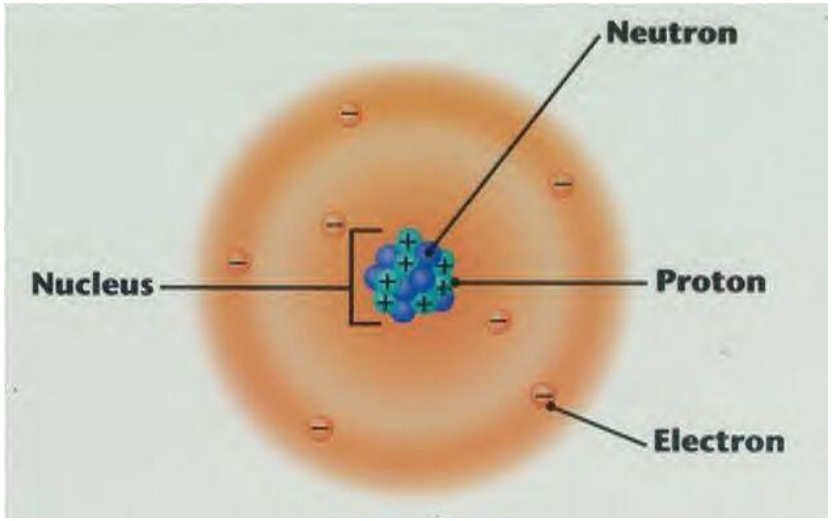
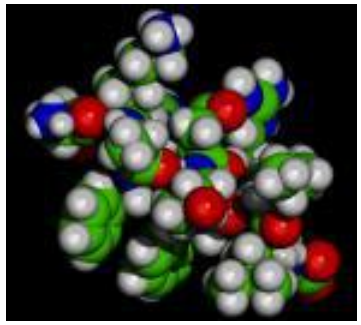
# Granulær syntese

Baseret på C. Roads:
”the computer music tutorial”
s.168 – s. 184

# Introduktion

- Al lyd og musik kan opfattes som sekvenser af del-lyde
- Typisk videnskabelig tilgang (superpositionsprincippet)
- Vi efterstræber altid ”elementar-partiklen”: (molekyler, atomer, elektroner/protoner/neutroner, quarker osv.)
- Grænserne flyttes konstant



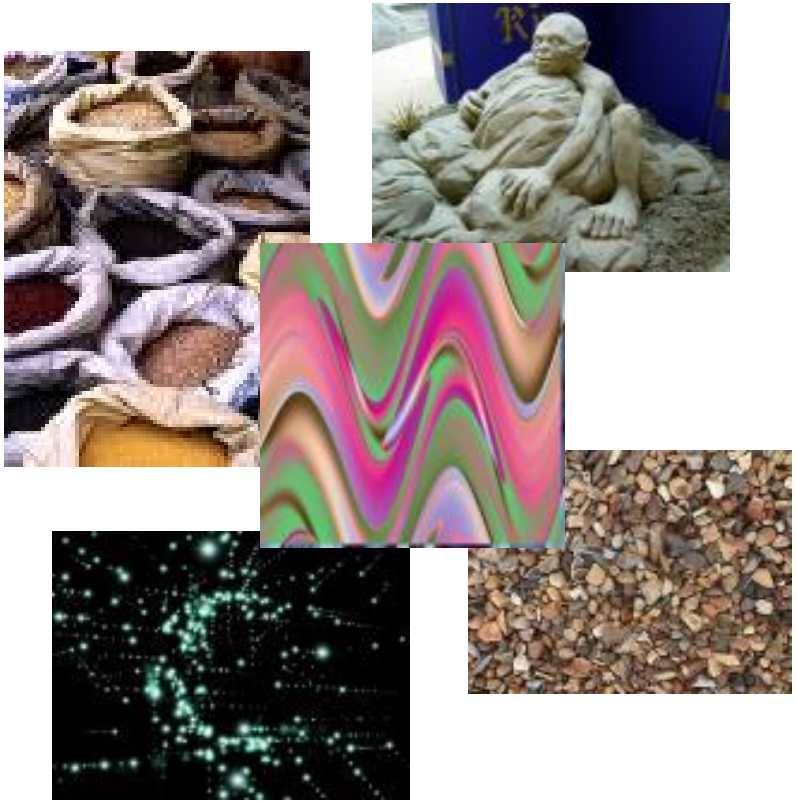



# Granulær musik

- Der er grænser for den menneskelige hørelses temporale opløsningsevne.
- Der er (næsten) ingen frekvens/timbre-begrænsning
- Overlap/enveloping  kan skabe kontinuert forløb

