# Granular Synthesis and Processing

- some history
- synthesis
- processing

## Granular Synthesis

• As an alternative in thinking about the construction of sound, Gabor (1947) first proposed the "acoustical quanta" as an alternative to the "timeless description" of sine waves.

• His acoustical quanta were small bursts of "harmonic oscillations" (i.e., a sine wave) individually contained within an amplitude envelope based on a Gaussian distribution curve. This is the classic definition of *granular synthesis*.

## Granular Synthesis to Granular Processing

• Iannis Xenakis was the first to apply Gabor's particle concept to music in his composition *Analogique A-B (1958-9)*.

• Barry Truax developed the first program to allow the realization of granular synthesis in real-time. His best know composition using this system is *Riverrun (1986)*.

• ***Granular processing*** developed separately by Truax and Roads. Grains were created from sampled soundfiles rather than synthesized with sinusoids. It becomes well established after 1990.

## Types of Granular Synthesis

- Synchronous Granular Synthesis: A stream of grains with a constant period produces a periodic envelop; this is a special case of AM which produces discrete sidebands.
- Quasi-Synchronous Granular Synthesis: A steam of grains with a varying period produces an non-periodic envelop; the sidebands are spread out in frequency and the spectral content is much more rich, resembling the output of a resonant filter.

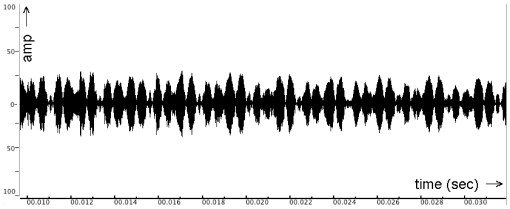
# Also,

- Asynchronous Granular Synthesis: properties of the grains are randomly varied (within limits) to produce a wide statistical distribution of grains.

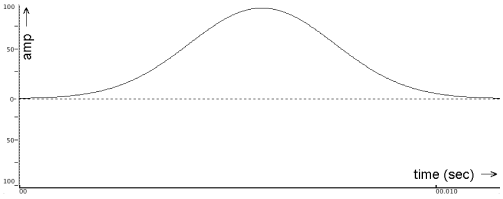
The most common usage is in *granular processing* where the soundfile offset is varied.

