ELECTRONIC MUSICAL INSTRUMENTS

A brief history

and basic concepts

Traditional musical instruments

- String, horn and percussive instruments.
- A standing wave (in string or inside a body), or vibrations (in percussive instruments) create audible sound waves.
- The sound is created according to the laws of physics.
- A musician is only able to modify created sounds, by articulation.

Electric instruments

- Electric guitar, Hammond organ and similar instruments.
- Electromagnetic disturbances in the pickup, due to string vibration or tone wheel rotation.
- The electric signal is amplified to create sounds.
- Still, a human is not able to control how the sound is created (only articulation and processing).
- Such instruments are not the topic of this course.

Electronic musical instruments (EMI)

These are the instruments we're interested in.

- A human fully controls the process of sound creation.
- Two main approaches:
  - sound synthesis: sounds created from scratch,
  - sampling: recording, processing, playback
- Various forms:
  - hardware: analog, digital, hybrid
  - software (virtual): on a computer

Sound synthesis

- Synthesis – from Greek *syntithenai* – „compose from elements”.
- A sound is created from scratch, with hardware or software created and controlled by a human.
- Algorithm – a method of creating musical sounds.
- Many synthesis algorithms were developed.
- Sound synthesizer – EMI that performs sound synthesis.
- Sampling is not a synthesis: sounds are not created, existing sounds (samples) are processed by a sampler.
- Modern EMIs are often samplers + synthesizers (2 in 1).

Two approaches to EMIs

What do we expect from EMIs?

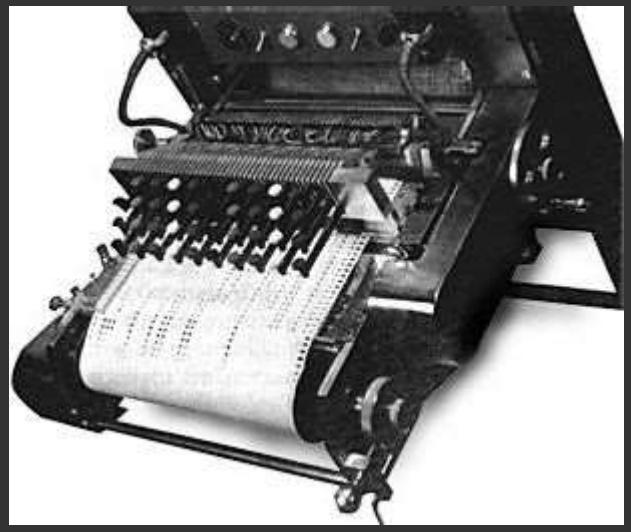
- Approach #1: we want new, interesting sounds (e.g. subtractive synthesis).
- Approach #2: we want “many instruments in one box”, a criterion: how realistically do the instruments sound.
- We should not say that “a synthesis algorithm is bad, because it does not sound as real instruments”. The main feature of such an algorithm is that it creates interesting sounds, different from real instruments.
- If we really need realistic instruments, we should use a sampler, not a synthesizer.

RCA Mark - the first sound synthesizer

RCA Mark I (1952) i RCA Mark II (1957) – mainframe computers that may be regarded as first sound synthesizers.

Sounds were produced by lamp oscillators
(12 in MI, 24 in MII)

A “sequencer” – tape reader – was used to control the instrument and play music without human intervention.



Moog Modular

In 1964, the first synthesizer developed by Robert Moog was released. Moog Modular was the first synthesizer that was controlled with a standard piano keyboard.

It was also the first commercially successful EMI, after the release of „*Switched On Bach*” album, containing classical music played on the Moog synthesizer (Wendy Carlos, 1968).