# Hvad er et ”grain”?

- ***DEF: 1 grain = 64.79891 milligrams***
- ***Der går altså ca. 15.000 på et kg!☺***
- Hvad er et ”grain”?
  - Enten skabt ved syntese
  - Eller ved sampling
  - Grain indeholder både en tids- og frekvensdimension
  - Tid: envelope’en og repetitionsfrekvensen
  - Frekvens: grundlyden
- Granulær syntese skaber nye muligheder, da der ingen begrænsninger er i hvad et grain kan bestå af. Alle inputs mulige og alle envelopes mulige.



# Grain generator instrument

- Den grundlæggende byggeblok

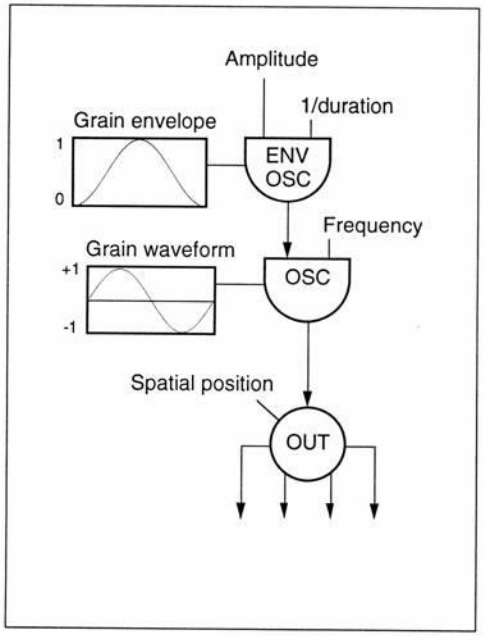



**Figure 5.11** A simple granular synthesis instrument built from an envelope generator and an oscillator with multichannel output.

# Enveloping

- Kort sekvens udgør råmaterialet (grundlyden)
- Enveloping (attack, sustain og release eller matematiske formler ”shaper” den til ønsket form

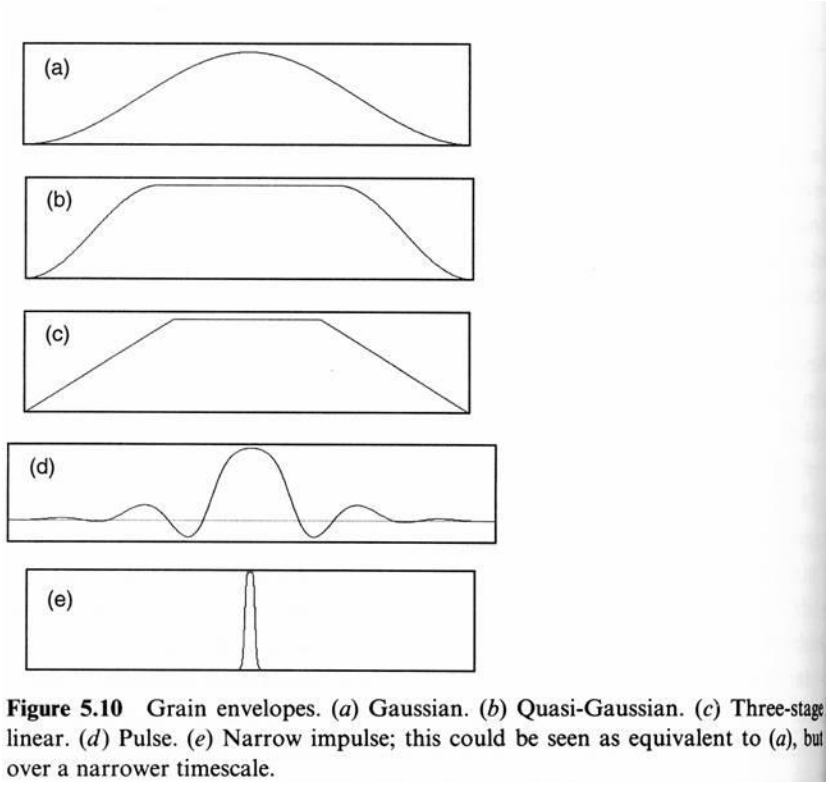



**Figure 5.10** Grain envelopes. (*a*) Gaussian. (*b*) Quasi-Gaussian. (*c*) Three-stage linear. (*d*) Pulse. (*e*) Narrow impulse; this could be seen as equivalent to (*a*), but over a narrower timescale.