# Making a Grain in Granular Processing

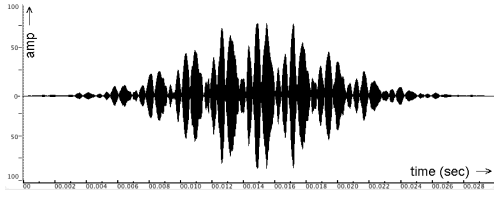
sampled sound



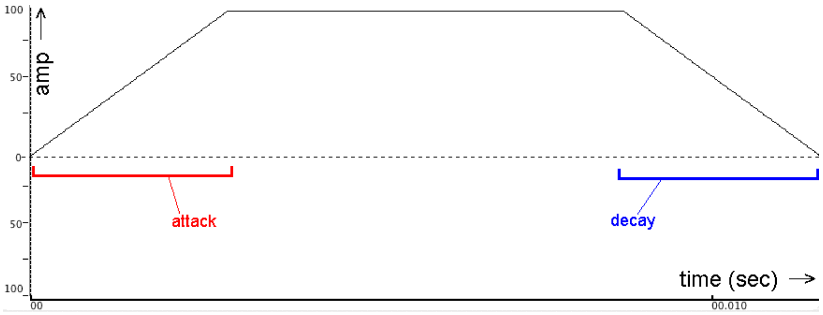

Gaussian envelope




sound grain



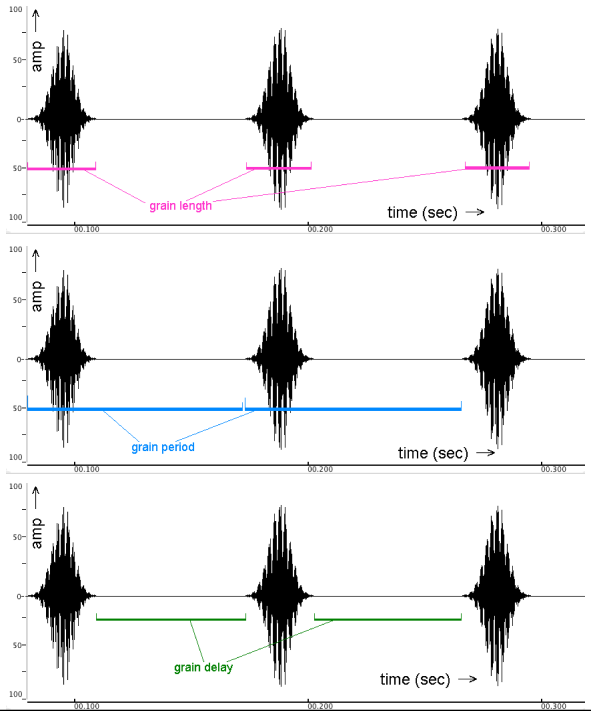
# Other envelopes




The trapezoidal envelope has been favored by Truax and others.

**Common Terms:**

length
period
delay



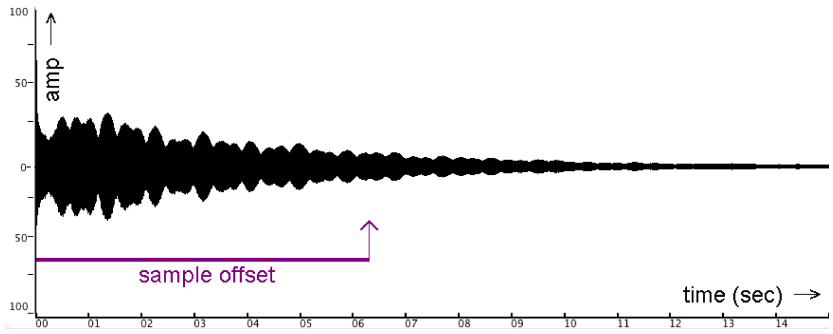
## Grain Length

- Grains are typically between 10 and 50 msec in length.
- In order to be heard as a pitched event, the minimum length is 13 msec for high frequencies and 45 msec for low frequencies.
- Lengths greater than 50 msec create the impression of separate sound events.

## Grain Period/Delay

- Grain period is typically randomized in order to avoiding any periodicity.
- Because grain duration and grain period are varied independently, the period may occasionally be shorter than the duration causing consecutive grains to overlap and produce a smoother texture.

## term: sample offset




## Grain Pitch

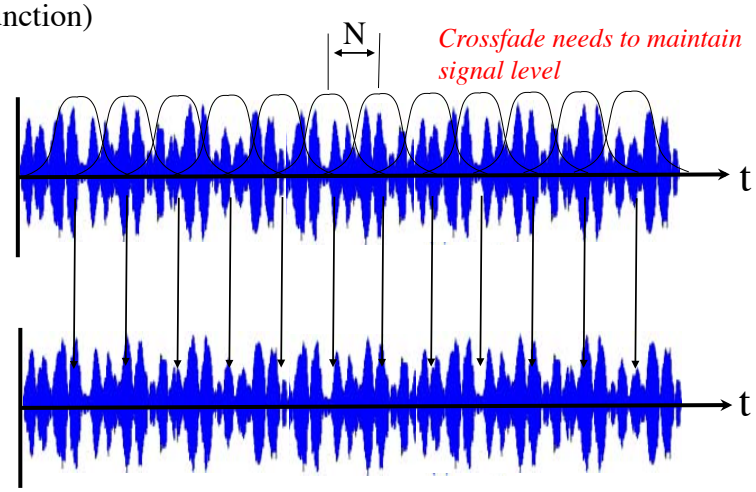
Grains can also be upsampled or downsampled

## Granular 'Events'

- Events include streams of grains produced by multiple voices (each of which produces one grain at a time)
- Control is often organized in terms of density expressed in grains/sec or number of voices producing grains.

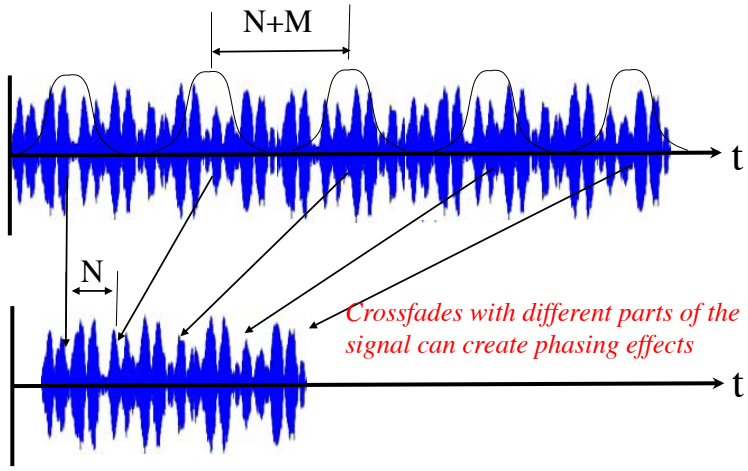
## Granular Time Stretching and Compressing

