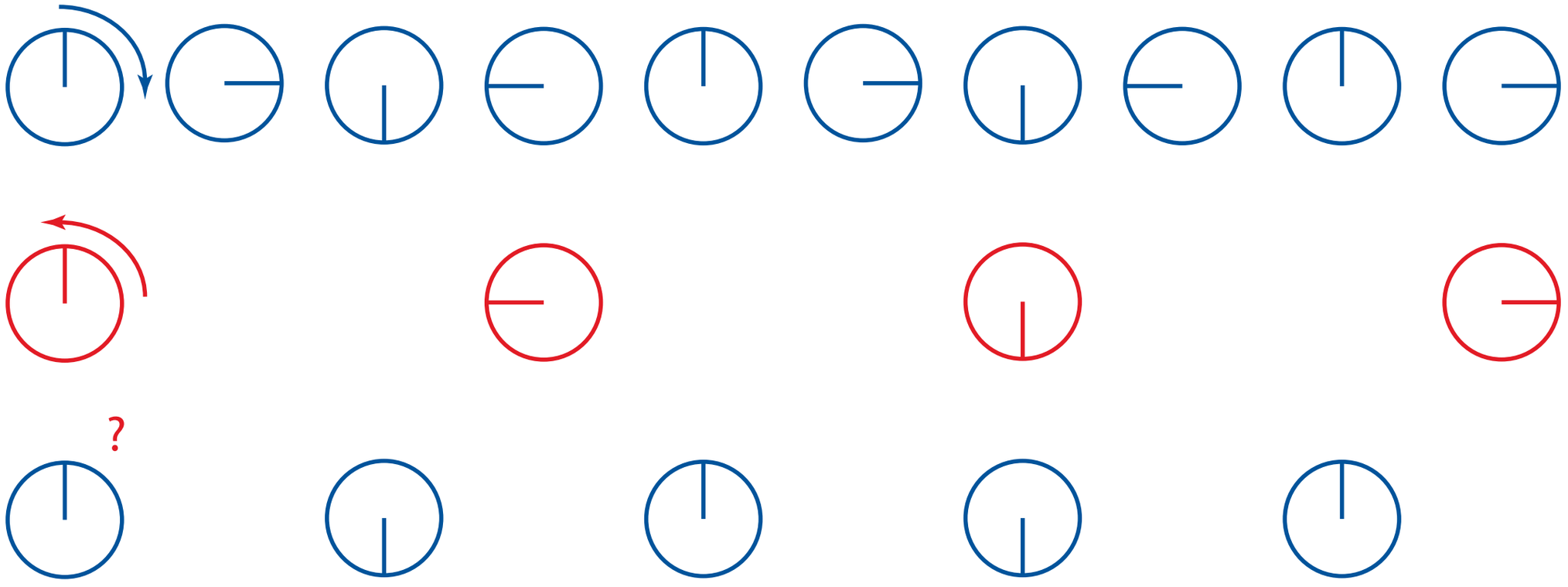


Square wave transformed into the frequency domain

Higher-frequency components are associated with abrupt transitions.