# High-level Granular Organizations

- GS muliggør at fx 1 million grains kan behandles på hver sin måde!
  - Varighed
  - Envelope
  - Frekvens (-skift)
  - Lokation (i samplet fil)
  - Rumlig placering
- Kræver modelværktøj!
  - Globale parametre osv.

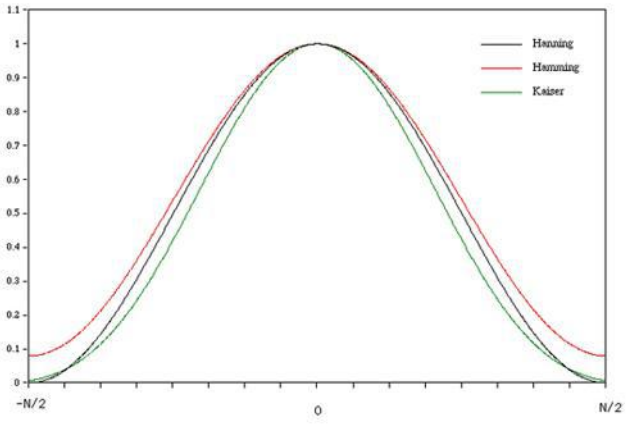
# Lydeksempler!

# Roads' 5 organisationsformer

1. Fourier and wavelet grids
2. Pitch-synchronous overlapping streams
3. Quasi-synchronous streams
4. Asynchronous clouds
5. Time-granulated or sampled sound streams with overlapped quasisync. or async. playback

# Fourier and wavelet grids

- FFT analyse baserer sin analyse på ”grains”, da den kræver at input kommer i faste bufferstørrelser
- FFT benytter vinduesfunktioner, da vi skal have et ”0” i begge ender af et sample.
- Impulser indeholder alle frekvenser (støj)
- Hanning/rektangulært vindue.
- De forskellige FFT-resultater er grains med tids- og frekvensinformation



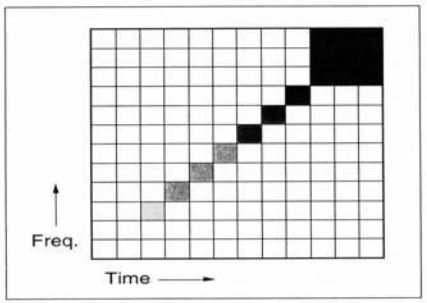




**Figure 5.12** Fourier grid dividing the time domain and the frequency domain into bounded units. Each row represents a frequency channel, and each column indicates a period of time. The darkness in each square indicates the intensity in that time-frequency region. This example shows a sound that ascends in frequency and grows more intense. In the STFT the frequency grid is linear; in the wavelet transform it is typically logarithmic.