Moog Modular – a modular instrument

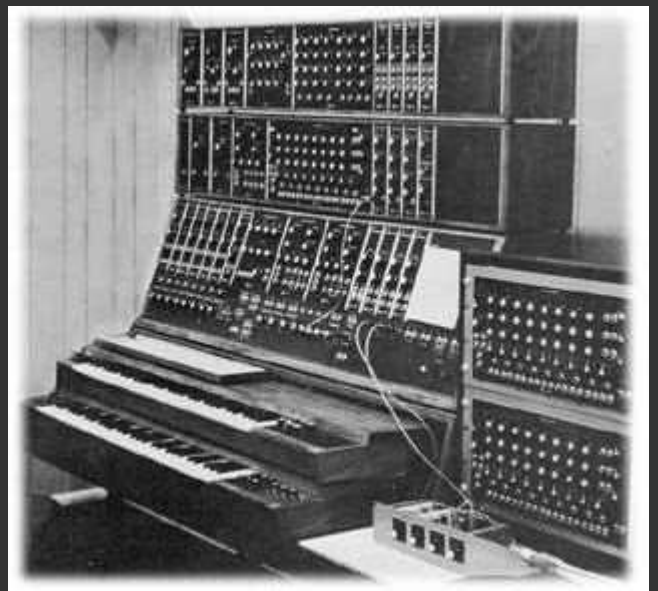
Moog Modular was an analogue modular synthesizer.

The instrument was built from modules – voltage controlled electronic circuits : oscillators, filters, amplifiers. They were controlled with knobs, switches and other modules.

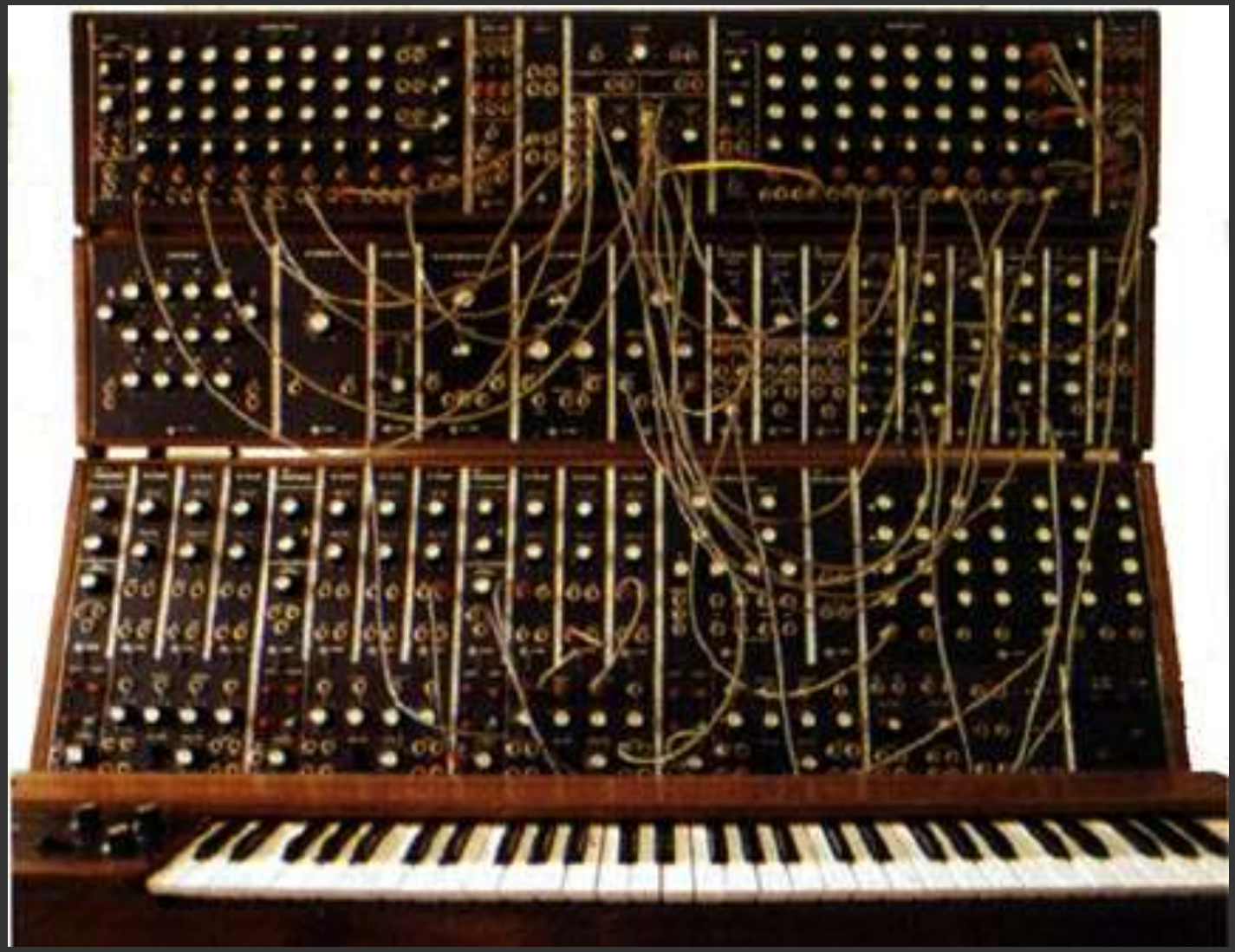
A musician had to connect the modules with cords (patches).

