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Traditio et Innovatio

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Image and Video Coding

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Literature / References

- Gonzalez, R.; Woods, E. : „Digital Image Processing“, Prentice Hall 2008
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- Tönnies, K. D.: Grundlagen der Bildverarbeitung, Pearson Studium, 2005
- Ohm, J.-R.: Digitale Bildcodierung, Springer-Verlag, 1995
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- Wang, Y. et al.: Video Processing and Communications, Prentice Hall 2002
- Rao K.R. et al.: The transform and data compression handbook, CRC Press 2001
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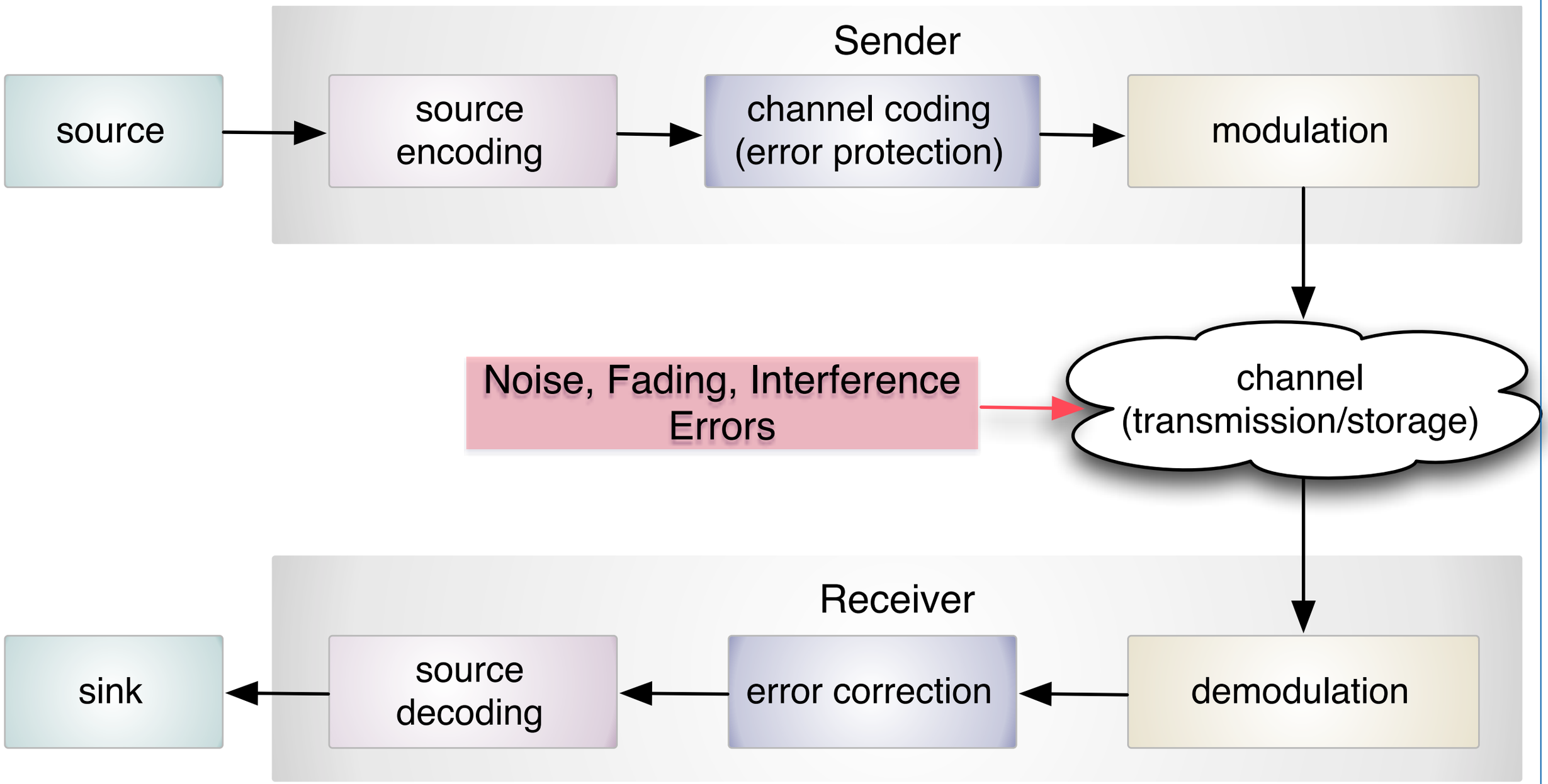
- Pennebaker, W.B. et al.: JPEG still image compression standard, NY 1993
- Mitchell J. L. et al.: MPEG Video Compression Standard. Chapman and Hall 1997
- Taubman, D.S. et al.: JPEG2000, Kluwer Academics Publishers, 2002
- Richardson I.: H.264 and MPEG-4 Video Compression, Wiley & Sons 2003
- Gersho A. and Gray R. M.: Vector Quantization and Signal Compression, Kluwer Academics Publishers 1992