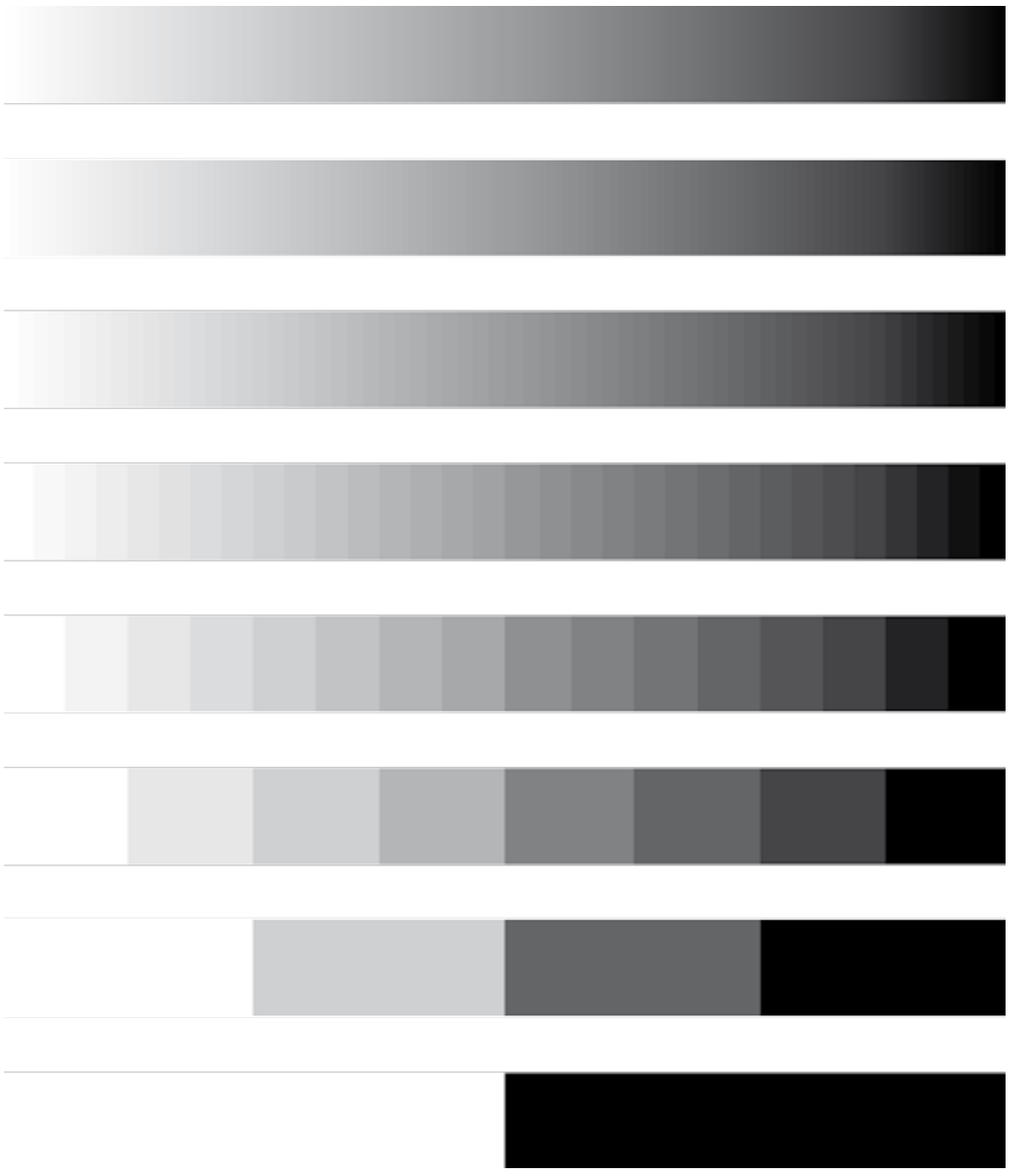
The Sampling Theorem states that, if the highest-frequency component of a signal is at f_h, the signal can be properly reconstructed if it has been sampled at a frequency greater than the Nyquist rate $2f_h$.

Undersampling leads to aliasing.

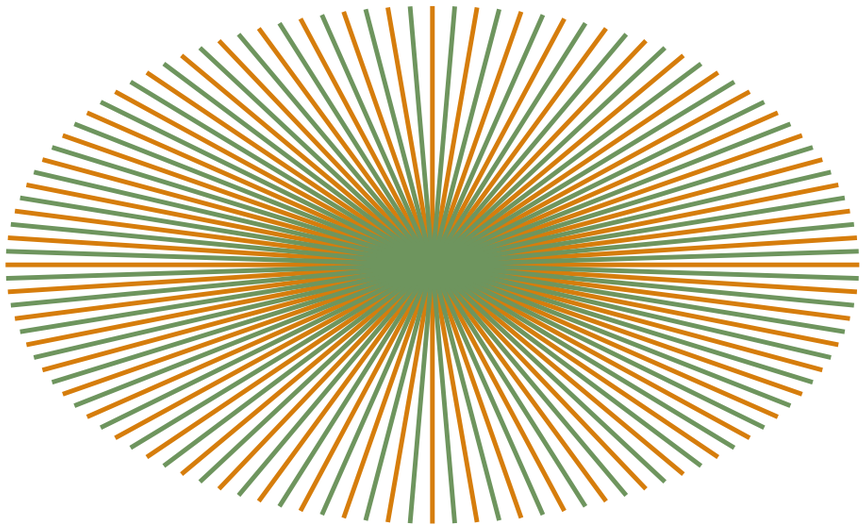


Sampling and undersampling

Using too few quantization levels leads to posterization and Moiré effects in images, or quantization noise in sound.