The subtractive synthesis was used.

The instruments were big, heavy, expensive and hard to use, but they provided musicians with new possibilities, not heard before.



Moog Modular in action



Minimoog

- Because Moog Modular was too heavy and too cumbersome, it wasn't suitable for live performances.
- Minimoog (1971) was a simplified, portable synthesizer with greatly reduced number of modules and fixed connections.
- It was much smaller, lighter and less expensive than Modular, so it became popular in musicians for both live performances and studio recordings.

Polyphonic EMI

- Early EMIs were monophonic: only a single sound could be generated at a time. That meant: no chords.
- Polyphony: a possibility to create multiple sounds (voices) at the same time. A separate synthesis setup is required for each voice.
- Polymoog (1975): Moog's polyphonic synthesizer.
- Since 1970's, all EMIs are polyphonic.

More than “keyboards”

Not all Analogue EMIs were the keyboards.

Drum machine
LinnDrum (1982)

Drum kit synthesizer
Simmons SDSV (1982)

More than “keyboards”

Guitar synthesizer
Roland G-707 (1984)

Wind controller
AKAI EVI-1000 (1984)

EMIs going digital

Digital technique brought new possibilities for EMIs:

- settings memory – easy configuration
- digital oscillators – no more out-of-tune instruments
- RAM – new methods of sound creation
- new algorithms (such as FM synthesis)
- sampling
- MIDI – controlling EMIs with sequencers

Hybrid A&D synthesizers

Roland Juno 6 (1982)
subtractive synthesis
digital oscillators

PPG Wave (1981)
wavetable synthesis
RAM as oscillators

Digital FM synthesis

- Frequency modulation (FM) as a new digital synthesis.
- Fully digital instruments.
- Relatively cheap.
- Easy to use, includes presets.
- New, interesting sounds