Significant Conferences, Journals

- Conferences
  - IEEE International Conference on Image Processing (ICIP)
  - Picture Coding Symposium (PCS)
  - International Conference on Visual Communications and Image Processing (VCIP)

- Journals
  - IEEE Transactions on Circuits and Systems for Video Technology
  - IEEE Signal Processing Magazine
  - IEEE Communications Magazine
  - IEEE Transactions on Image Processing

General Transmission Model



source coding ⇔ channel coding

Scope

- Separation of source coding and channel coding
  - allows independent adaptation to
    - properties of information source and sink
    - properties of transmission channel
  - direct reusability of source coding output and transmission channel for other means
  - Drawbacks
    - joint source/channel coding enables balanced optimization between coding and error protection (graceful degradation)
    - unexploited redundancy by separate coding

- Scope of image compression part of lecture:

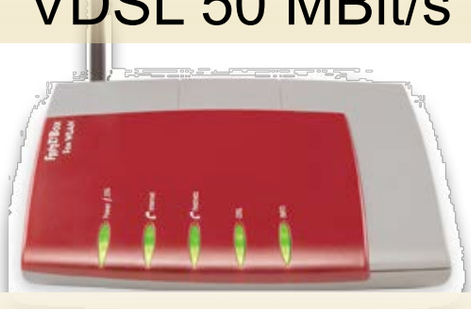
data compression = source coding

CIF = common interchange format (5-30 Hz)
QCIF = quarter common interchange format (10-30 Hz)

Necessity of data compression

Width		Height		RGB		FPS		Data rate
720	•	576	•	3	•	25	=	31.1 MB/s
1920	•	1080	•	3	•	25	=	155.5 MB/s

Capacity	CD 700 MB	DVD 8.5 GB	Blu-ray 50 GB	HDD 4 TB
				
Storage time	22 s ⇔ 4.5 s	4.5 min ⇔ 54 s	26 min ⇔ 5 min	35 h ⇔ 7.1 h

Bandwidth	UMTS 1.4 MBit/s	ADSL2+ 16 MBit/s	VDSL 50 MBit/s	Ethernet 1GE
				
Transmission 90 min film	11 d ⇔ 55 d	1 d ⇔ 4.8 d	7.4 h ⇔ 1.5 d	0.37 h ⇔ 1.8 h

Aspect ratio and non square pixels

Cinematic recordings

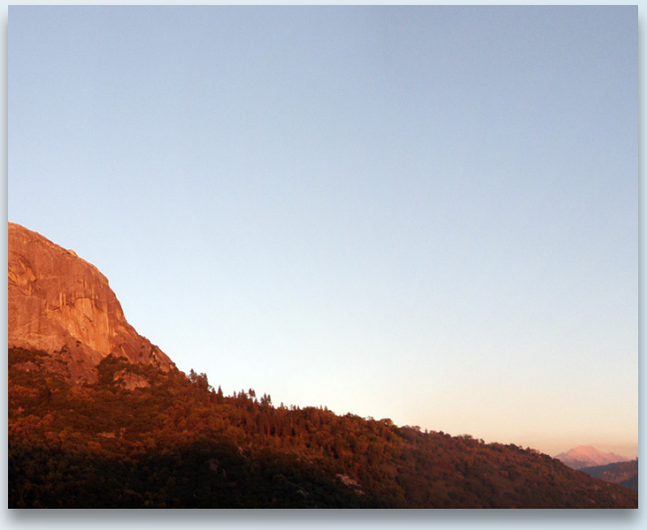
- traditionally recorded on 35 mm film
- horizontal image contraction on film (anamorphic representation)
- typical frame aspect ratios
  - 2,35:1 (21:9, Cinemascope)
  - 1,85:1 (100:54)

