Signal Analysis in Interactive Real-Time Music Systems

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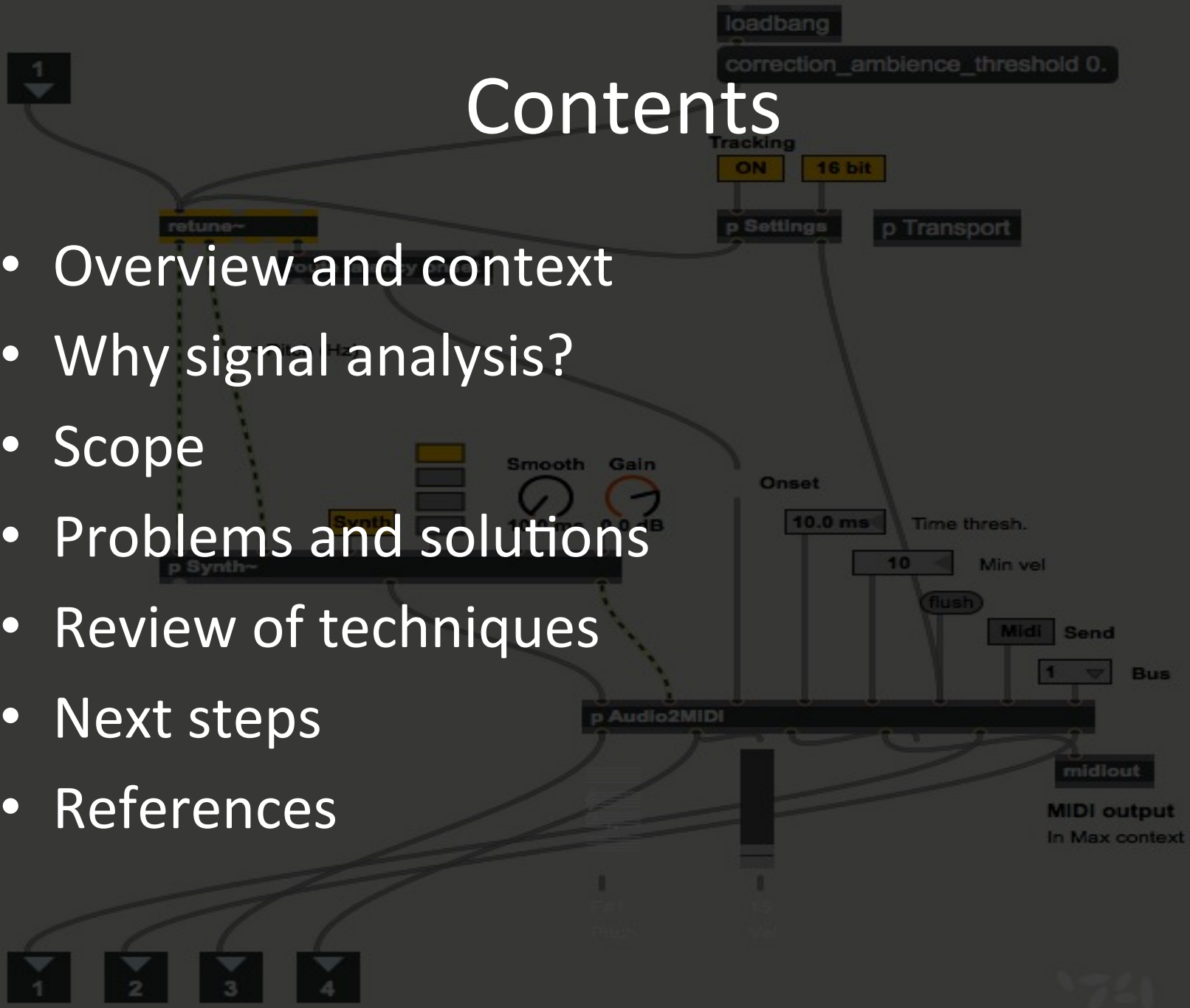