256, 128, …, 2 grey levels

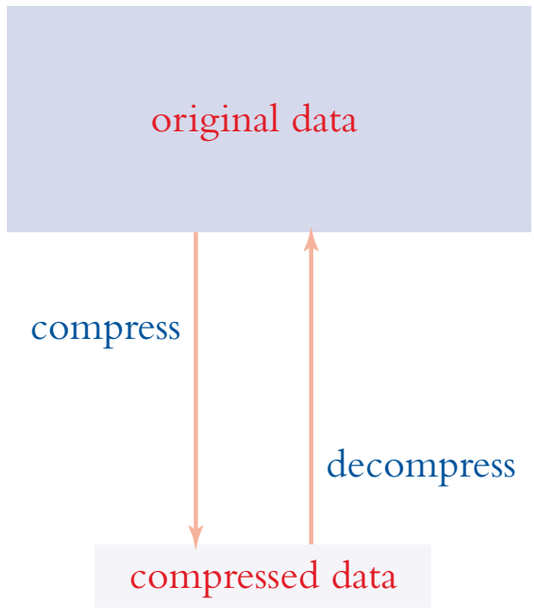


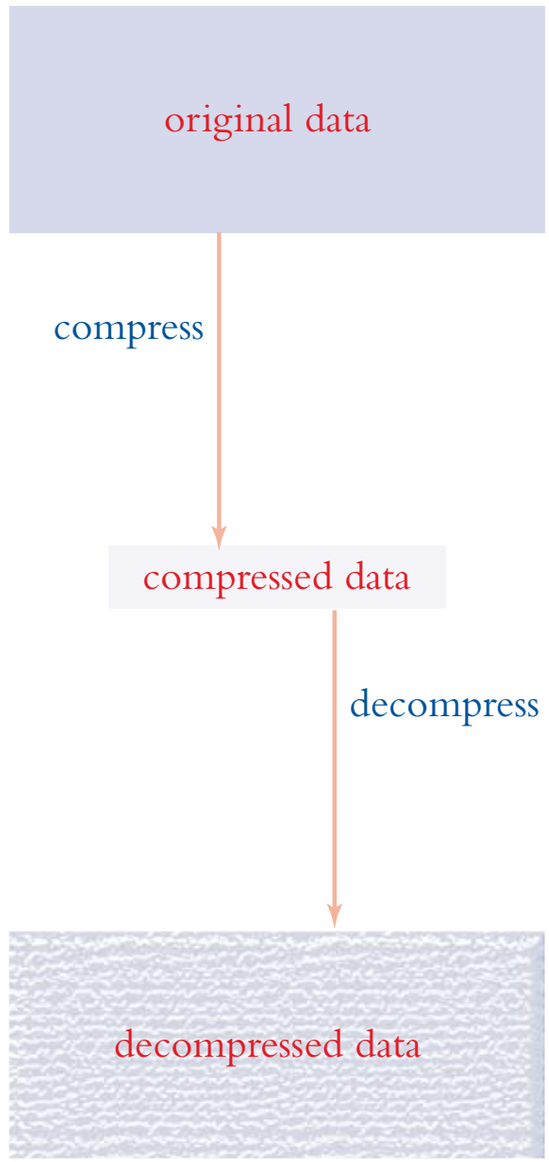
Moiré patterns

Posterization

Compression must often be applied to media data.

Compression may be lossless or lossy.





Lossless compression ***Lossy compression***

Different compression algorithms are applicable to different types of media data. Their effectiveness depends on the characteristics of the data itself.

Digital Representation of Media

There are established ways of representing images, video, animation, sound and text in bits.

