ALGORITHMS OF SIGNAL PROCESSING IN PASSIVE SOUND RANGING SYSTEMS AND THEIR PRACTICAL REALIZATION

Viktor Tarasov, Viktor Boltenkov, Dmytro Kropachev
SDB "Molnija", 270005,Odessa,Prohirivskaja Str.45,Phone: (0482) 22-32-27, Fax: (0482) 32-49-06

The main structures of signal processing in passive sound ranging systems are considered. The most perspective structures are selected. The practically realized structure of quasi-optimal signal processing are suggested.

INTRODUCTION

Practically algorithms, realized for today, for primary processing (PP) of signals in passive sound ranging (PSR) systems [1], working in a real time scale (RTS), are quasi-optimal, i.e. the classical optimal algorithms of a detection and parameter estimation of useful signals (or in a generalized aspect optimum algorithms of distinguishing of signals), are simplified by the developer with the purpose of security of their practical realizability in conditions of limited hardware and software resources. The developers, as a rule, sacrifice an optimality of algorithms of a detection. It reduces in a drop of probability of a right detection and resolving power in temporal area. The estimation parameter algorithms of useful signals tend to realize by an optimal image.

The most important task for a developer practically realizabled algorithms for PP of signals in PSR systems remains evolutionary (in accordance with magnification of hardware and computing resources) approximation of quasi-optimal algorithms to optimal. On it the paths of evolutionary development are represented expedient to be minimized hardware processing, by limiting its problem of reception of signals, transformation them in a digital aspect, transmission them on the communication line and input in the universal processor. In this connection there is a possibility basic volume of PP of signals in a PSR system to shift on the universal processor and to realize PP in basic at a program level. For want of such approach the emerging at the command of the developer of more powerful computing tools, allows to realize new structures of PP algorithms, more and more coming nearer to optimal, by a modification mainly PP software of signals in PSR systems.

ALGORITHMS AND THEIR PRACTICAL REALIZATION

The classical theory of a signal detection exactly determines algorithms of optimal detector work, however for want of it signal and noise processes should be described completely by a priori known (down to parameters) laws of distribution.

Considered acoustic signal process - random non-stationary process, which is not described completely yet by a priori known laws distribution because of strong variability of the acoustic channel of propagation and insufficiency of experimental data. The noise process in PSR systems is a wind noise, which is close to normal process on sites of its stationarity, but is not white noise.

Generalization of the optimal detector classical theory on a case of a priori indeterminacy, which is carried out on base of outcomes of the statistical theory of a pattern recognition, in the total lead to an adaptive detection of signals on back-ground of noise including a procedure of training, which in a parametrical case is reduced to an evaluation of parameters of a signal and noise (and in a common nonparametric case - to an evaluation of their laws of distribution), and purely detection procedure, in which instead of parameters of a signal and noise are used their evaluations obtained during training.

However practical realizations, known for the authors, of algorithms for PP of signals in PSR systems represent structures of algorithms implying from modifications of classical optimal detector algorithms (maximum of function of a likelihood (MFL)) for want of the simplifying suppositions concerning the laws of distribution of signal and noise processes.

The authors believe that the most interesting structures of algorithms base on attempts of the developers to apply in PSR systems algorithms of MFL estimator of signal time delay or their modifications represented in [2]. Fundamental work in this direction is [3], which author only refered to work [2] as a fundamentals for a construction of a structure of algorithms and had presented the simplified realizable structure of algorithms as he had not enough resources for full realization. Represented in work [2] structures of signal time delay estimate algorithms are a generalized cross-correlator based on combination of procedures of whitening prefiltering and cross-correlation. Attempt to exclude from optimal detector structures for random signal process an a priori information about signal process by coprocessing a receiving information two spatially - carry of receiving channels for want of establishing supposition, that the signal process is identical on both receivers, and also for want of suppositions, that the signal process does not correlate

with noise processes on receivers, which also rely mutually uncorrelated white noise processes, lead to a detector structure on base of cross-correlator. The generalization of a detector structure on base of cross-correlator on a case of unwhite normal noise processes lead to a detector structure on base of combinations of a whitening prefiltering procedure and cross-correlator. Thus the optimal detector structure differs from the optimal time delay estimate structure by availability in the optimal detector structure a threshold procedure realizing algorithms of decisionmaking about a detection. Threshold level is determined by an a priori expected energy of useful signals, if not take attention on necessity to reduce the threshold level in the correspondence with a realization of a whitening prefiltering procedure. If is strict to hold of the supposition about random signal process, from which a priori indeterminacy of energies of useful signals in particular follows, becomes clear, that for optimal detector on base of combination of prewhitening and cross-correlator procedures it is impossible to define a threshold level ensuring optimal performances of detector. Therefore developer should exclude from a structure of algorithms for PP of signals in PSR systems a threshold procedure and conduct a detection on a maximum of cross-correlation function (CCF), for want of it sharply will increase probability of false detections. The exit can be found or on a path of addition of the concept of a combination of prefiltering and cross-correlation procedures by new idea, or on a path of searching of admissible simplification of signal process.

In SDB "Molnija" the authors developed algorithms for PP of signals in PSR systems on base of combinations of prefiltering and cross-correlation procedures realized in the sliding temporal window. These algorithms were embodied in an experimental model representing special multiprocessor. Conducted researches and the trials of an experimental model have shown, that the problem of false detections can be decided by addition of the concept of a combination of prefiltering and cross-correlation procedures by idea of a so-called "space" filtration of the false detections consisting in sifting of detections on several spatially carried independent acoustic basises (AB). However it leads to sharp magnification of necessary hardware and computing resources.

The quasi-optimal structure of PP of signals realized as a software, working in a RTS on the universal processor IBM PC 486 is developed by authors. In a quasi-optimal structure of PP of signals in a PSR system it is possible to select the following basic stages of processing:

- Reception of acoustic signals by sound receivers (SR) on linear AB;
- Transformation of signals SR in a digital aspect in two frequency ranges (5 - 40) Hz and (5 - 120) Hz;
- Signaling SR on communication lines and buffered input them in the processor;
- An evaluation of levels of noise and adaptation to them threshold levels of detectors;
- Detection, evaluation of a moment of arrival and selection of useful signals working in a frequency band (5 - 40) Hz;
- Elimination of signals of a ballistic wave using signal fragments in a range (5 - 120) Hz and other hindering signals;
- Shaping possible pairs of signals appropriate to the same radiant;
- Definition of a class of chosen useful signals on their temporal and frequency structure;
- Definition of a class of a pair, selection of the most probablis pair of signals from the generated pairs and definition of necessity of cross-correlation processing of signals of a pair;
- Parameter estimation of signals and cross-correlation estimation of a delay of signals;

CONCLUSIONS

The most perspective structures of signal processing in passive sound ranging systems are selected:

- the structure for PP of signals based on combination of procedures of prefiltering, cross-correlation and "space" filtration of the false detections;
- the structure for PP of signals based on combination of procedures of an adaptive detection, prefiltering and cross-correlation.

The authors suggested the structure of quasi-optimal algorithms for PP of signals which based on combinations of procedures of adaptive noise detector and cross-correlator and which realized as software working in RST on universal processor. This structure is most suitable for practical realization for today.

The addition developed quasi-optimal algorithms for PP of signals in a PSR system by adaptive noise whitening prefiltering procedures can be conducted in near future with passage on the more productive processor.

The finishing the detector of a represented structure for PP of signals in a PSR system, that is adaptation the detector not only to noise, but also to signal process and, thus, evolutionary passage to rigorous adaptive detector is in the long term looked through also.

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