Interactive Real-Time Systems: Definition

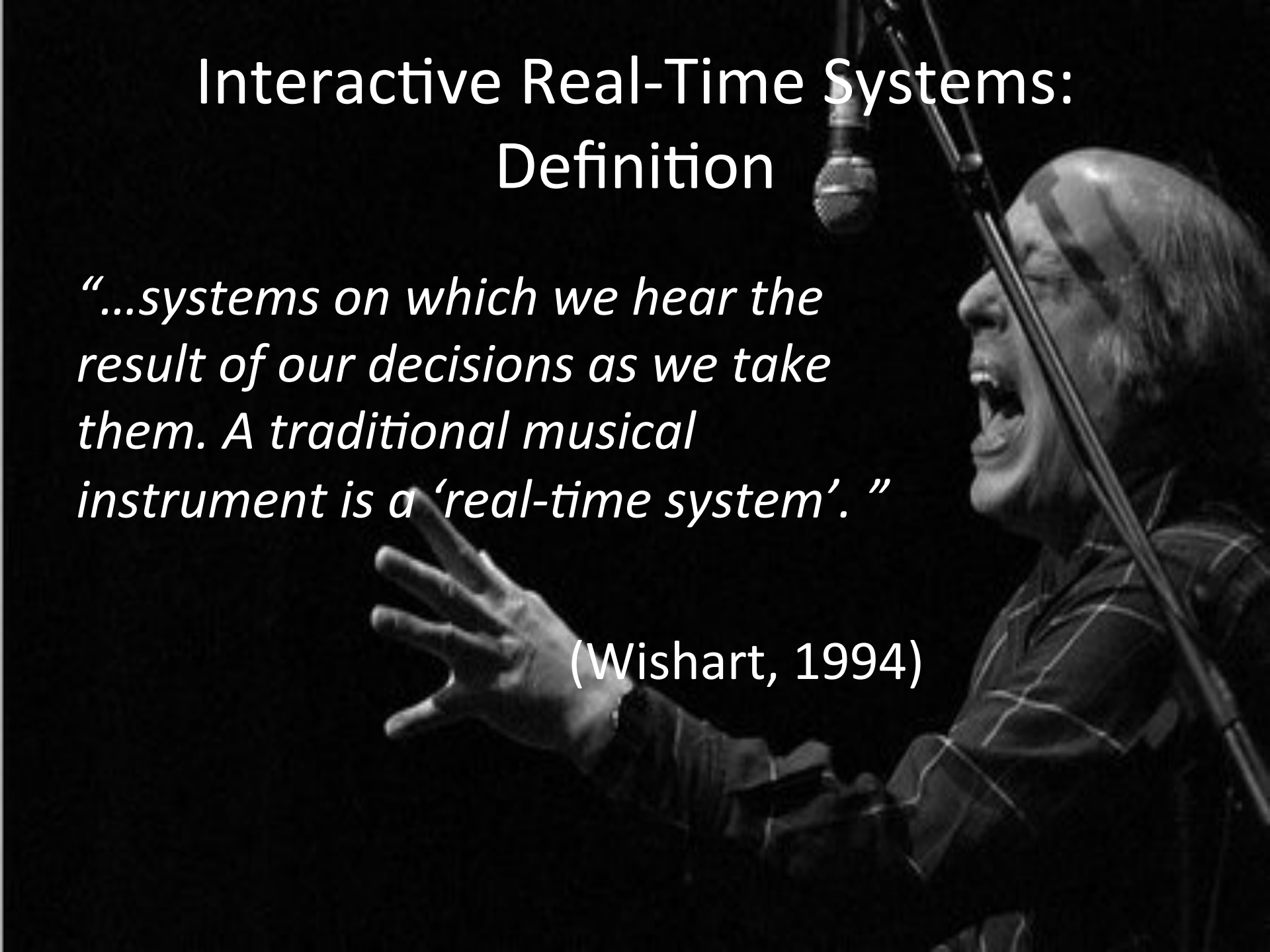
"An interactive composing system operates as an intelligent instrument – intelligent in the sense that it responds to a performer in a complex, not entirely predictable way, adding information to what a performer specifies and providing cues to the performer for further actions…The computer responds to the performer and the performer responds to the computer, and the music takes its form through that mutually influential, interactive relationship."

