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INTELLIGENT DIGITAL AUDIO EFFECTS FOR AUTOMATIC MIXING

All demonstrations available from
www.elec.qmul.ac.uk/digitalmusic/automaticmixing/
Motivation

There’s no reason why musicians who’d rather get on with making music than get too deep into band recording using reasonably conventional instrumentation shouldn’t be EQ’d and balanced automatically by advanced DAW software.

DAWs could optimise their own mixer and plug-in gain structure while preserving the same mix balance.
Classification

Is this art or engineering?

Music Mixture

Technical constraints

Acoustic

Electronic

Interface

Aesthetic constraints

Common Practice

Uncommon

Repetitive task
Approach

- Create tools that automate complex mixing tasks
- Develop effects which dynamically adapt to multi-channel input of a mixer
- Analyse content of each channel with respect to other channels
- Must be suitable for automatic live mixing tasks
  - Operate real-time
  - Preserve system stability

Cross-Adaptive Effects

Also called inter-channel dependent or MIMO (multi-input / multi-output) effects
Cross-Adaptive Effects

\( ch_1 \) to \( ch_N \) are audio signals.

\( fv_1 \) to \( fv_N \) are features extracted from audio channels

\( cv_1 \) to \( cv_N \) are control vectors that drive digital audio processors
Automatic mixing host

- Time Offset Correction
- Auto Panner
- Auto Fader
- Normalised-EQ
- Channel Enhancer
- Hardware Control Surface
Automatic stereo panner
Automatic Panner

- Side chain processing for real time applications
- Multiple channel processing dependency
- Accumulative spectral decomposition
Automatic Panner Stereophonic Masking

- Reducing directional spectral masking improves intelligibility.

Directional spectral masking

Panning space directional masking minimization
Automatic Panner Results

- Spectral decomposition rules manage to converge and adapt to inputs.
- Reduction in directional masking maximizes stereophonic separation.
- The automatic panner requires a better priority scheme.
Automatic Panner Evaluation

1) Listen to the examples

2) Answer The questions

How Different is the panning in A compared to B?

Exactly the Same

 Completely Different

Which file, A or B, has better Panning Quality?

A Quality is Ideal

B Quality is Ideal

Please justify your answer in terms of A & B:

3) press next to go to the next question

Audio ON\OFF

SoundCard Settings

Please write your name & e-mail in the box before you start the test:

Name: name

e-mail: mail@mail.com

Headphone Level

Min

MAX

Play From Beginning
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Automatic Panner
Spectral Enhancer
Objective

Minimising signal masking through the characterisation of spectral channel interdependence

What do we define as spectral masking?

Spectral masking is the loss of spectral content perception of one or more channels when they are mixed together.

- not the same as psychoacoustic masking
- results from signal and noise occupying the same frequency bins
- noise spectrum masks spectrum of the signal
Inter-channel dependent spectral enhancer

- Master channel ‘writes’ spectral enhancing contour and has no signal processing applied to it.
- Slave channels ‘read’ spectral contour and receive a processing control value.

Master channel has continuous information regarding properties of all channels.
Understanding the display

Filter bank division $= k_2$

Spectral enhancing contour

Attenuation

Frequency
Attenuation

\[ + \]
Bypass

\[ - \]

Affects all Channels just like a normal ducker would do

\[ + \]

Q

\[ - \]

Affects Only Channels just with same spectral content
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Spectral Enhancer

Accumulated Un-Masked Index 112 %

Un-masked

Masked

Masking Limit
Automatic gain maximisation and feedback prevention
Feedback prevention

- Feedback Suppressors:
  - Frequency shifting
  - Auto-notch filtering
  - ...

- Goal of mixing engineer to adjust frequency response while staying below threshold for feedback
  - Flatten response
  - Maximise gain

- Don't Treat the Symptoms - Treat the Cause!

- Need gain limiter which does not introduce artifacts or prevent EQ
Feedback explained

Given the following acoustic model:

- $H_{ETOT}(x)$ is feed-forward transfer function of the system
  - product of individual transfer functions of microphone, equaliser, amplifier and speaker.

- $H_{ATOT}(x)$ is acoustic feedback transfer function of the system

The system will introduce undesired acoustic feedback if: $H_{ATOT}(x) \cdot H_{ETOT}(x) > 1$
Feedback prevention

Given the following acoustic model:

- if equalizer gain is 0dB when flat and system is on marginal condition before undesired feedback,
- can still use the equalizer by forcing $H_{eEQ}(x)$ to remain below 0dB.
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Feedback prevention / Gain maximisation
Multi-Channel Time Offset Correction for Mixing
Undesired destructive interference of signals, known as comb-flittering, is common in day-to-day audio mixing.

Comb-filtering caused by:

• Using more than one microphone to record a single sound source

• Mixing an electric instrument direct box signal with its acoustic amplified signal.

• Use of parallel signal paths with different latency times

• Digital implementations which do not compensate for difference in latency time of different algorithms
Comb Filter

Peaks at frequencies $1/d, 2/d, 3/d…$

Notches at frequencies $1/(2d), 3/(2d), 5/(2d)…$

Where $d$ is delay between signals

Comb Filtering effect: a white noise signal added to a copy of itself, delayed by 1ms
Problem
Aim
Delay - distance between impulse response absolute maxima and the instant when the impulse was input into the system.

Polarity - whether the impulse response is positive or negative will determine the polarity of the system.

General algorithm flow diagram for an automatic mixture cross-adaptive time offset corrector.
Results

Impulse response of signal before correction (top) and after the correction (bottom) for a weakly correlated signal.
Results

Impulse response of signal before correction (top) and after correction (bottom) for a highly correlated signal.
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Time offset and polarity correction
Automatic faders
Auto-gain

Auto-faders
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Automatic Faders and Gain Control
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Putting it all together

- NO automatic tools
- Auto-Gain ON
- Auto-Fader ON
- Auto-Pan ON
- Varying Auto-Pan control
- Normalise Equaliser ON
- Transfer function of Equaliser
- Equaliser Flat
- Equaliser Boost
- ALL Automatic tools Running
Conclusions

• Automatic Mixing is underdeveloped
  • can be achieved by using side processing
• Automatic stereo panning reduces spatial/spectral masking
• Cross-channel gain maximisation can avoid feedback
• Fader settings can be automated for equal loudness
• Enhance a channel using inter-dependent spectral features
  • Minimises spectral masking of a channel by other channels
  • Allow user control of effect by modifying Q and attenuation parameters
• Time offset corrector reduces comb-filtering due to delays between audio signals in a mixer
  • correct delays with +/-4 sample accuracy, optimize polarity for all channels

Need a cross-adaptive, inter-channel dependent effect host-VST3?
Current Work

- Automatic Monitor Mixing – accepted for AES Journal
- Reverse engineering the mix – submitted to DAFX
- Adaptive noise gating – submitted to DAFX
- Automatic fader and gain control – submitted to WASPAA
- Turing Test

Future Work

- Hardware and VST3 implementations
- Targeted mixing
- Auto-EQ
- automatic ambisonics source placement
  - based on musician position tracking
  - Based on source content
- Feedback prevention with environmental measurements
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Demonstrations:
www.elec.qmul.ac.uk/digitalmusic/automaticmixing/

Research group:
www.elec.qmul.ac.uk/digitalmusic/automaticmixing/audioengineering.html