Time-Frequency Detection: Application to Sub-Bottom SONAR

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Summary

Arescon Research has developed a method to detect narrow-band transient signals in a noise contaminated environment. This method has some very desirable properties for applications where high accuracy and reliability is required for "time-of-flight" measurements. Very accurate ranging with a low "false alarm" rate and discarding of noisy signals is pre-requisite when signals are subject to further analysis. This report demonstrates some of the properties of the time-frequency approach for post-processing of data from a sub-bottom profiling parametric sonar.

Introduction

The **ATLAS Parasound** system is a parametric high-resolution sub-bottom profiling sonar. A common problem with high-resolution marine acoustic systems in general is the moving platform. Roll-, pitch- and heave-compensation have to be accurate down to the actual range-resolution of the system. In some cases the capability of compensating systems may be insufficient.

An example of an echo-record showing the effect of these deficiencies is shown in figure 1. The range-errors are quite detrimental in this particular case, the lack in coherency of later returns makes interpretation a difficult task. Additionally the recordings show crosstalk from a second acoustic system on board the vessel (a multi-beam bathymetry sounder), which has leaked through the bandpass filter.

In order to re-detect first breaks in the signals for subsequent alignment, a simple peak-detector will most likely fail due to this crosstalk.

Bottom Detection and Re-alignment

The time-frequency method, described in [1] performs extremely well as a *first break detector* under those circumstances, since the frequency range for detection can be limited to a very narrow band around the center-frequency of the sonar. The result is shown in figure 2.

As mentioned in [1], the time-frequency algorithm has the capability to reject noisy signals, where otherwise detection would be unreliable. The rejected traces are missing in the output-dataset in figure 2. Crosstalk does obviously not have an

influence on detection, it is never mistaken for a first break.

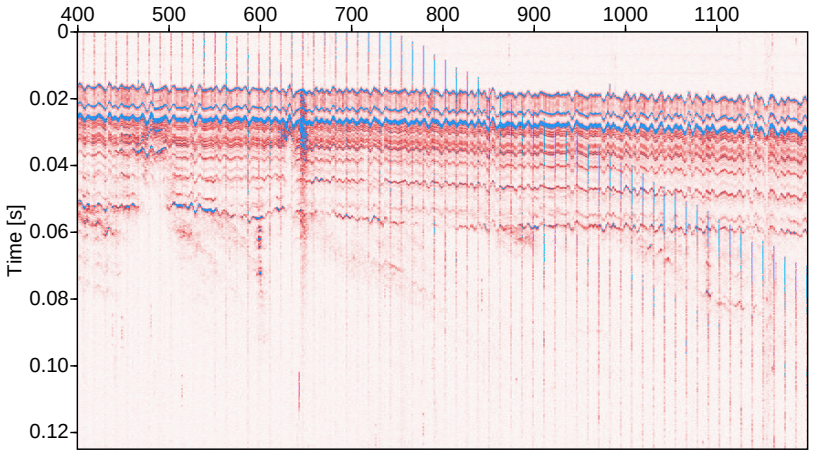

Figure 1: 4 kHz **Parasound** echo traces. Due to insufficient heave compensation the bottom first break and later returns show a wavy incoherence. Also crosstalk from a second acoustic system is present, showing as a slanting series of stripes mixed with the **Parasound** signals.

After successful detection, break-times along neighboring traces are filtered with a *median* filter for re-alignment. The overall improvement is best seen in a detail from the same profile. Figures 3 and 4 show examples from the sloping bottom later in the profile. The rather complex sub-bottom structure below the upper turbidite layers is well resolved after re-alignment.

An example of a time-frequency 3-D sonogram is shown in figure 6 with the original echo in figure 5. The sonogram starts with the first break of the signal. After the first break, the signal-amplitudes taper off until a sub-bottom structure gives rise to a second group of amplitudes. However, due to frequency selective absorption, this second group of amplitudes has already shifted towards lower frequencies.

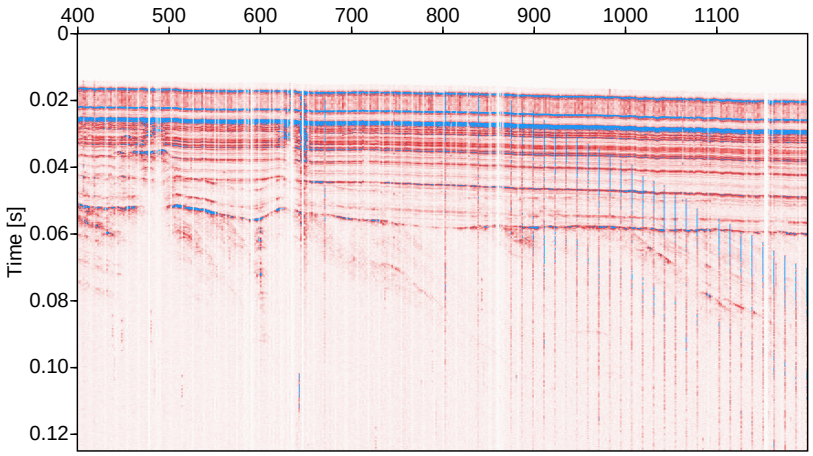

Figure 2: 4 kHz **Parasound** echo traces after time-frequency detection and realignment. The time-frequency algorithm can tell crosstalk from genuine signal. Coherency is restored.

References

[1] ROSENBERGER, A. High resolution time-frequency representation of narrowband transient signals. Tech. rep., arescon ltd., Sidney, B.C., 2000.