(Chadabe, 1984)

Interactive Real-Time Systems: Definition

"…systems on which we hear the result of our decisions as we take them. A traditional musical instrument is a 'real-time system'. "

(Wishart, 1994)



Interactive Real-Time Systems: Rationale

- Allow the work to be recreated in the moment (Wishart, 1994)
- Increase accessibility to music-making (Machover, 1999)
- Facilitate listening in composition (Machover, 1999)
- Allow for multi-timbral control (Eigenfeldt, 2009)
- Increased range of expression (Reas & Fry, 2007)
- Composition as a process not a product (Nyman, 1999)

Interactive Real-Time Systems: Rationale

"…good things often happen – in work, in romance, and in other aspects of life - as a result of successful interaction during opportunities presented as if by chance…it seems to me reasonable that such a perception should also find expression in music".

(Chadabe, 1984)

Context (My Research)

- Co-performers
- Exploration of chaos within parameters of popular song forms
- Varying levels of interactivity (varies at composition and performance stages)
- The human performer and system to be responsible for both high and low-level parameters (unlike conductor models)

Why Signal Analysis?

- New possibilities in timbral processing
  - Early systems were MIDI / control-data based (Eigenfeldt, 2007)
  - More powerful computers have opened up the possibility of more studio-based processes on the stage (Eigenfeldt, 2007)

Why Signal Analysis?

- Advantages of the instrument as controller
  - Minimises additional equipment (Richards, 2006)
  - Minimises additional performance demands
  - Allows co-performance of human and system
  - Non-invasive (Kristensen, 2012)

Why Signal Analysis?

- Range of features that can be detected

"The last 20 years have seen…the development of algorithms capable of onset detection, beat tracking, pitch detection, downbeat detection, chord recognition and many other forms of musical audio analysis." (Stark, 2014)

Peeters (2004) Proposes a whole library of measures.

Why Signal Analysis?

- Additional possibilities with further processing
  - Score-following (Winkler, 2001; Waite, 2014)
  - Pattern recognition using Machine Learning techniques (Caramiaux & Tanaka, 2013)

Scope

- The artist as programmer
- Max externals, VSTs or easily-configurable standalone software
- Use of transparent mappings
- Non-invasive techniques
- Portability

Problems & Solutions

- Accuracy vs Latency
  - Hardware alternatives (Pardue et al (2014)
  - New algorithms (Kristensen, 2012)
  - Combining approaches
    - Multimodal approaches (Wishart, 1994)
    - Input filtering and additional processing (Stark, 2014)
  - Adapting the system
  - Audio analysis is never perfect (Jam Origin, 2014)

Problems & Solutions

- Additional control

"Open air gestures are not traditionally associated with music-making, offering the performer an opportunity to transcend habitual movement patterns and explore fresh links between gesture and sound."

(Mainsbridge & Beilharz, 2014)

