



Dr Chris Town

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Common image/video formats: Video JPEG • PAL: 768x576 pixels at 25 Hz, interlaced • MPEG • NTSC: 640x480 pixels at 30 Hz, interlaced • GIF/PNG • HD: 1,280×720 pixels (720p, progressive) at 60Hz or 1,920×1,080 pixels (1080i/1080p • TIFF interlaced/progressive) at 50Hz • BMP Dr Chris Town Dr Chris Town

Nyquists's sampling theorem: The highest spatial frequency in an image is ½ the corresponding pixel dimensionality. Nyquist's Sampling Theorem: If a signal f(x) is strictly bandlimited so that it contains no frequency components higher than W, i.e. its Fourier Transform F(k) satisfies the condition

$$F(k) = 0 \text{ for } |k| > W$$
 (1)

then f(x) is completely determined just by sampling its values at a rate of at least 2W. The signal f(x) can be exactly recovered by using each sampled value to fix the amplitude of a sinc(x) function,

$$\operatorname{sinc}(x) = \frac{\sin(\pi x)}{\pi x}$$
(2)

whose width is scaled by the bandwidth parameter W and whose location corresponds to each of the sample points. The continuous signal f(x) can be perfectly recovered from its discrete samples $f_n(\frac{n}{W})$ just by adding all of those displaced sinc(x) functions together, with their amplitudes equal to the samples taken:

$$f(x) = \sum_{n} f_n\left(\frac{n\pi}{W}\right) \frac{\sin(Wx - n\pi)}{(Wx - n\pi)} \tag{3}$$

Thus we see that any signal that is limited in its bandwidth to W, during some duration T has at most 2WT degrees-of-freedom. It can be completely specified by just 2WT real numbers (Nyquist, 1911; R V Hartley, 1928).

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The nature of retinal signal processing might be summarised as:

- $\bullet\,$ image sampling by photoreceptor transducers, with pooling of signals from rods
- spatial centre-surround comparisons implemented by bipolar cells (direct central input from photoreceptors, minus surround inhibition via horizontal cells)
- $\bullet\,$ temporal differentiation by a macrine cells, subserving motion sensitivity
- separate coding of "sustained" versus "transient" image information by different classes of ganglion cells (large receptive fields \Leftrightarrow transient; small fields \Leftrightarrow sustained)
- initial colour separation by "opponent processing" channels (yellow vs blue; red vs green) coupled sometimes with spatial opponency (on-centre, off-surround)
- generation of nerve impulse spikes in a parallel temporal modulation code on the 1 million fibres of the optic nerve from each eye (= 2nd Cranial Nerve)

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