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OPTIMIZATION ALGORITHM FOR SYNERGY OF CTBT VERIFICATION TECHNIQUES IN ADDRESSING IMS AND OSI TASKS

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Diagram of methods integration

Verification method
Measurement of field $F_i(r,t)$
r - coordinates of observation point
t - current time

Discrimanator
Calculation of parameter $D_i(F_i)$
D_i - standard discriminator for ith verification method

Construction of distributions by modeling NE
Functions $P(D_i|H)$ & $P(D_i|\bar{H})$
$H, \bar{H}$ - hypotheses about availability or absence of a model NE

Likelihood ratio
Determination of dependence $\Lambda_i(D_i)$

$$\Lambda_i = \frac{P(D_i|H)}{P(D_i|\bar{H})}$$

Optimal discriminator – integrated likelihood ratio

$$\Lambda_K = \prod_{i=1}^{N} \Lambda_i$$

N - number of integrated verification methods

Decision-making unit

Ordering of integrated likelihood ratios for model NE

$$\Lambda_K(j) \geq \Lambda_K(j+1)$$

j - index of element in ordered array Λ_K

Selection of decision-making threshold

$\Lambda_{tr} = \Lambda_K(L)$ where $L = P_{det} \cdot M$
M - number of model signal of a NE
P_{det} - required probability of NE detection

Construction of operating characteristic
Dependence of P_{fa} false alarm probability on detection probability

$$P_{fa} = \frac{1}{M}\sum_{i=1}^{L}\frac{1}{\Lambda_K(i)}$$

Prerequisite for application of the optimization algorithm

- one source (NE);
- availability of $F_i(r,t)$ model in NE;

Field of application

- integration of independent NE verification techniques

$$\begin{cases} P(D_i, D_j|H) = P(D_i|H) \cdot P(D_j|H) \\ P(D_i, D_j|\bar{H}) = P(D_i|\bar{H}) \cdot P(D_j|\bar{H}) \end{cases};$$

- integration of OSI techniques;
- integration of information from IMS stations within one method (seismic, infrasound, hydroacoustic, radionuclide);

Examples of discriminators

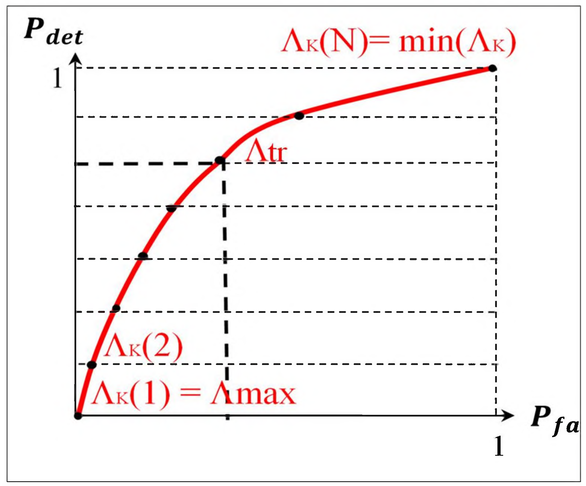
When addressing IMS tasks:

- amplitude of an infrasound signal in the frequency bandwidth of ANE recording with set yield and coordinates;
- concentration of different radionuclides in the atmosphere in ANE (UNE);
- logarithm of amplitude ratio of different types of bulk and surface seismic waves in UNE;
- number of pulsations in W-phase of a hydroacoustic signal in UNE.

When addressing OSI tasks:

- amplitude anomalies of gamma-field, magnetic field;
- concentrations of radioactive noble gases, aftershocks.

Substantiation of selecting Λ_K as a discriminator



When expanding the subspace of decision-making about NE, the probability of detection and false alarm is increased:

$$\Delta P_{fa} = \frac{\Delta P_{det}}{\Lambda_K}$$

Likelihood ratio is equal to the angle of the tangent to the OC graphics.
The distance between the ordinate points of OC is equidistant and determined by the formula:

$$\Delta P_{det} = \frac{1}{M}$$

When lowering the threshold, the number of model signals that have exceeded the threshold increases by one.

$$\Delta P_{fa}(j) = \frac{1}{M \cdot \Lambda_K(j)}$$

Therefore, the selection of Λ_K as a discriminant provides a convex operating characteristic that is optimal by Neumann-Pearson criterion.