Yamaha DX7 (1983) – a huge commercial success in 1980s

Digital sound workstations

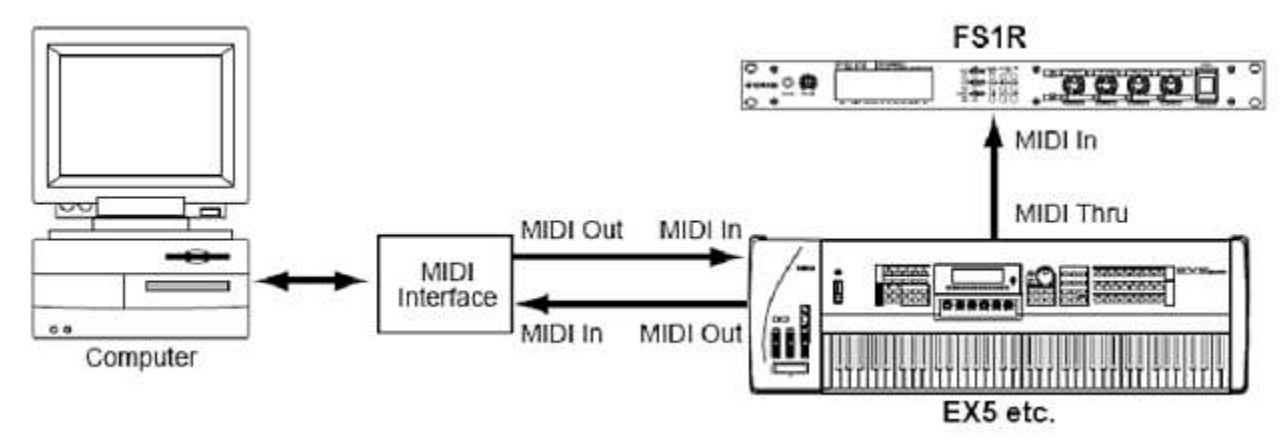
- A hybrid of musical instruments and computers.
- Multiple methods: additive, FM, sampling.
- Extremely expensive (15 000 $ - 200 000 $)
- Impressive capabilities of sound creation (sampling!!!)

Synclavier II
(1980, New England Digital)

Fairlight CMI
(1979-85)

MIDI

- MIDI (*Musical Instrument Digital Interface*):
  a standard of data exchange between digital EMIs.
- Used to control EMIs by musicians and devices.
- All EMIs that implement MIDI are compatible.
- Divides traditional EMIs into:
  - controllers (keyboard, computer, etc.)
  - sound modules (synthesizer, sampler, etc.)



MIDI controllers

MIDI keyboard

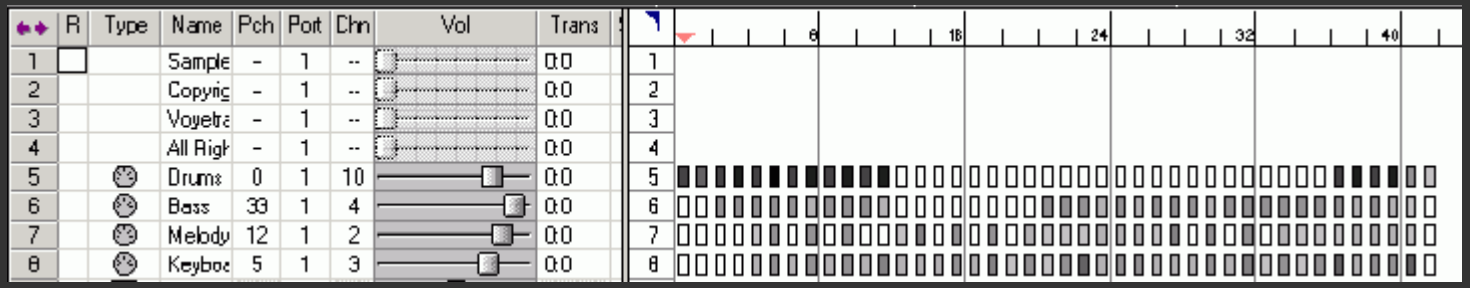
MIDI drum pad

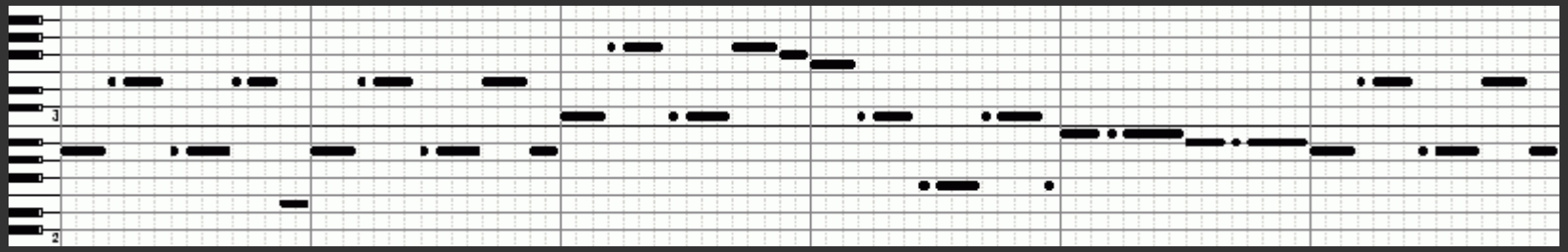
MIDI drum set

MIDI guitar

MIDI sequencer

- Usually a computer software.
- Sequences of MIDI codes (“notes”) are recorded.
- MIDI codes are sent to the controlled module.
- Sequencer plays the music instead of a musician.