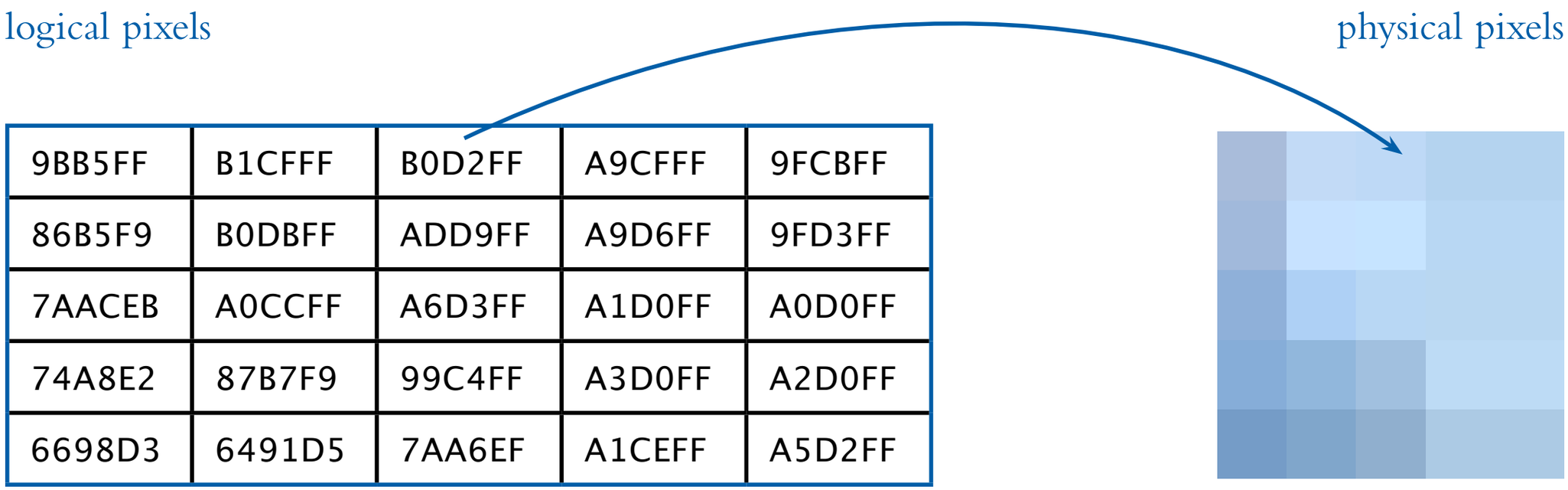
Media data may be represented as a textual description in a suitable language, or as binary data with a specific structural form.

Images are displayed as arrays of pixels and represented using an internal model. Generating the pixels from the model is called rendering.

An image made up of pixels

Images may be modelled as bitmaps or vector graphics.

A bitmap is an array of logical pixels (stored colour values) that can be mapped directly to the physical pixels on the display.



Simple bitmapped image representation

In vector graphics, the image is stored as a mathematical description of a collection of individual lines, curves and shapes making up the image, which requires computation to render it.