Application to non-widescreen standards

- e.g. DVD 720x576 pixels (1,25:1)

Letterbox

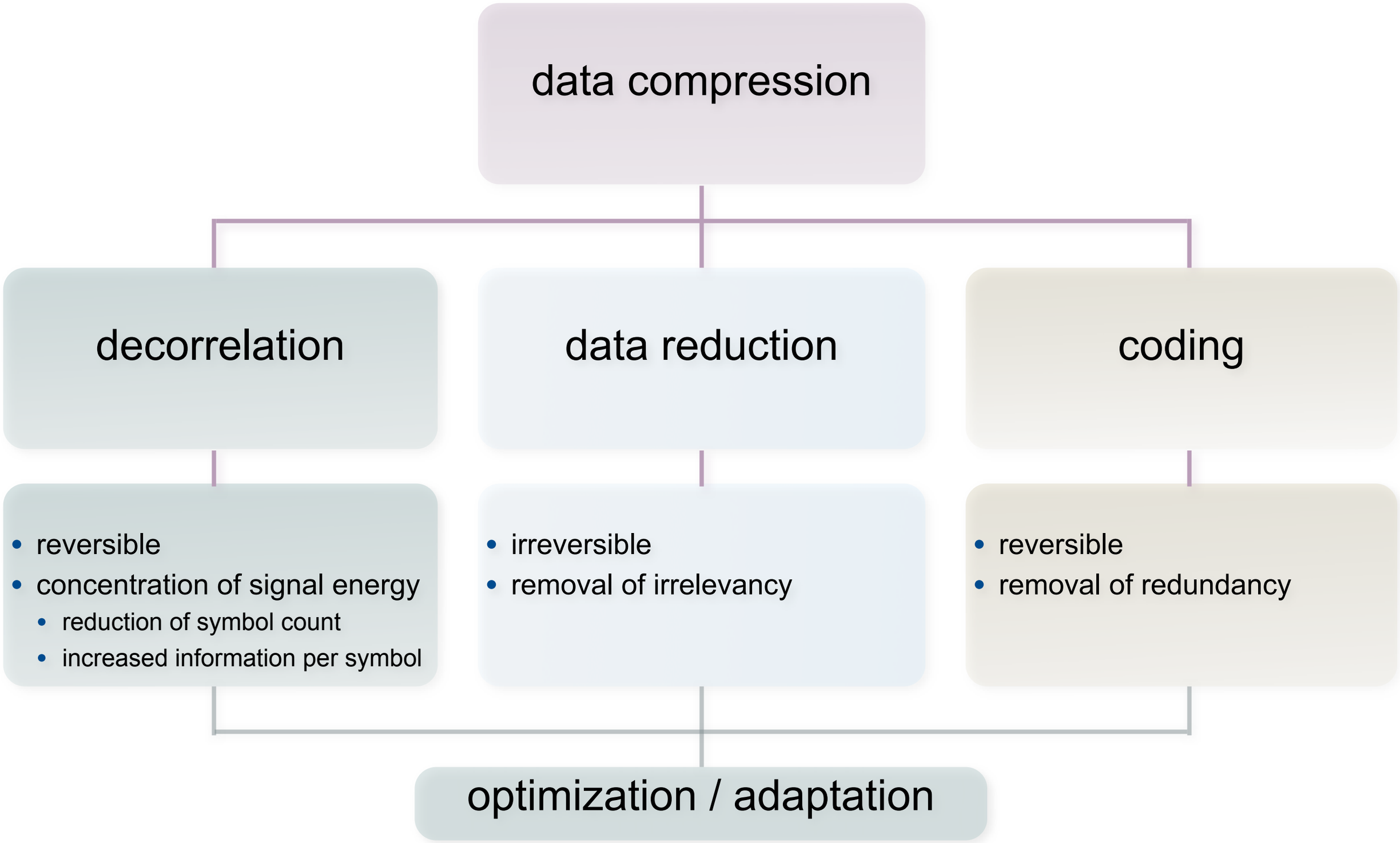
Cropping (Pan/Scan)