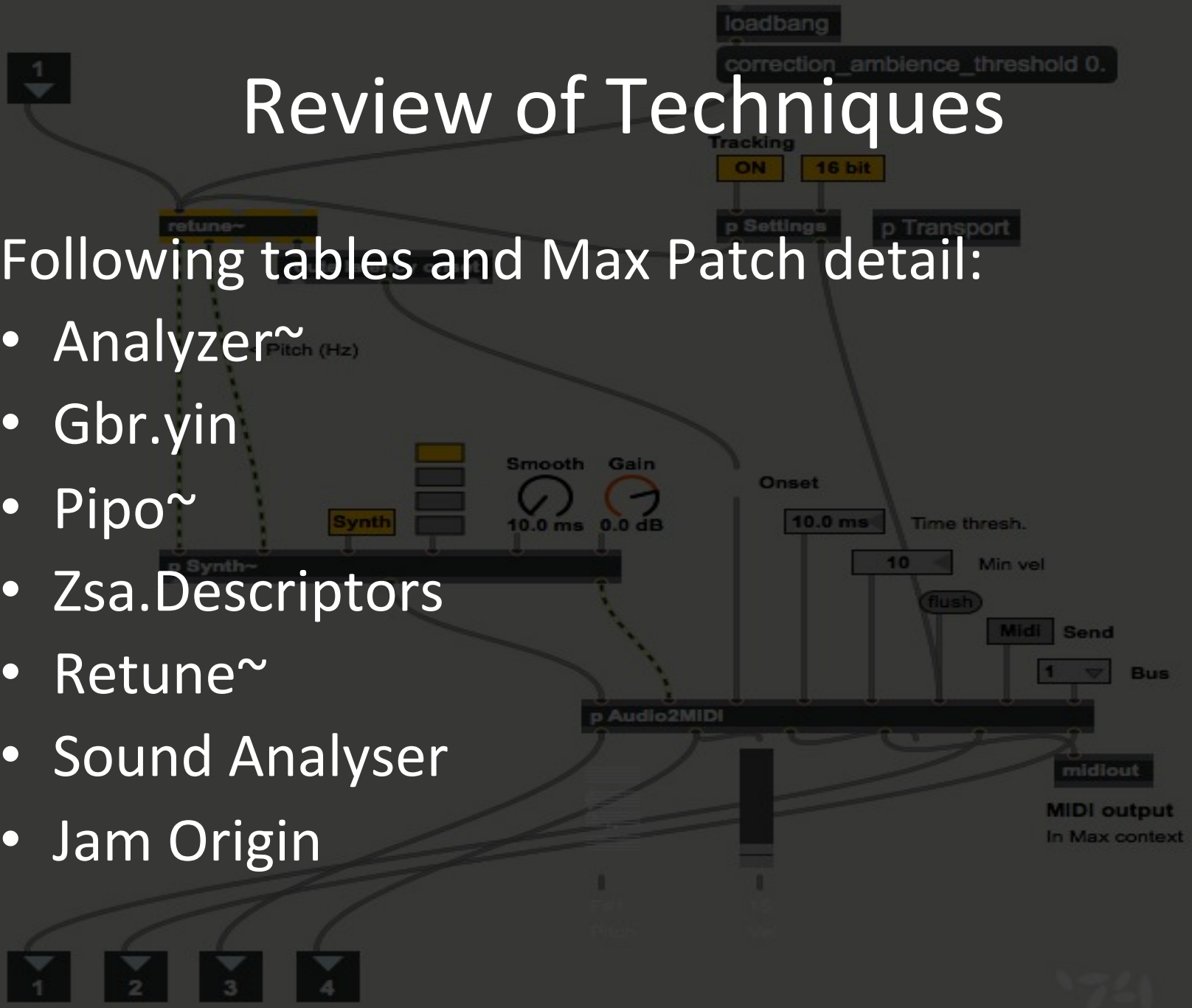
Problems & Solutions

- Computational load
  - Use of multiple computers and wireless communication protocols (Stark, 2014)
  - Development of new, more efficient techniques (Kristensen, 2012)
  - Don't use Max…

Review of Techniques

Following tables and Max Patch detail:

- Analyzer~
- Gbr.yin
- Pipo~
- Zsa.Descriptors
- Retune~
- Sound Analyser
- Jam Origin



Signal Analysis Methods Overview (1)