Sampling

An entirely new approach to EMIs:

- sound samples are recorded and processed
- instruments are built from samples
- a sampler plays back these instruments
- new possibilities of sound creation
- this is not a sound synthesis

AKAI S-900 (1986)
MIDI controlled
sampler

„PCM synthesis”

Very simplified instruments:

- sound samples programmed in ROM (hence, they are called “ROMplers”)
- very easy to use (plug & play)
- cheap
- many instruments in a single “box”

Yamaha S03 SL

Physical modelling

A novel approach:

- we try to model an instrument, not its sound
- a computer model may be controlled just as the real one
- better sounds, as (contrary to samplers) it allows for articulation
- this method did not meet the expectations – the problem was too hard to solve.

Yamaha VL-1 (1994) – waveguide synthesizer

Computer soundcards with synthesis

PC soundcards were used mainly for games:

- simplified FM – SoundBlaster 16 (1992)
- PCM synthesis (sample based) – Gravis Ultrasound (1992), Creative SoundBlaster AWE32 (1994)
- possibility of using custom samples (SoundFont 2)
- software synthesis (without a soundcard)
  - DirectMusic (część DirectX) (1999)

Sound synthesis is no longer used in PC games. All sounds and music are prerecorded.

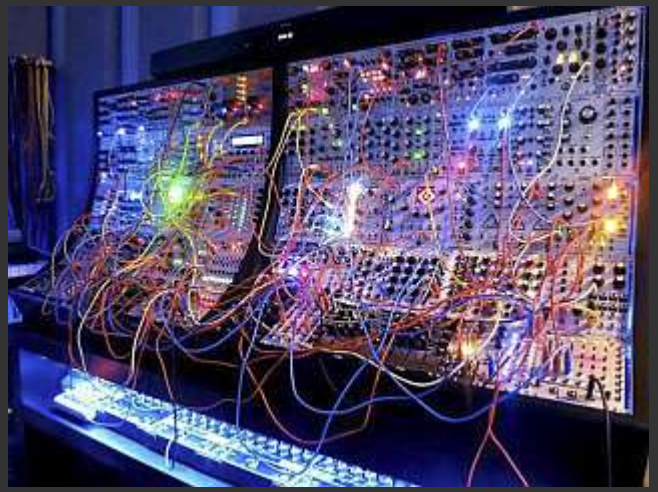
Analogue synthesis is back

- *Virtual analog* – digital emulation of analogue synthesis
- Modern features (MIDI, presets)
- Often combined with sampling and FM.

Clavia Nord Lead 2X (1997)

Eurorack - the return of modular synthesizers

- Eurorack – a standard for modular synthesizers (1995)
- Modules produced by various vendors
- Connected with patches, just as the original Modular!



Software synthesis

- Virtual EMIs inside a PC
- VSTi (*Virtual Studio Technology instruments*) standard
- Programmed as plugins that work inside a host – DAW (*Digital Audio Workstation*)
- Receive MIDI codes and produce sounds using any method possible (synthesis algorithms, sampling).

Synth1

free subtractive VSTi synthesizer

Software synthesis

Arturia Moog Modular
– Moog Modular emulator.