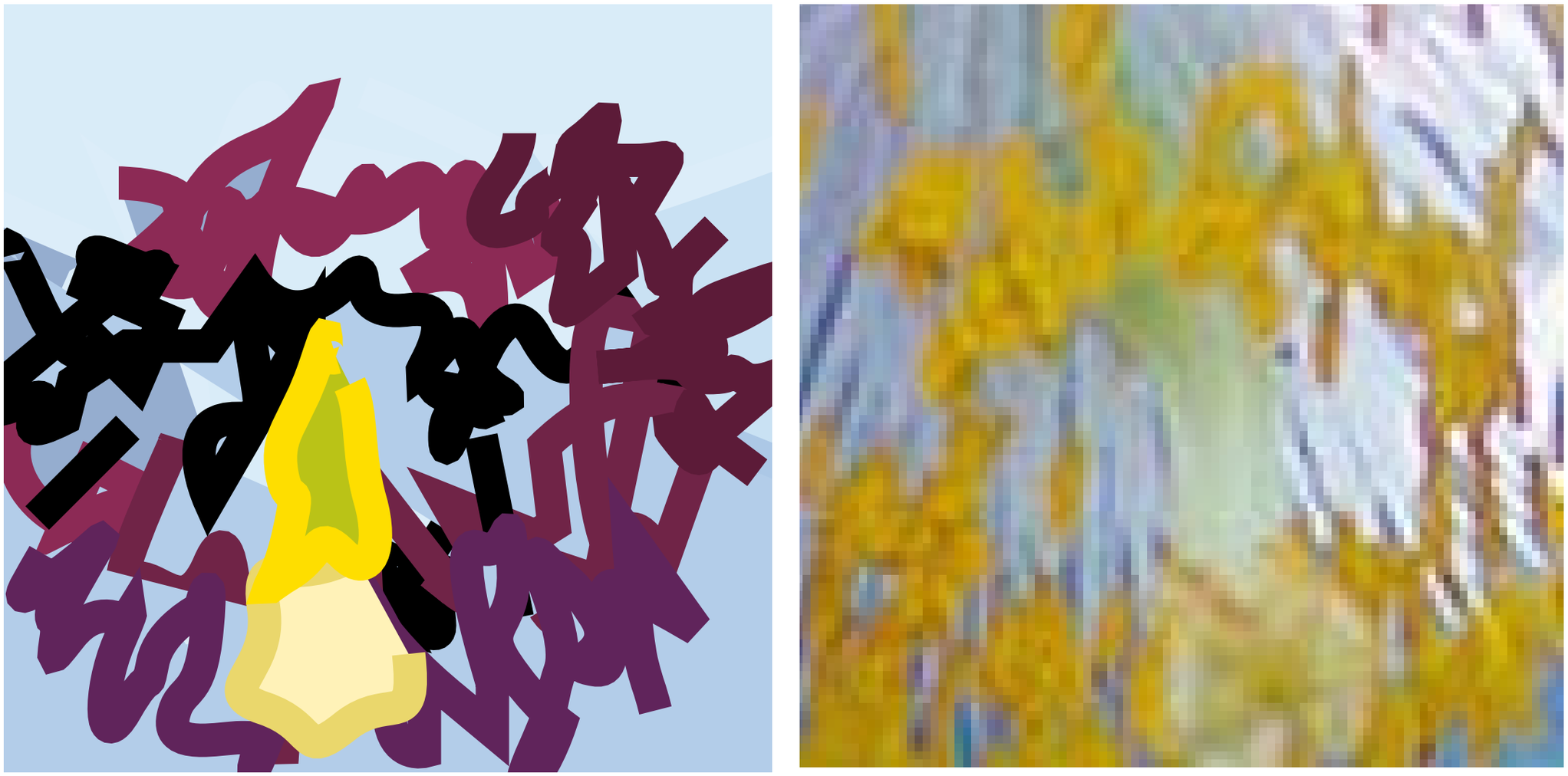
```
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.0//EN"
  "http://www.w3.org/TR/2001/REC-SVG-20010904/DTD/svg10.dtd">
<svg  xmlns="http://www.w3.org/2000/svg">
   <path fill="#F8130D" stroke="#1E338B" stroke-width="20"
    d="M118,118H10V10h108V118z"/>
</svg>
```

A simple vector graphic image

Vector graphics are often smaller than bitmaps, are resolution-independent and can be scaled without loss of quality, but they are only suitable for certain sorts of synthetic image, not photographs.