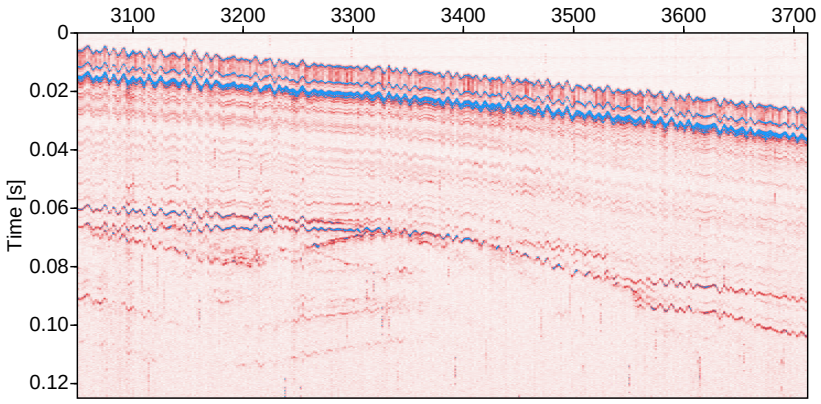

Figure 3: Original 4 kHz **Parasound** echogram suffering from insufficient heave compensation.

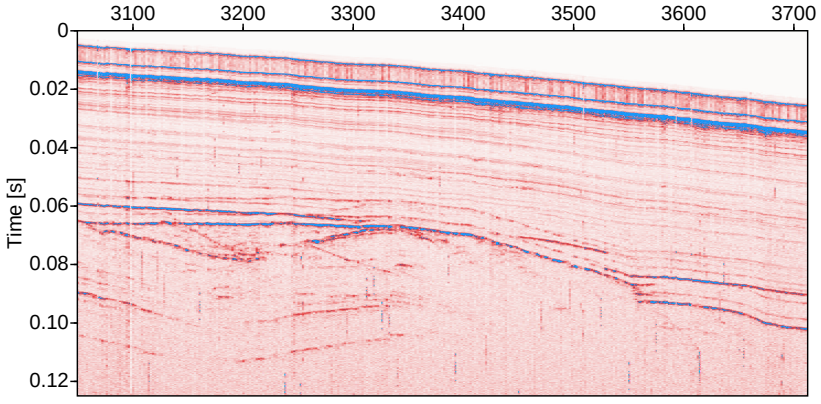

Figure 4: 4 kHz **Parasound** echogram after re-alignment with the time-frequency detector.

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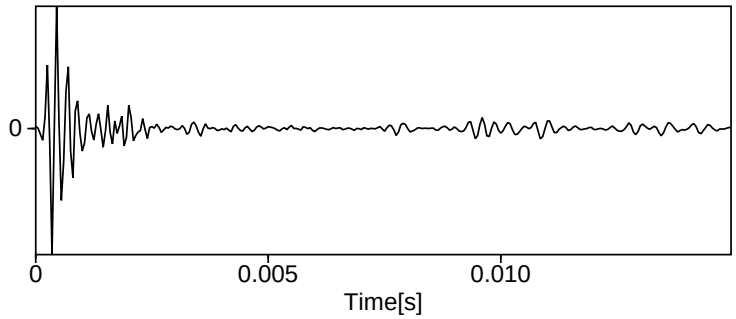

Figure 5: Echo from a **Parasound** record, its time frequency spectrum is shown in figure 6.

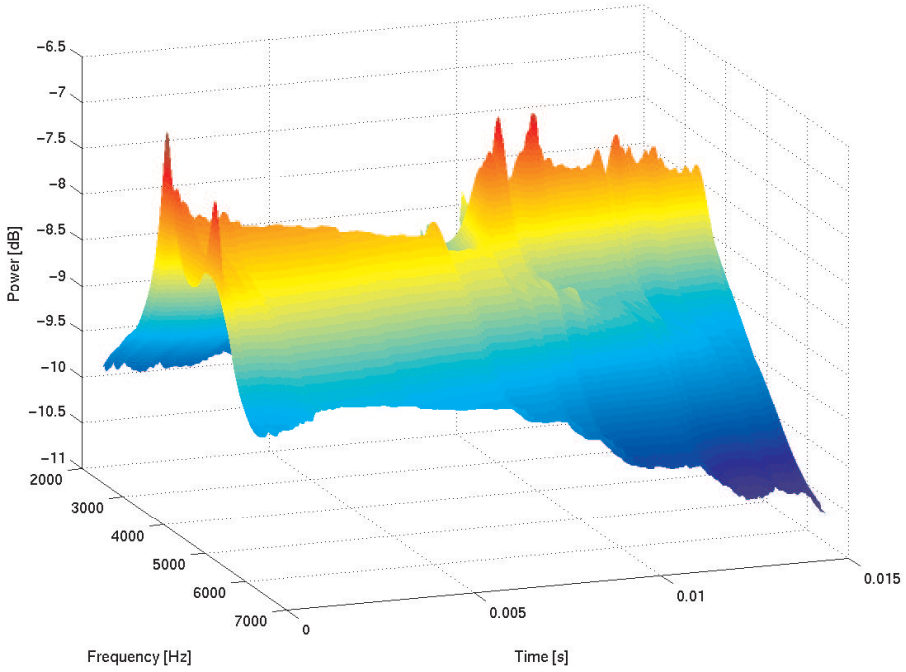

Figure 6: 3-D Sonogram of a **Parasound** echo. The sonogram was calculated in a frequency band from 2 to 7 kHz, the time axis starts with the first break. Later returns from the sub-bottom sediments have lost energy and shift towards lower frequencies.