# FFT fortsat

- Overlapping
- Wavelet er logaritmisk

```
n = 1024;
z = B Sqrt[1 - (2 (i - n/2) / (n - 1))^2];
kaiser = BesselI[0,z] / BesselI[0,B];
Plot3D[kaiser, {i,0,n}, {B,5,100},
    ViewPoint->{-1.1,1},
    PlotPoints->{100,40},
    Boxed->False, FaceGrids->None, Mesh->True,
    AxesLabel->{"index","B",""}
    ]
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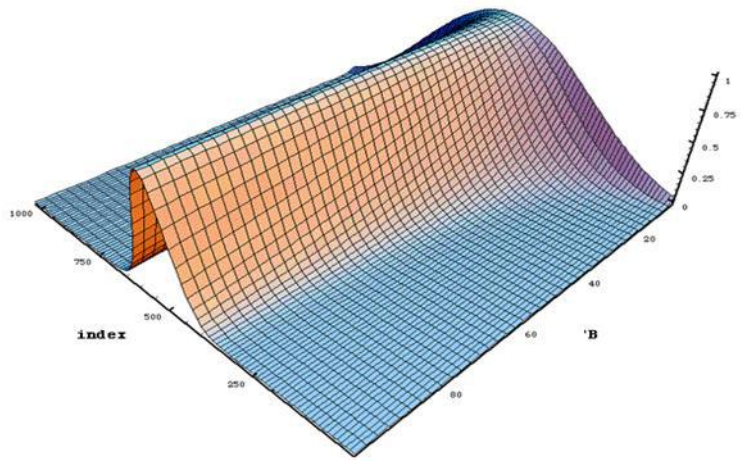


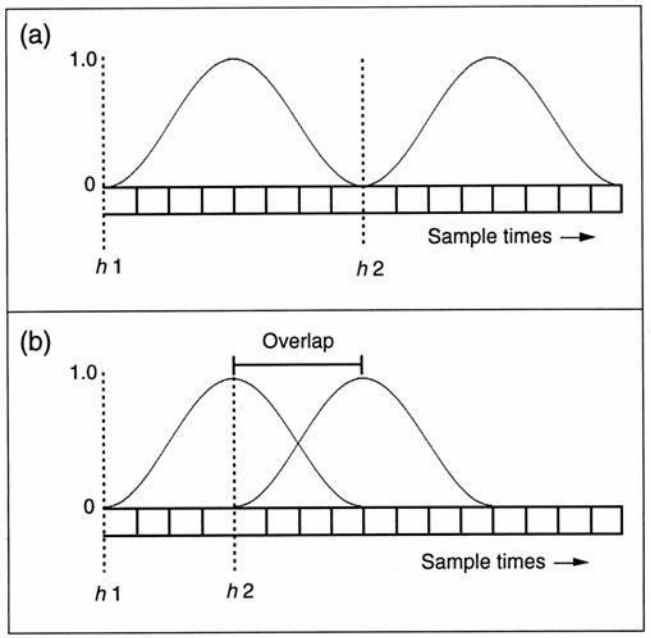


**Figure 13.16** Varying hop size for analysis windows that are eight samples long. $h1$ and $h\,2$ are the starting times for each window. (*a*) Nonoverlapping windows when hop size = window size. (*b*) Overlapping windows when hop size is less than window size. In this case the hop size is four samples.

# FFT

- Hvis ens grundlyd består af input fra en FFT-analyse, forsimples udtrykket, da frekvensanalyse lider af vinduesfunktionens midlende effekt.
- Frekvensanalyse af 10 minutters musik giver en ubrugelig middelværdi af en række grains/samples

# Pitch-synchronous overlapping streams

- Pitch detection (evt FFT)
- FFT
- Resynthesis
- Impulsresponsfiltrering med overlap ved afspilning

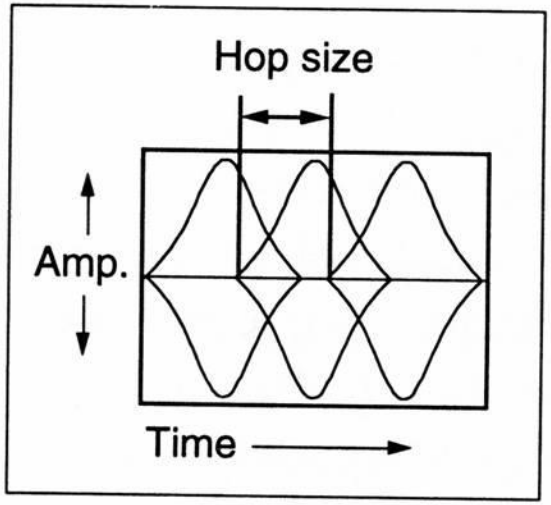


**Figure 5.13** Stream of overlapped grains.

# Quasi-synchronous streams

- Variabelt delay (til en vis grad) mellem en serie grains ved afspilning
- Ligner en form for AM