A vector drawing and a digital photograph

Transforming the vector image and applying effects to the bitmap

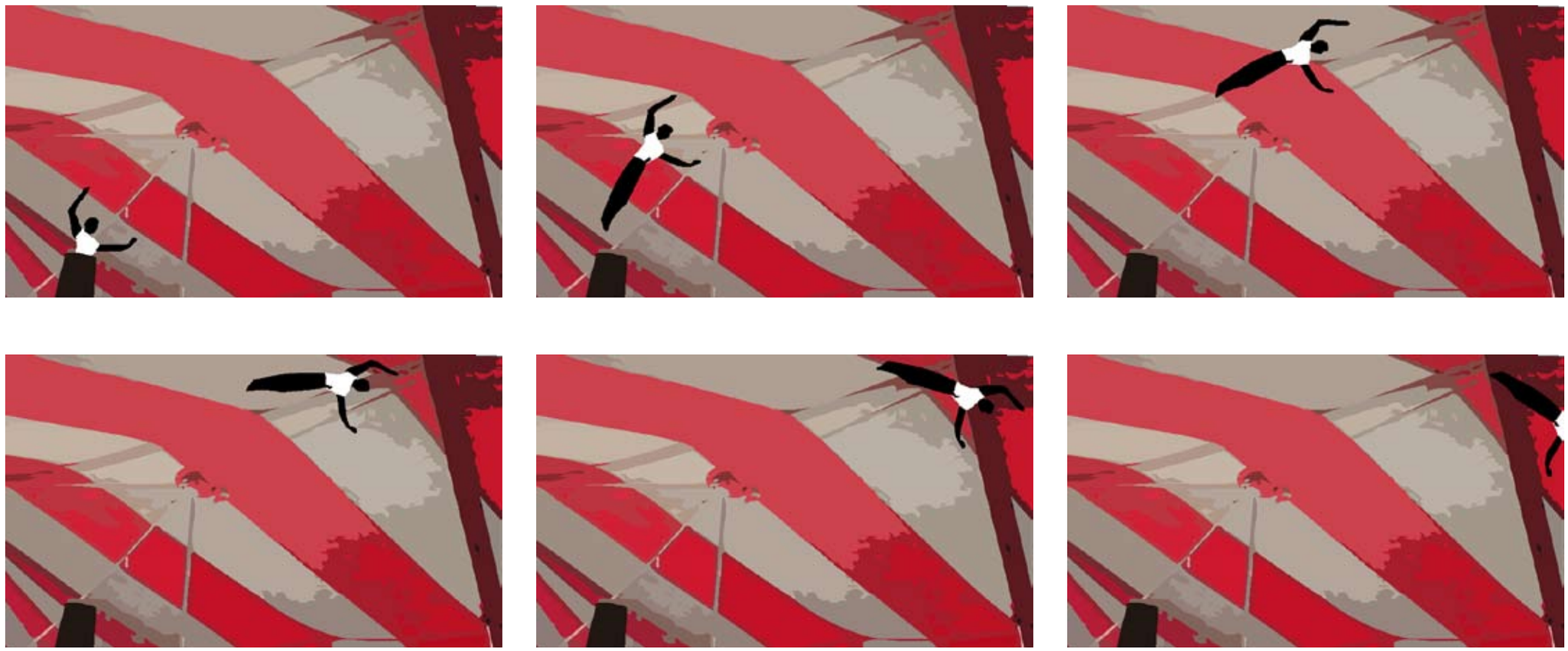


Scaling a vector image (left) and a bitmap (right)

Moving pictures can be created as live-action or animation.

Live-action must be stored as video.

Animation may be represented in other more flexible or efficient ways.



Frames from an animation

Video frames require a lot of storage so video is invariably compressed for delivery.

Sound can be represented as a sequence of samples after digitization.

CD audio is sampled at 44.1 kHz, higher sampling rates are sometimes used.

Audio delivered over the Internet is compressed, often using the MP3 codec.

A character set is a mapping from characters to character codes.

Unicode is a character set capable of representing text in all known languages.

A font is a set of character shapes, called glyphs.

ABCDEFGHIJKLMNOP
QRSTUVWXYZ
abcdefghijklmnopqr
stuvwxyz
1234567890

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q
r s t u v w x y z
1 2 3 4 5 6 7 8 9 0

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s
t u v w x y z
1 2 3 4 5 6 7 8 9 0

ABCDEFGHIJKLMNOPQRS
TUVWXYZ
abcdefghijklmnopqrst
uvwxyz
1234567890

A small selection of fonts

Many aspects of layout must be controlled when text is displayed.

MOLOREET VOLOREET EX-EROS
Etum adionse feuis non henim ipsusting etum iriure magna feu feummy nis augiam, quat.
Minit nibh exer aut augait wisim autpat. Ut irilit pratisci blamconse min ullaorper il deliquamet, volorer ostrud te magna at. Uptatie dolore doluptat nim velisci psuscidui tat. Lum veniatum vel init lum velit am dolutat, sissequis numsandreet at.

Moloreet Voloreet Exeros

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Layout and typography

Interactivity is produced by executing a program in response to user input.

In multimedia, programs are often written in a scripting language, such as JavaScript or ActionScript.

Metadata is structured data about data, which may be attached to media files to help with searching and classifying them.