Anamorphic

➠ Representation of digital video commonly requires appropriate resampling

General data compression tools



General lossy codec

Encoder

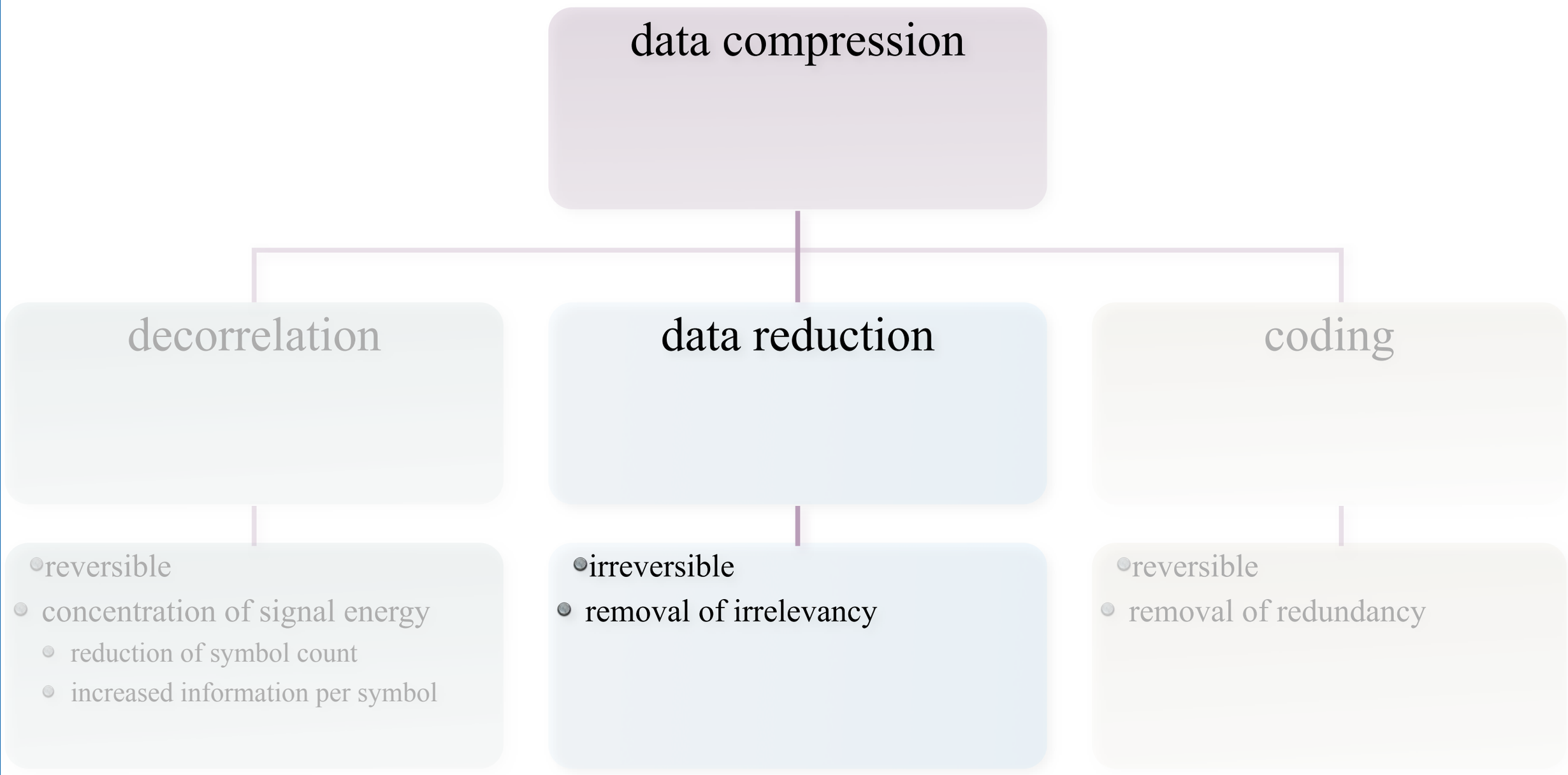
- **decorrelation**
  - prediction
  - transformation
- **data reduction**
  - quantization
- **coding**
  - precoding
  - entropy coding

transmission / storage

Decoder

- **inverse transformation**
  - **prediction**
- **data reconstruction**
  - inverse quantization
- **decoding**

General data compression tools



Characteristic Features

- Removal or reduction of irrelevancy
- Pre-assumption:
  - relevant and irrelevant parts are separated from each other as far as possible
- Quantization:
  - number of symbols or samples keeps constant
  - precision decreases
  - reduced symbol set results in lower entropy
- Sub-sampling:
  - precision keeps constant
  - number of symbols or samples decreases