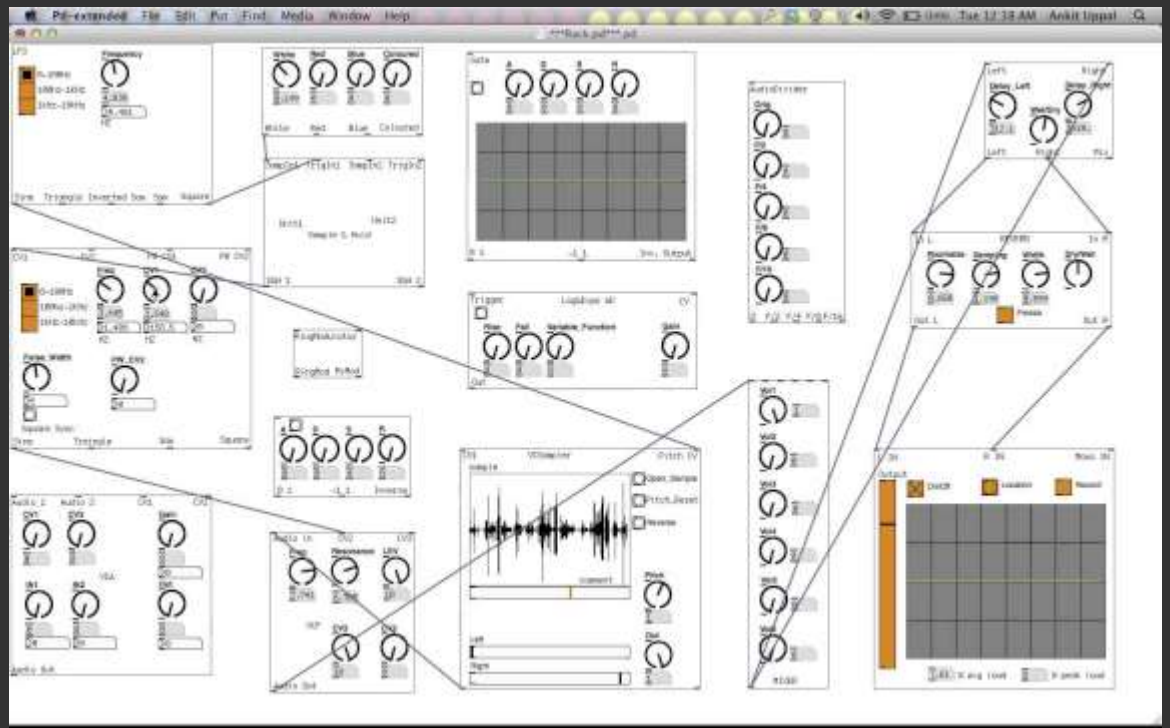
Sound quality and similarity to the original were praised by many musicians.

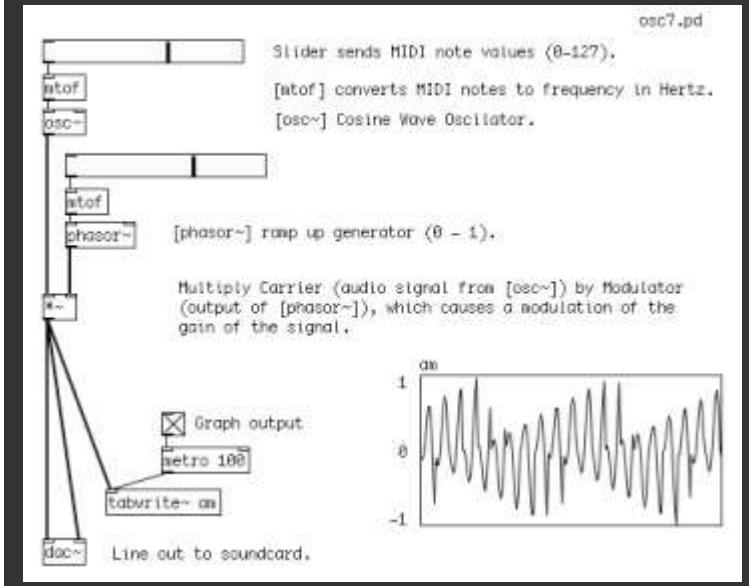
Now you can have the Modular in your laptop. We've come a long way!