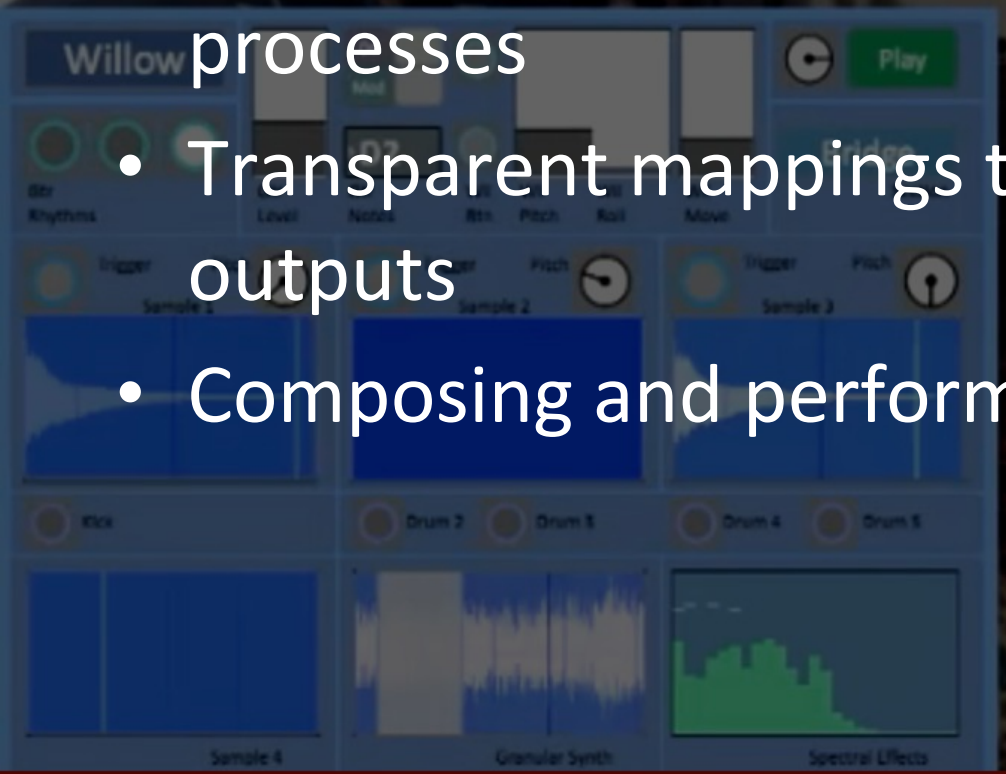
Name	Hosting	Features	Testing
Analyzer~ (Jehan, 2001)	Max	Pitch detection: fundamental and partials RMS values of frequency components Loudness, Brightness, Noisiness, Bark Attack	Lots of features combined into 1 external Poor on higher pitches
Gbr.yin~ (Schnell & Schwarz, 2005)	Max (Ftm&Co)	Pitch detection RMS Quality factor (periodicity) Autocorrelation	Very reliable, especially when used on bass notes with low-pass filtering
Pipo slice:yin (Françoise et al, 2014)	Max (MuBu)	Pitch detection RMS Quality factor (periodicity) Autocorrelation	Not yet tested
Zsa.descriptors (Malt & Jourdan, 2008)	Max (in pfft~)	Pitch detection: fundamental, virtual fundamental Amplitude/emergy detection Spectral: Bark, Mel, Centroid, Flux & more	Basic tests suggest unstable pitch tracking

Signal Analysis Methods Overview (2)

Name	Hosting	Features	Testing
Retune~ (Cycling 74, 2014)	Max 7 / M4L	Pitch detection RMS	Additional creative possibilities
Sound Analyser (Stark, 2014)	VST and OSC	Time domain: RMS, Peak, Zero Crossing Rate Frequency domain: Spectral Centroid, Flatness and Crest. Onset detection: Energy Difference, Spectral Flux, High Frequency Content and Complex Spectral Difference. Pitch detection: Yin, Chord recognition Spectra: FFT Magnitude, Mel-frequency representations and the Constant-Q	Can't configure algorithms Unstable on pitch detection.
MIDI Guitar (NB not free!) (Jam Origin, 2014)	VST / Standalone	MIDI: Pitch, Velocity, Pitch Bend Monophonic / Polyphonic	Very reliable Saves a lot of work Highly configurable.

Next Steps

- Further testing
- Linking to processing
- Transparent mappings to generative processes
- Transparent mappings to audio and visual outputs
- Composing and performing



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