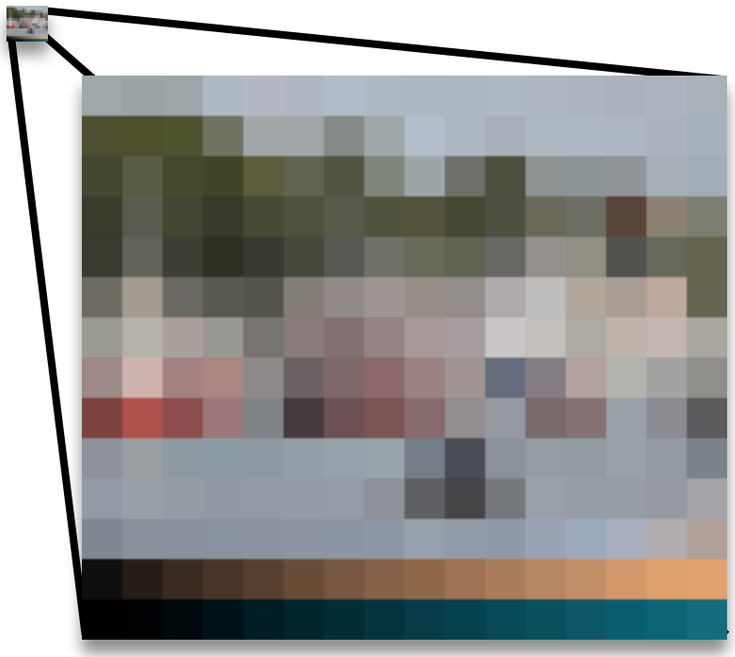
Example: spatial resolution

256x224 pixels

128x112 pixels

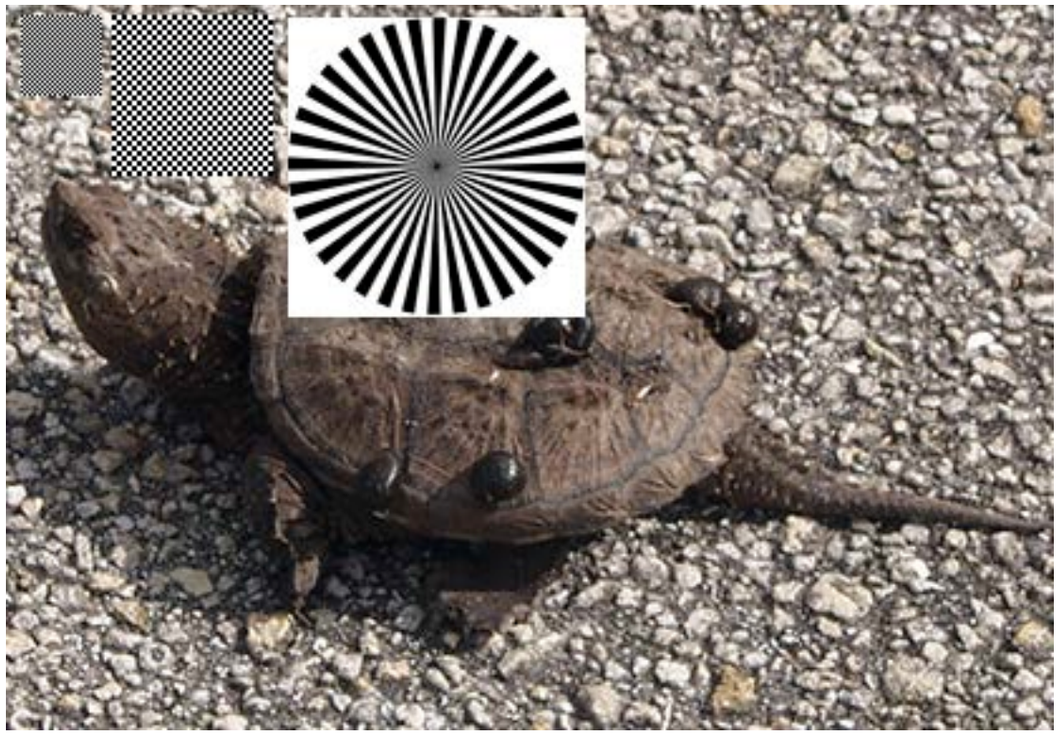
64x56 pixels

32x28 pixels



16x14 pixels

Original



Nearest Neighbor

Bi-cubic

Windowed Sinc (Lanczos)

