gabor

**Holography**: A photographic technique which creates a three-dimensional image. It was born as Dennis Gabor’s attempt to improve the electron microscope. Gabor considered the possibility of taking first a "bad" picture and correcting it by light-optical means. But in an ordinary electron picture this is not possible, because important information has dropped out; the phase of the electron waves. The phase information dropped out because there was nothing to compare it with. Gabor supplied a known wave to provide a phase standard. If one were to illuminate the "bad" picture with the coherent background, or a light-optical simulation of it, the true image will come out, because the original wavefront is reconstructed. Gabor termed the "bad" image, (which is indeed entirely unlike the object, it rather looks like a collection of fingerprints) a "hologram" (from the Greek holos, "the whole"), because it contained all the information. He then verified the theory, in 1948, by light-optical experiments with coherent light. Holography did not become practical until the advent of highly coherent laser light.

[1900- 1979]
Holography is a photographic technique which creates a three-dimensional image. It was born as an attempt to improve the electron microscope. It was well known since 1936 that the resolving power of electron microscopes had to stop tantalizingly short of resolving atomic lattices, because the aperture of electron objectives could not be increased beyond a certain limit, owing to the spherical aberration which could not be corrected. Gabor considered the possibility of taking first a "bad" picture and correcting it by light-optical means. But in an ordinary electron microgram this is not possible, because one-half (the more important half) of the information has dropped out: the phase of the electron waves. Gabor thought "of course the phase has dropped out, because there was nothing to compare it with. Let us see what happens if we put in a known wave, as a phase standard." A little mathematical analysis showed that this would indeed work, one has only to superpose on the "bad" image, which is entirely unlike the true image, a "coherent background", (nowadays called a "reference wave".) If now one illuminates the "bad" picture with the coherent background, or a light-optical simulation of it, the true image will come out, because the original wavefront is reconstructed. Gabor termed the "bad" image, (which is indeed entirely unlike the object, it rather looks like a collection of fingerprints) a "hologram" (from the Greek holos, "the whole"), because it contained all the information. He then verified the theory, in 1948, by light-optical experiments with coherent light. These "classic" holograms are now well known, and have been often reproduced.

Other work by Gabor during his time with the BTHCo was his Theory of Communication, which is now known as "structural" theory as distinguished from the Shannon-Wiener "statistical" theory. One of its results was what Gabor called the "complex signal" and which is in the same relation to the real signal as the "phasor" to a sine wave.

http://www.ieeeghn.org/wiki/index.php/Dennis_Gabor

autobiography
http://www.nobelprize.org/nobel_prizes/physics/laureates/1971/gabor-autobio.html

Gabor's research focused on electron inputs and outputs, which led him to the invention of re-holography.[5] The basic idea was that for perfect optical imaging, the total of all the information has to be used; not only the amplitude, as in usual optical imaging, but also the phase. In this manner a complete holo-spatial picture can be obtained.[5] Gabor published his theories of re-holography in a series of papers between 1946 and 1951.[5]

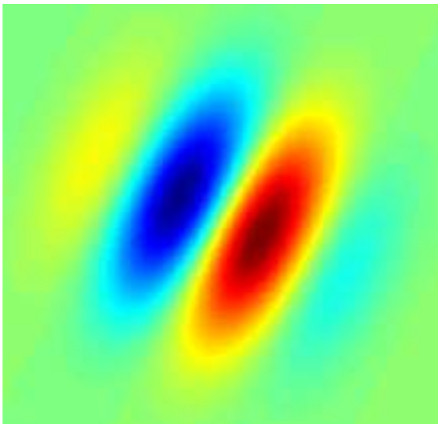
Gabor also researched how human beings communicate and hear; the result of his investigations was the theory of granular synthesis, although Greek composer Iannis Xenakis claimed that he was actually the first inventor of this synthesis technique.[8] Gabor's work in this and related areas was foundational in the development of time–frequency analysis.

http://en.wikipedia.org/wiki/Dennis_Gabor

## Gabor filter:

In image processing, a **Gabor filter**, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation.

J. G. Daugman discovered that simple cells in the visual cortex of mammalian brains can be modeled by Gabor functions.[1] Thus, image analysis by the Gabor functions is similar to perception in the human visual system.



