Interconnection of Musical Monophonic Signals by the Edit of the Music from Objective Points of View
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Abstract: The praxis of interconnection of the montage of musical monophonic signals has many aspects from which one is the prolonging and shortening of signals. To perform such a montage there are two basic possibilities to do that - by choosing the point where the cut is performed and by selecting a particular fader. The point is that the result can have subjectively perceived rushes and disturbances. Fortunately, we can classify why does that happen using a number of objective criteria such as amplitude, frequency, phase, and spectra. Within this paper, we will discuss the problems of subjectively perceived disturbances during prolonging or shortening a monophonic signal and we will try to analyze them by an objective attempt.

1. Introduction

The praxis of interconnection of the montage of musical signals is the basic and the simplest creative sound signal processing which modify the content of the musical information recorded on recording medium. It has many aspects from which one is prolonging and shortening of signals. To perform such a montage it is necessary to make following two steps:

- to select a point where cut is performed,
- to set the treatment of edit by crossfade.

If the merging of two pieces of sound medium with recorded sound signal was successful, we can judge from two aspects: subjective and objective. There are following evaluation criterions:

- the volume (dynamic),
- the pitch (intonation, tune),
- the color

in the subjective domain and:

- the amplitude,
- the phase
- the frequency,
- the spectrum

in the objective domain.

If the merging has not been made successfully, the broken continuity of signal subjectively rushes. Although in the praxis the sound engineers prefer the subjective evaluation, the knowledge in objective criterions can help to edit more effectively and faster. In the objective domain we can diagnose causes of disturbance. It helps sound engineers with the analysis of waveform and the analysis of spectra.

2. Objective evaluation criterions of design of edit

Because all above listed evaluation criterions in the objective domain interfere, there is necessary to prepare the modeling situations to demonstrate the influence of the cut of record on the several objective criterions. The signals were generated artificially but their dominant characteristics serve the purpose.

2.1. The amplitude evaluation criterion

This criterion consults sequence of amplitude. It is possible to analyze it from three visual angles. The first case presents the merging of two records with perceived break of the constant perception of volume down or up. (Fig. 1)
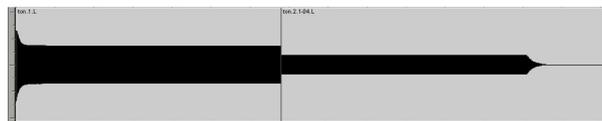

Figure 1. The case of decrease of amplitude in the view in large time scale.

This case can be caused by different recording levels or by different interpretation of recorded music.

The second case shows the merging point of two "pieces of tape" quite different with time scale. It looks up on the cut like a joint of immediate

values of amplitude.

The point of cut is the same in accordance with amplitude criterion
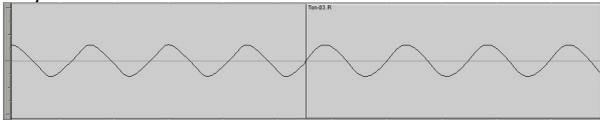
The point of cut is different in accordance with amplitude criterion
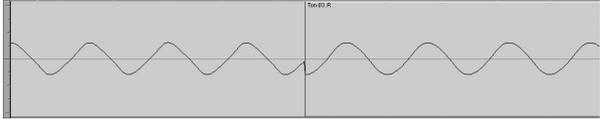

Figure 2. Comparison of immediate join of amplitude at waveform

This case is in the digital recording perceived as the crump. It can be caused by unequal value of samples. The example on the figure 2 is the fallout of the disturbance of phase criterion, but it can possible arise from merging of two non periodical signals.

The third point of view does not stem from point of cut, but from influence of crossfades by disturbances of the other criterions. The decrease or increase of amplitude is only in the signal within crossfade.
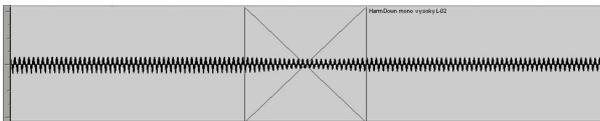

Figure 3. The influence of wrong join of signal in different phase on amplitude within linear crossfade.

2.2. The phase evaluation criterion

The phase criterion includes more aspects on joint of phase of signal. The basic case stems from different point of cut of periodical signals where the end of first "piece of tape" is terminated in different phase than the (can be the same) signal recorded on other "piece of tape" starts.

The continuity of the periods is well-kept

The continuity of the periods is disturbed from wrong joint of phase of signal
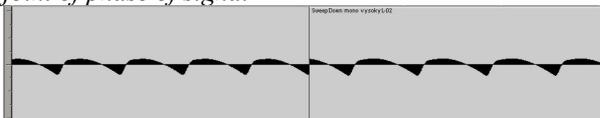

Figure 4. The comparison of continuity of periodical signal merged in the phase and out of phase.

Note that this example is similar to the example shown in Figure 2. The result of this case is the break of amplitude.

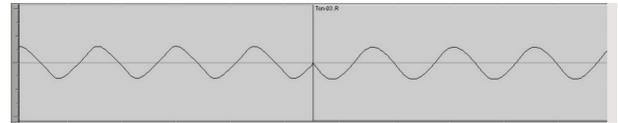The special case is the simple change of polarity of signal phase.

Figure 5. The example of change polarity of phase in the point of cut.

It can happen if the software sound editor setting is set up to "catch to zero".

The second case lies in the right joint of phase of low modulation frequency in the music presented by vibrato, tremolo, actually quaver or wah-wah effect (below 10 Hz).

