Studies in progress at the I.U.N. to get better signal to noise ratio in problems of continous Seismic Profiling*

by

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Abstract

This present communication is concerned about studies in progress at the Istituto Universitario Navale (I.U.N.) — Napoli, Italy, in order to get a better signal to noise ratio in problems of continuous seismic profiling at sea.

Particularly it has been proposed to record the cross-correlation function between the reflected signal and a suitable artificial signal. The latter has to be constructed in such a way that it results, as much as possible, equal to the reflected signal from only one bottom discontinuity plus the geometric and electric wavelets due to the ghost and reverberation reflections.

The description of the Sparker and Boomer emitter-systems, used by the Electrophysics Group of the I.U.N. in problems of continuous seismic profiling and some experimental results (concerning mainly the electronic and the communication aspects) are referred in Reference [1,2].

The signal $v_r(t)$ received by the hydrophone can be considered equal to the sum of the useful signal $v_u(t)$ and all different kind of noise. The latter in general shows a mean power level of the same order of magnitude, or even larger than that of the useful signal. Thus $v_r(t)$ is given by :

$$v_r(t) = v_u(t) + n(t) + n_v(t) = v_u(t) + n_a(t) + n_p(t) + n_v(t)$$

where :

$n(t)$ is the noise always present at the receiver and therefore it is independant of $v_u(t)$.

This noise has two components :

$n_a(t)$ is the random component (with zero mean) of $n(t)$.

$n_p(t)$ is the periodic component (including the possible mean value of $n(t)$).

$n_v(t)$ is the noise due to ghost [3], and to reverberation [4] reflections.

This component depends on the signal $v_u(t)$.

In the scientific literature many models of the reverberation and ghost reflections are studied. In our application however we take into account only the first multipath reflections, neglecting higher order reflections since the energy levels of the signals are quite small.

The statement of the problem is the following : having the received signal $v_r(t)$, how can we manipulate it in order to get a signal, as close as possible, to the desired signal $v_u(t)$? To answer this question one has to know the characteristics of every noise component.

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In Reference [1] some characteristics of the noise components are referred. The noise $n_p(t)$ (noise mainly due to the vibrations of several moving parts of the ship) and a portion of the random noise (portion that is due to the movement of the hydrophone in the water) shows a spectrum with frequencies smaller than the useful ones, and for the latter even a very small mean power level compared with the other terms. Consequently the effects of $n_p(t)$ and part of $n_a(t)$ can be easily attenuated by means of an analogic high-pass filter.

Notice that this filtering cuts the signal spectrum in the law range, and, if the energy of the removed frequencies is comparable with that of the others, the signal changes its shape, and after filtering it shows new maxima and minima.

The new shape can produce at the recorder a sort of electric ghosts which are to be added to the geometric ones.

In Reference [5] two statistical techniques are suggested to lessen the effects of n_a (t).

a. statistical averaging of the signal in the time domain,

b. cross correlation techniques.

The above techniques can be realized by the Correlator HP 3721A owned by the I.U.N..

The technique of the statistical averaging of the complex spectrum of the signal can be used. This last method does not require any syncronism.

After these operations in practice only $n_v(t)$ lasts still affecting the useful signal.

In Reference [1] it is shown that $n_v(t)$, under our hypothesis, depends on the emitter-hydrophone system geometry respect to the sea surface and to the ship. Therefore one operation could be to optimize that geometry in order to improve, as much as possible, the shape of the signal (changing the depth of the emitter and that of the hydrophone) according to the desired purposes (resolution and/or penetration).

Besides we are studying the applicability of the following techniques.

The first method, which, as far as we know, has not been used by others researchers, consists in recording graphically not the signal $v_r(t)$, but the cross-correlation between $v_r(t)$ and a suitable signal x(t).

The signal x(t) must be as close as possible the copy of the signal reflected by only one discontinuity plus the wavelets due to electric and geometric ghost and reverberation reflections.

The record obtained by this method shows an attenuation of the ghost lines and an amplification of the signal at the delay corresponding exactly to the delay of the useful signal in $v_r(t)$.

On the other hand we must say that this technique is not effective against the multiple reflections from the bottom, and against the noise $n_p(t)$ and $n_a(t)$ since x(t) is a transitory signal.

The improvement of the record by this method can be increased, recording the cross-correlation between the cross-correlation of $v_r(t)$ and x(t) and the autocorrelation of x(t) (iterative method).

Other two methods, whose working principles are well known and can be got from reference [4,6,7,8], are under studying at I.U.N. The first consists in getting the delay and amplitude parameters of the ghost and reverberation wavelets from correlations, and then in controlling a suitable negative feedback by those parameters. The second one consists in designing an inverse filter whose frequency response must be the inverse of the complex spectrum of the useful signal plus ghost and reverberation wavelets.

The Electrophysics Group of I.U.N. has just started to study the applicability of those techniques, using the R/V *Dectra* dell'I.U.N., and the results will be available in the next future.

Besides of the experimental research in the sea described above, a theoretical research has been started. The object of this research is the simulation of the signals and of the techniques suitable to obtain a better record of the data, by the IBM 360/44 Computer of the « *Centro di Calcolo Elettronico della Facoltà di Scienze - Università di Napoli* ».

About the techniques of filtering the signal by a computer on line and in real time, we hope to obtain from C.N.R. financement which we have already required for this purpose.

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Intervention

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De très nombreux groupes (Bergen, Utrecht, Hannovre, Stockholm, Trieste, Bologne, Pau, Villefranche, Rueil, Monaco) en Europe travaillent sur les améliorations possibles du sondage sismique continu. Le prix de ces travaux est considérable. Il serait souhaitable de coordonner les efforts techniques par une réunion spéciale.

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