- Grain envelopen afgør modulationstypen og dermed sidebånd og andre modulations-fænomener

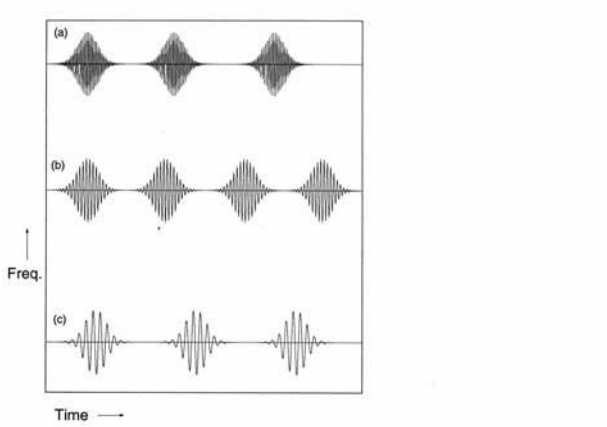


**Figure 5.15** Schematic depiction of three streams in quasi-synchronous granular synthesis. The placement of a stream on the vertical axis indicates the grain frequency (i.e., the frequency of the waveform). The onset time between the grains is randomized.

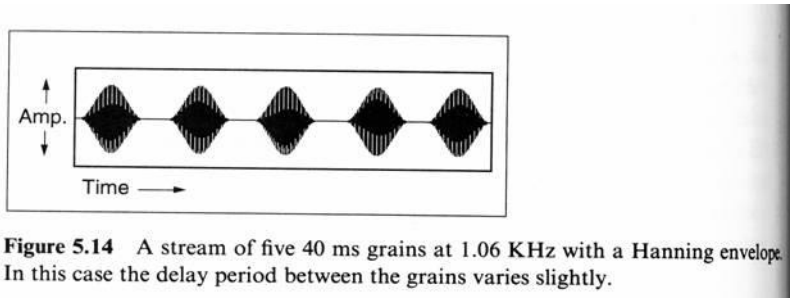


**Figure 5.14** A stream of five 40 ms grains at 1.06 KHz with a Hanning envelope. In this case the delay period between the grains varies slightly.

# Asynchronous clouds

- Delay helt variabelt
- ”A precision spray jet for sound”
- 6 grundlæggende parametre definerer ”cumulus” skyens form og indhold

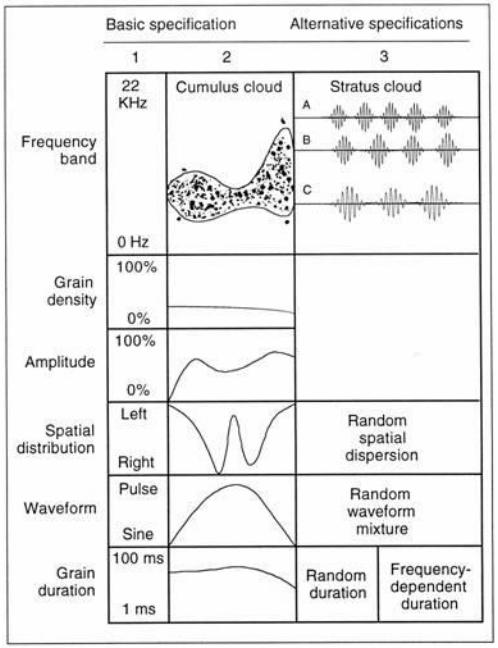


**Figure 5.16** Pictorial representation of cloud parameters in asynchronous granular synthesis. The column labeled 1 shows the typical parameter ranges. Column 2 shows basic specifications for standard clouds. Column 3 shows alternative specifications for the frequency band, spatial distribution, waveform, and grain duration parameters.

# Tidsmæssig udstrækning og spektrum

- Duration-parameteren styrer flere ting på samme tid
- Ren sinus (uendelig)
- Gaussisk (endelig)
- Impuls (infinitesimal)

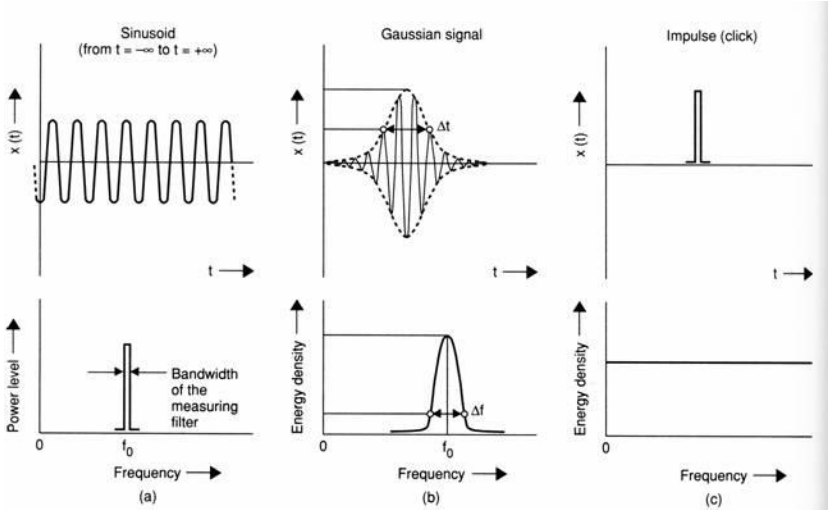