Original modulated signal
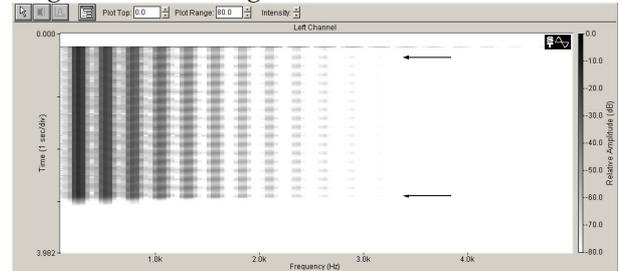
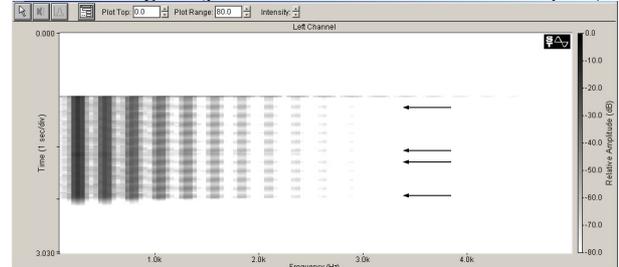*Shortened signal (periodical modulation is interrupted)*

Figure 6. The example shows wrong shortening of modulated signal

The change of periodicity of modulation is perceived very sensitive as wobble.

2.3. The frequency evaluation criterion

This criterion is very important because it pertains in music to the basic musical information. The successful edit of music depends on substance of this information. There are two cases of mistakes by editing the montage.

The first case is concerned with the frequency perceived as pitch (melody). For objective analysis shortened or prolonged signal with audible disturbance in the point of cut is better way to use
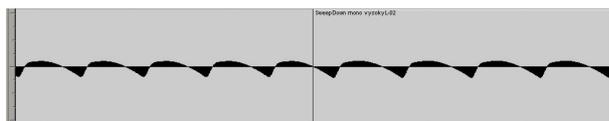
spectrograms than waveforms.

Figure 7. The change of the length of period after point of cut of shortened sweep down signals

In shown example is possible to descry that the length of period increases after point of cut (Figure 7). With the application of the crossfade there is new problem joined with violation of frequency criterion.
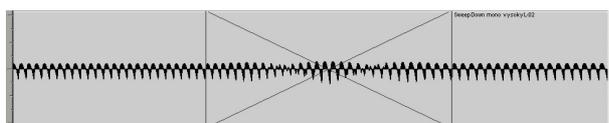

Figure 8. The crossfade applied on merging two neighbouring frequencies

In the crossfade, it arises the beat frequency. At the same time there is duplicate musical information because two frequencies are audible together.
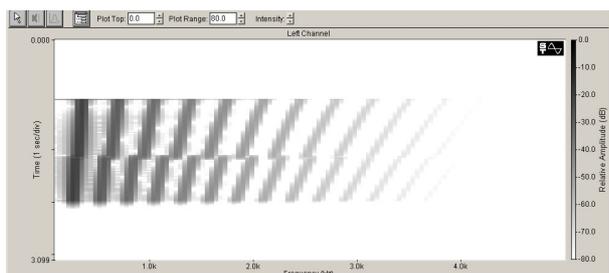

Figure 9. The duplication of frequencies in the point of cut with an applied crossfade.

The second case is even more dependent on musical information. The frequency which can be modified while the cut is made is the modulation frequency (the same as in the previous criterion).

The break of modulation rate can be perceived as forced change of tempo and it interrelate with the perception of rhythm.

2.4. The spectra evaluation criterion

The last objective criterion for evaluating of monophonic musical signals montage refers to spectra. This criterion can include all previous criterions from objective domain but is perceived as the color in the subjective domain.

The audible violation of spectra criterion must not be apparent from waveform and it is possible to reveal the objective reason from the other waveforms shape after point of cut.
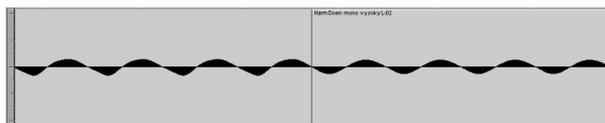

Figure 10. The detail on waveform of right merged signal due to previous criterions

In the example it is possible to see from waveform very similar amplitude, right joint of phase and the same length of periods (Figure 10).
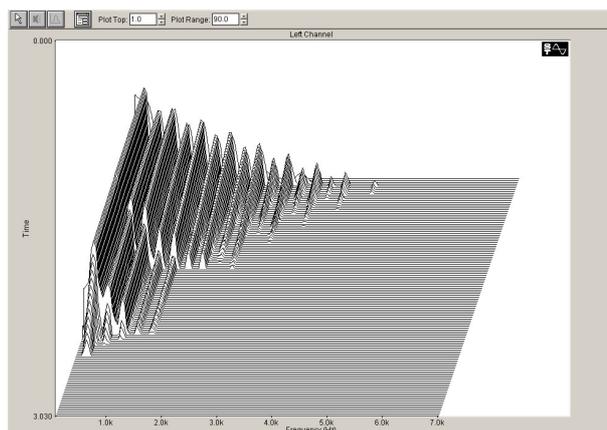

Figure 11. The spectra analysis of shortened signal

But spectral analysis can objectively detect the loss of harmonic tones perceived as change of color and volume.

3. Discussion

The praxis of sound editing depends in the first place on subjective evaluation. To this purpose there are the sound editors with their tools. They give the work often only in waveform as the most important information about the signal.

The modest goal of this paper consists in a quick review of basic characteristics of audio signal applied on artificial processing of recorded signal by the editing.

Acknowledgements

References

[1] Vrzal, M. (1974): Typology of sound signal editing in recording practice, *The 32nd International Acoustical Conference - EAA SYMPOSIUM "ACOUSTICS BANSKÁ ŠTIAVNICA 2002"*.