Subsampling Example: (reduction to 30% plus enlargement for display)

The image matrix

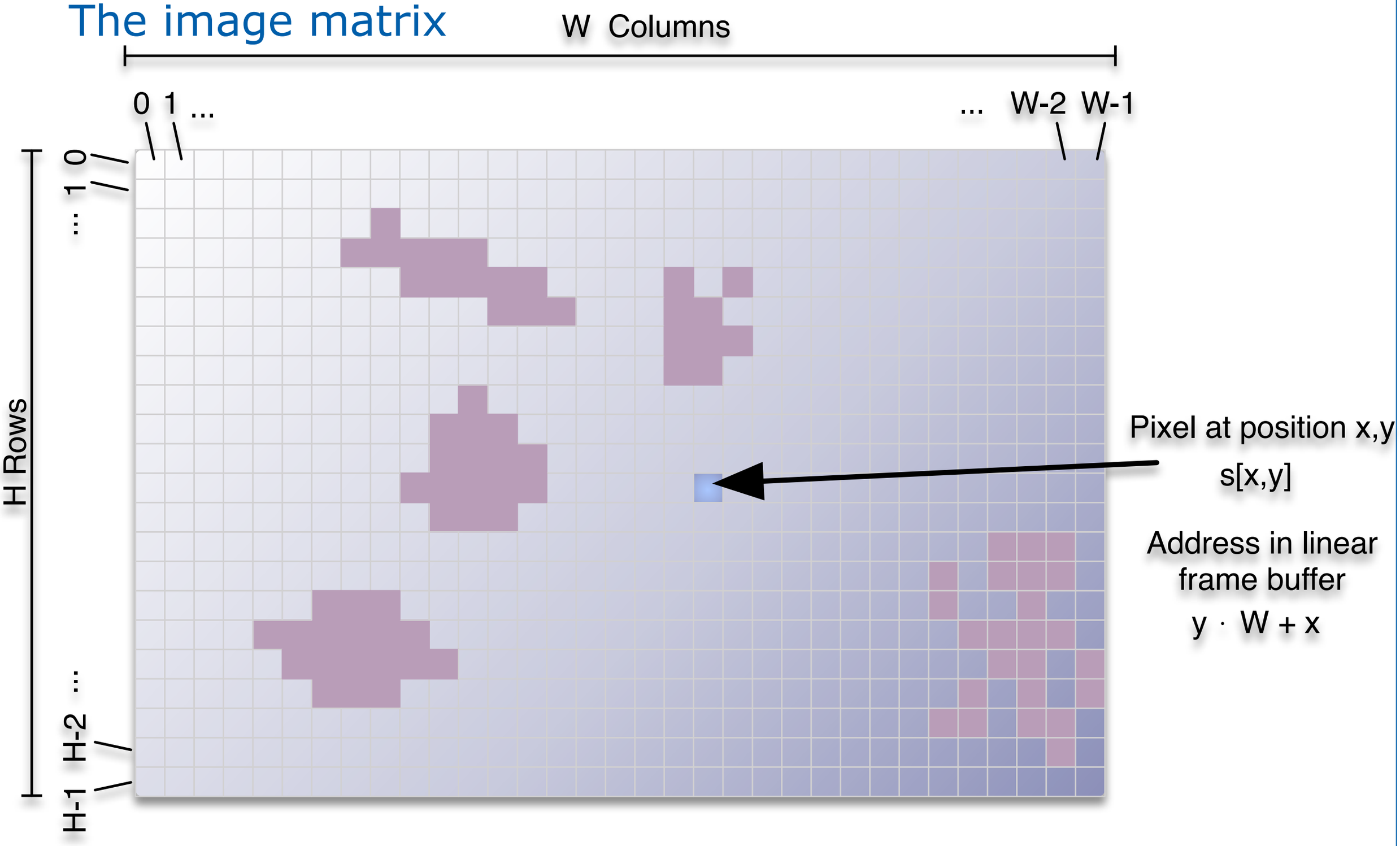
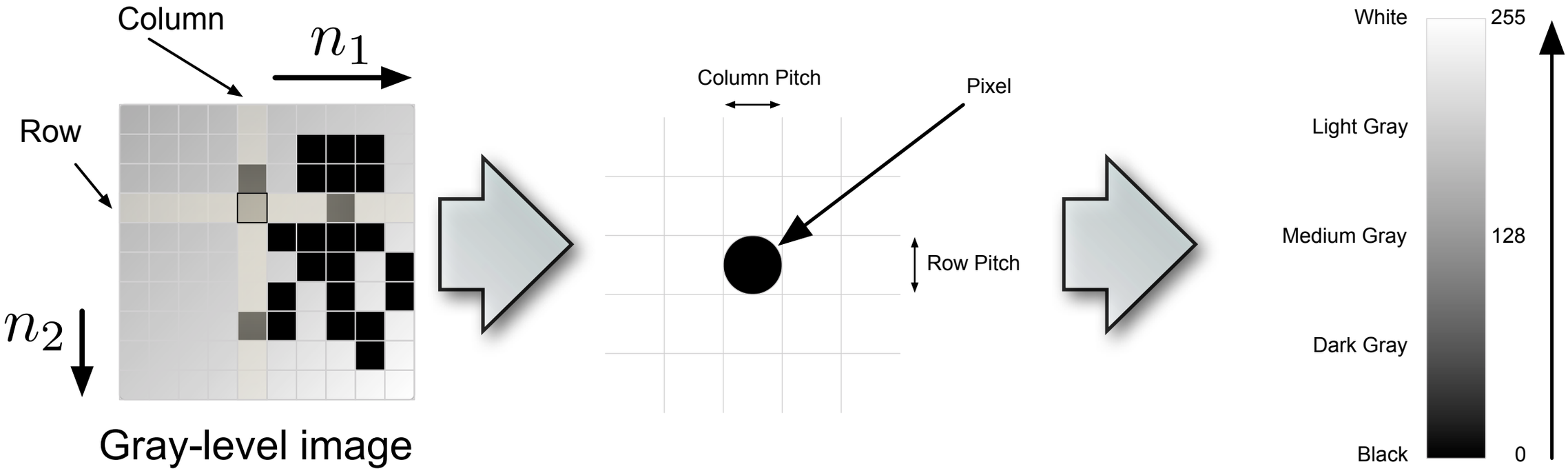