**Figure 5.17** Time-domain functions (*top*) and spectra (*bottom*) of three elementary signals, after Blauert (1983). (*a*) Sine wave of infinite duration corresponds to a single line in the spectrum. (*b*) Gaussian grain and corresponding formant spectrum. (*c*) Brief impulse and corresponding infinite spectrum.

# Forskellige former for clouds

- Hvordan lyder de?
  - Overlap?
  - Klangfarver
  - Syng dem (må gerne transponeres! ☺)
- Hvad er grain density?
- Hvad er waveform?

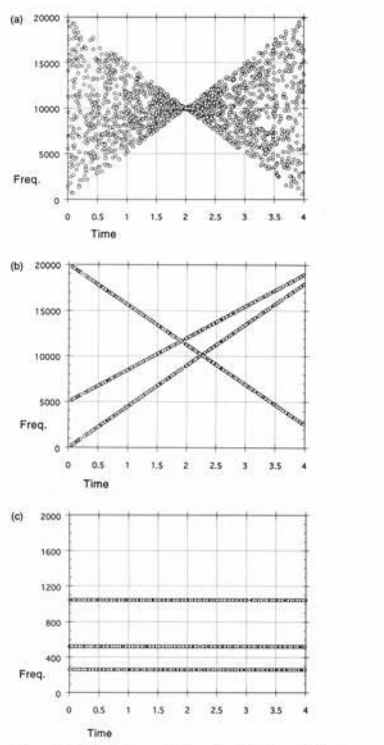


**Figure 5.19** Cloud forms. (*a*) Cumulus. (*b*) Glissandi. (*c*) Stratus.

# Time-granulated or sampled sound streams with overlapped quasisync. or async. playback

- Samples køres gennem et råkostjern, som findeler materialet
- Afspilningen af disse grains kan ske synkront eller i mere eller mindre tilfældig rækkefølge og med forskellig sampling-rate (resampling/timestretch)
- ”Ole sad på en knold og sang”

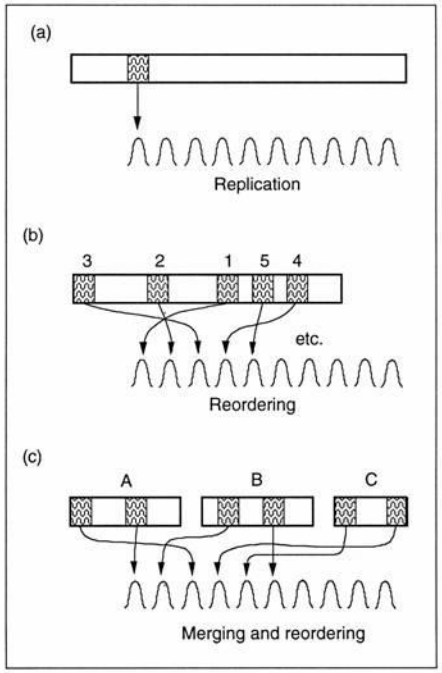


**Figure 5.20** Three approaches to time granulation from stored sound files. (*a*) One grain is extracted and turned into a “roll.” (*b*) Grains are randomly extracted from a sound file and recordered. (*c*) Grains are randomly chosen from different sound files and reordered. The grains need not be strictly sequential and may overlap.

# Øvelser

- Prøv at hente Audiomulch eller granulab og skru på parametrene, lav egne grains, evt. fra synth
- Benyt evt. MAX/MSP
- Lav flere eksempler, som de andre skal synge

# Flere musikeksempler!