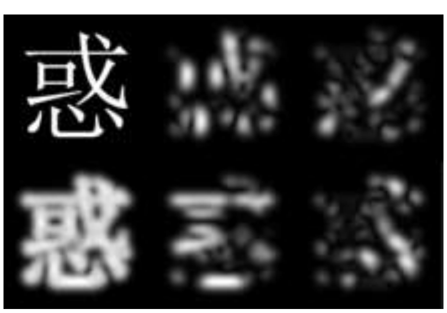
2-D gabor filter

http://en.wikipedia.org/wiki/Gabor_filter

A set of Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image.

Gabor filters are directly related to Gabor wavelets, since they can be designed for a number of dilations and rotations. However, in general, expansion is not applied for Gabor wavelets, since this requires computation of bi-orthogonal wavelets, which may be very time-consuming. Therefore, usually, a filter bank consisting of Gabor filters with various scales and rotations is created. The filters are convolved with the signal, resulting in a so-called Gabor space. This process is closely related to processes in the primary visual cortex.[3] Jones and Palmer showed that the real part of the complex Gabor function is a good fit to the receptive field weight functions found in simple cells in a cat's striate cortex.[4]

The Gabor space is very useful in image processing applications such as optical character recognition, iris recognition and fingerprint recognition. Relations between activations for a specific spatial location are very distinctive between objects in an image. Furthermore, important activations can be extracted from the Gabor space in order to create a sparse object representation.



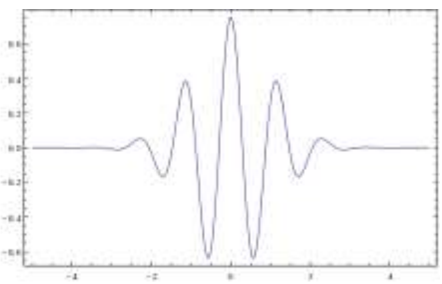
Demonstration of a Gabor filter applied to Chinese OCR. Four orientations are shown on the right 0°, 45°, 90° and 135°. The original character picture and the superposition of all four orientations are shown on the left

Example implementation form MATLAB

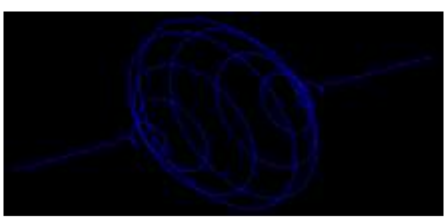
See also: Morlet wavelet

In mathematics, the **Morlet wavelet** (or **Gabor wavelet**)[1] is a wavelet composed of a complex exponential (carrier) multiplied by a Gaussian window (envelope). This wavelet is closely related to human perception, both hearing[2] and vision.[3]

In 1946, physicist Dennis Gabor, applying ideas from quantum physics, introduced the use of Gaussian-windowed sinusoids for time-frequency decomposition, which he referred to as *atoms*, and which provide the best trade-off between spatial and frequency resolution.[1] These are used in the Gabor transform, a type of short-time Fourier transform.[2] In 1984, Jean Morlet introduced Gabor's work to the seismology community and, with Goupillaud and Grossmann, modified it to keep the same wavelet shape over equal octave intervals, resulting in the first formalization of the continuous wavelet transform.[4] (See also Wavelet history)



## Real valued Morlet Wavelet



## Complex valued Morelt Wavelet

http://en.wikipedia.org/wiki/Morlet_wavelet

## wavelet history

A **wavelet** is a wave-like oscillation with an amplitude that starts out at zero(0), increases, and then decreases back to zero. It can typically be visualized as a "brief oscillation" like one might see recorded by a seismograph or heart monitor. Generally, wavelets are purposefully crafted to have specific properties that make them useful for signal processing. Wavelets can be combined, using a "reverse, shift, multiply and sum" technique called convolution, with portions of an unknown signal to extract information from the unknown signal.