Grains can be extracted from soundfile every N samples to reconstruct the original signal (N depends on windowing function)



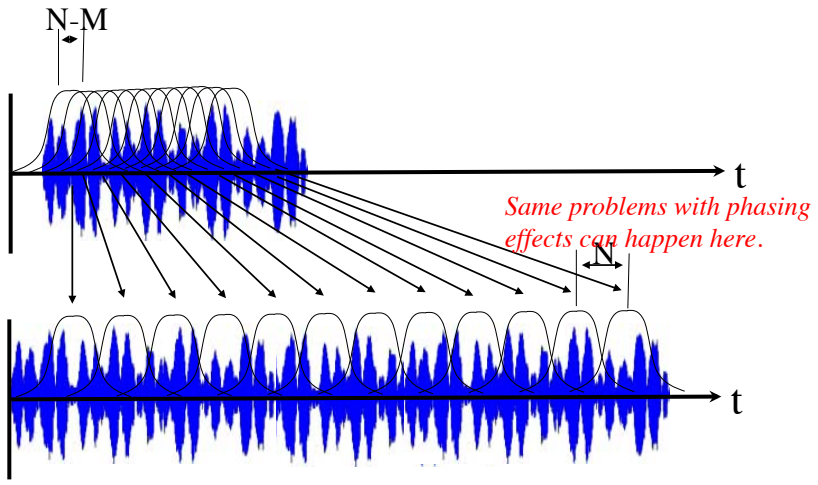

## Granular Time Stretching and Compressing

If grains are created every N+M samples and used to reconstruct the original every N samples, then time is compressed by a factor of (N/(N+M)) while retaining the original pitch.



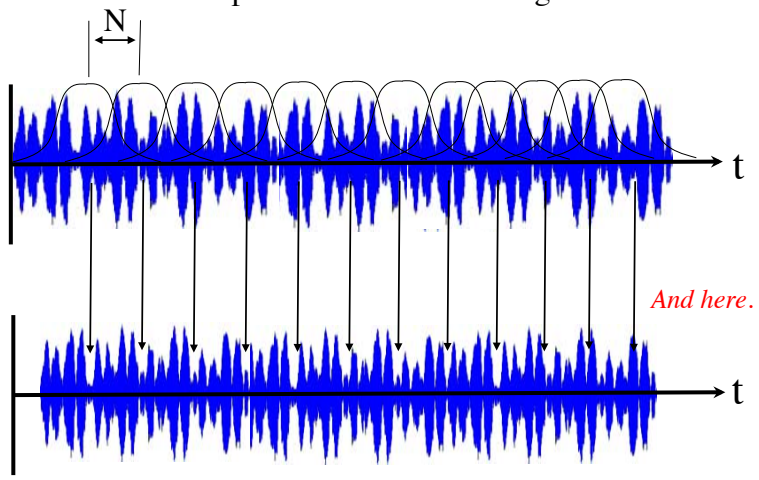
## Granular Time Stretching and Compressing

If grains are extracted every N-M samples and used to reconstruct the original every N samples, then time is stretched by a factor of (N/(N-M)) while retaining the original pitch.




## Granular Pitch Shifting

If grains are extracted from soundfile with a pitch shift factor of P, stretching the grain window to P*N and reconstructing every N samples will allow for pitch shift without change of duration



## Granular Processing

*Granular time stretching and compressing and granular pitch shifting can be applied to sounds independently of each other!*

Both though can cause phasing artifacts.

## Wavesets

By Trevor Wishart's definition, a waveset is a segment of a mono audio signal between one non-positive to positive zero crossing and the next. (T. Wishart : Audible Design)

Wavesets are an alternative way of thinking about grains.

# Wavesets

Soundfiles can be analyzed for their wavesets and the results stored in a library for waveset synthesis.

There is no attempt to hide artifacts!