Image Matrix addressing and level scale



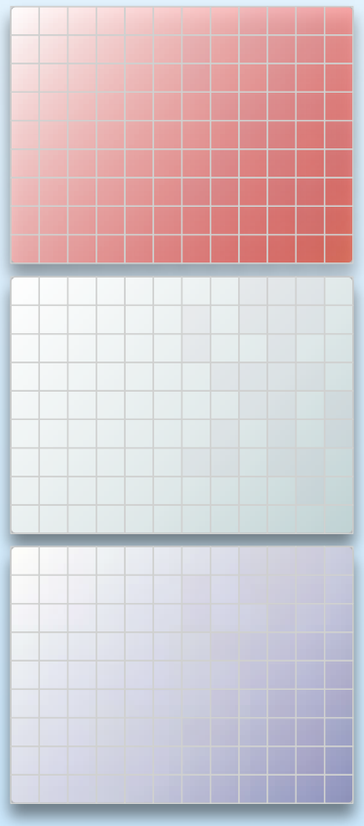
Gray-level image
(2D signal)

$$S = \{s[n_1, n_2]\} \quad \text{with} \quad s[n_1, n_2] = g \in G = \{0, 1, \ldots, 255\} \quad \text{for } 8\ Bit \text{ per pixel}$$

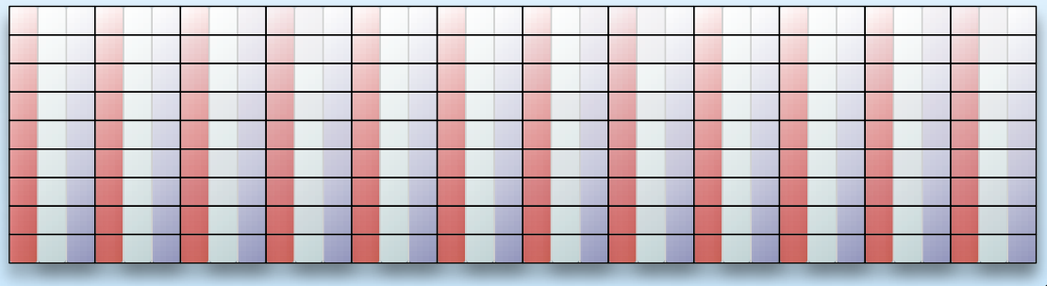
- row-column addressing natural for most framebuffer types but beware of Matlab®, where coordinates are swapped in the default toolsets and run from 1 (matrix/mathematics) notation instead of 0 (absolute offsets)

