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The autonomous post production of a piano recording

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This investigation aims to determine if the basic post production techniques typically applied to a piano recording can be done so entirely autonomously by software, in the form of a VST Plugin. Using spectral analysis the software will compare the incoming audio to a predetermined ideal and apply compression and equalisation accordingly, then alter the parameters of the effects in real time in order to maintain a relatively constant tone and volume. In the context of a popular music production this will be extremely useful during the mixing process, as it will automatically control the large dynamic and frequency range of the piano.

The tonal qualities of a signal are by definition qualitative and therefore can only be assessed relatively.

To do this an "ideal" trace is created by having an experienced mixing engineer apply the corrective post production that is to be carried out by the plugin on various piano recordings and establishing an average.

Three ideal traces are used; one for each of the most common types of piano – upright, studio grand and grand.

- The ideal trace represents the decisions of the mixing engineer which can be used as a reference to which the input is then compared, leaving the software to determine what needs to be done to have the input and ideal traces be as similar as possible.
- The software does this by literally comparing the two traces to find areas which are more than a pre-set distance apart, and using compression and equalisation to correct them.

Processing

- Filter gain is determined by the difference in the Y-axis between input and ideal trace.
- Filter centre frequency and Q factor is determined by differences in the X-axis between traces.
- A high pass filter will also be implemented, whose cut-off frequency is determined by the first point where the traces cross.
- These processes will result in a piano tone extremely difficult to create with existing products.

Regression

- An overall shape can be observed in the traces of most pianos and recordings. This is in fact a common trace shape for a large variety of musical instruments.
- The slight differences in that shape determine the tonal qualities of a sound by showing the spread of amplitudes across the spectrum.
- The results also show that the trace is very jagged. A combination of its jagged shape and flickering movement make it very difficult to observe how the trace changes over time, and also to determine its shape.
- A smooth trace can be made with non-linear regression—a 5th order polynomial is derived with acts as a trend line of the data.
- This is achieved with software via the Gauss-Newton algorithm.

Comparison

- The ideal trace is used as a reference to which the input is then compared, leaving the software to determine what needs to be done to have the input and ideal traces be as similar as possible.
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The Fast Fourier Transform (FFT) is an algorithm for efficient computation of the DFT.

\[ X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i kn}{N}}, \quad k = 0, \ldots, N-1 \]

The tonal qualities of a signal are determined via frequency domain analysis.

Conversion between the time and frequency domains is achieved with the Fourier Transformation.

The Discrete Fourier Transform (DFT) calculates the Fourier Transform of a discrete signal.

\[ \hat{x}_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i kn}{N}}, \quad k = 0, \ldots, N-1 \]

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