For example, a wavelet could be created to have a frequency of Middle C and a short duration of roughly a 32nd note. If this wavelet were to be convolved at periodic intervals with a signal created from the recording of a song, then the results of these convolutions would be useful for determining when the Middle C note was being played in the song. Mathematically, the wavelet will resonate if the unknown signal contains information of similar frequency – just as a tuning fork physically resonates with sound waves of its specific tuning frequency. This concept of resonance is at the core of many practical applications of wavelet theory.

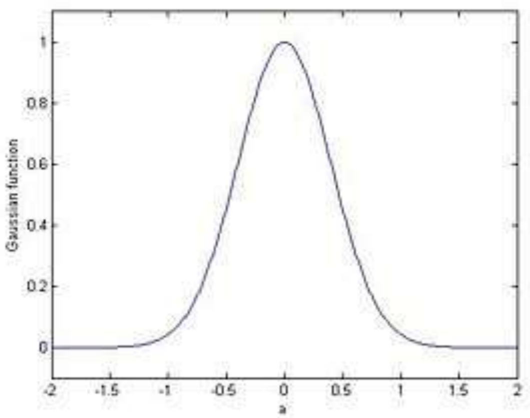
As a mathematical tool, wavelets can be used to extract information from many different kinds of data, including – but certainly not limited to – audio signals and images. Sets of wavelets are generally needed to analyze data fully. A set of "complementary" wavelets will deconstruct data without gaps or overlap so that the deconstruction process is mathematically reversible. Thus, sets of complementary wavelets are useful in wavelet based compression/decompression algorithms where it is desirable to recover the original information with minimal loss.

## http://en.wikipedia.org/wiki/Wavelet#History

## Gabor transform

The **Gabor transform**, named after Dennis Gabor, is a special case of the short-time Fourier transform. It is used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time. The function to be transformed is first multiplied by a Gaussian function, which can be regarded as a window function, and the resulting function is then transformed with a Fourier transform to derive the time-frequency analysis. The window function means that the signal near the time being analyzed will have higher weight. The Gabor transform of a signal x(t) is defined by this formula:

$$G_x(t,f) = \int_{-\infty}^{\infty} e^{-\pi(\tau-t)^2} e^{-j2\pi f\tau} x(\tau)\, d\tau$$



Magnitude of Gaussian function

Outside these limits of integration $|a| > 1.9143$, the Gaussian function is small enough to be ignored. Thus the Gabor transform can be satisfactorily approximated as

$$G_x(t,f) = \int_{-1.9143}^{1.9143} e^{-\pi(\tau-t)^2} e^{-j2\pi f\tau} x(\tau)\, d\tau$$

This simplification makes the Gabor transform practical and realizable.

The window function width can also be varied to optimize the time-frequency resolution tradeoff for a particular application by replacing the $-\pi(\tau - t)^2$ with $-\pi\alpha(\tau - t)^2$ for some chosen alpha.

The Gabor transform is invertible. The original signal can be recovered by the following equation

$$x(t) = \int_{-\infty}^{\infty} G_x(t,f) e^{j2\pi tf}\, df$$

http://en.wikipedia.org/wiki/Gabor_transform

## Gabor atom/Gabor function

In applied mathematics, **Gabor atoms**, or **Gabor functions**, are functions used in the analysis proposed by Dennis Gabor in 1946 in which a family of functions is built from translations and modulations of a generating function.

In 1946, Dennis Gabor suggested the idea of using a granular system to produce sound. In his work, Gabor discussed the problems with the Fourier analysis, and, according to him, although the mathematics is perfectly correct, it is not possible to apply it physically, mainly in usual sounds, as the sound of a siren, in which the frequency parameter is variable through time. Another problem would be the underlying supposition, as we use sine waves analysis, that the signal under concern has infinite duration – see time–frequency analysis. Gabor proposes to apply the ideas from quantum physics to sound, allowing an analogy between sound and quanta. Under a mathematical background he proposed a method to reduce the Fourier analysis into cells. His research aimed at the information transmission through communication channels. Gabor saw in his atoms a possibility to transmit the same information but using less data, instead of transmitting the signal itself it would be possible to transmit only the coefficients which represent the same signal using his atoms.

“atoms” provide the best trade-off between spatial and frequency resolution

## http://en.wikipedia.org/wiki/Gabor_atom