Organization of color components

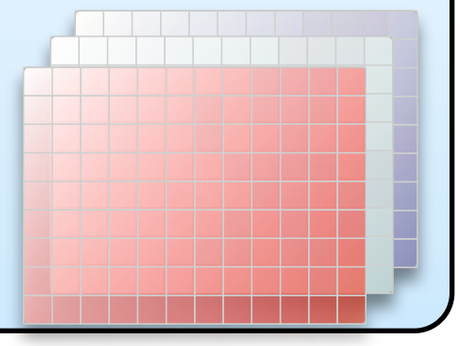
planar RGB



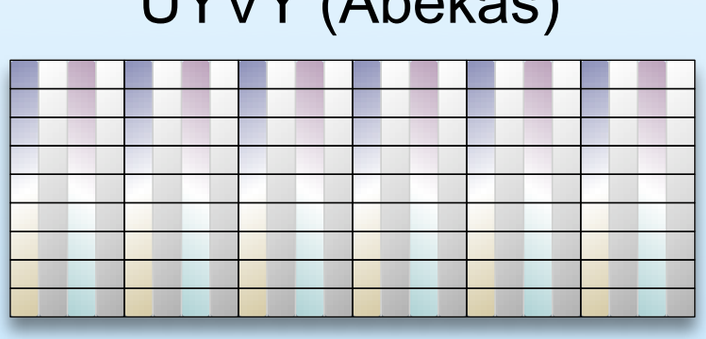
packed RGB 24 Bit



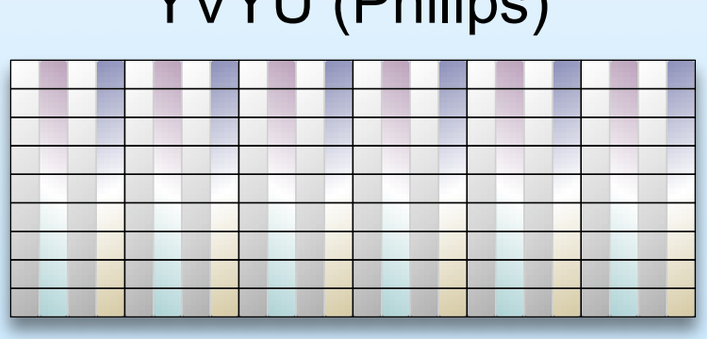
RGB as 3D matrix (logical)



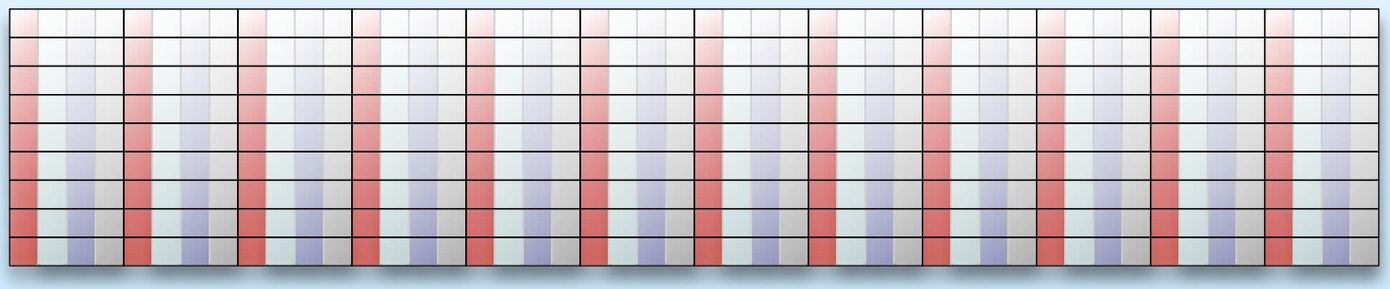
packed YCbCr 4:2:2, UYVY (Abekas)



packed YCbCr 4:2:2, YVYU (Philips)



packed RGB 32 Bit (RGBA)



- only a few common examples shown, RAW data organized to the needs of actual applications
- beware of Endianess issues when dealing with data accesses >8 Bit

General data compression tools