Computer music tools

Tools for making music with a computer

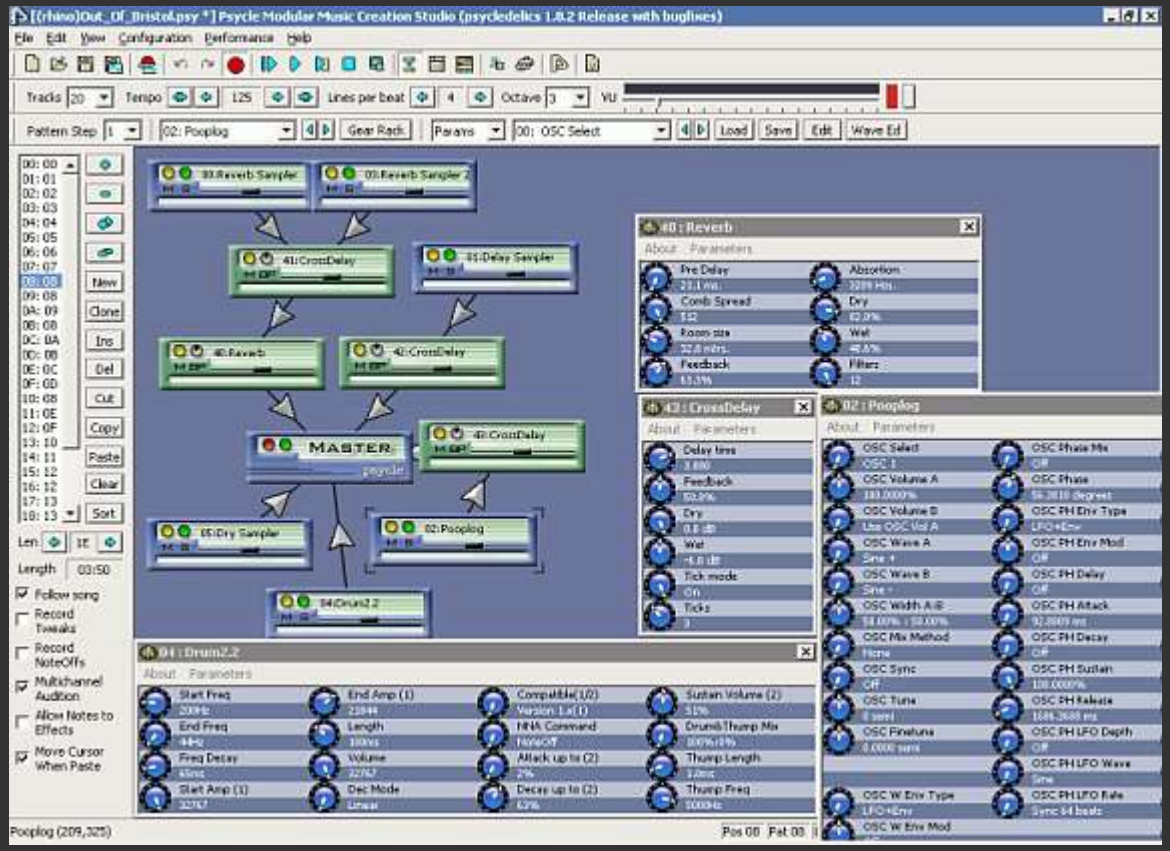
- Specific programming languages, e.g. *CSound*, complicated (writing code)
- Visual programming – Max/MSP (commercial) and Pure Data (pd, free)





Computer music tools

- A virtual studio built from blocks (“machines”) and controlled with sequences of codes.
- Examples: *NI Reactor* (commercial), *Psycle* (free)



More on the history of EMIs

- Wikipedia
  http://en.wikipedia.org/wiki/Category:Electronic_music_instruments
- Synthmuseum
  http://www.synthmuseum.com/
- Vintage Synth Explorer
  http://www.vintagesynth.com/
- 120 years of electronic music
  http://120years.net/
- Synth Zone
  http://www.synthzone.com/
- Moog Archives
  http://www.moogarchives.com/