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INTERSTAGE OPTIMIZATION OF DATA PROCESSING OF DISTRIBUTED AIRSPACE MONITORING SYSTEMS

The synthesis and analysis of the data processing optimal structure of survey radar surveillance systems are carried out in the work. By creating a temporary information database of signaling data for the required number of surveillance radar surveillance system, each element of which stores signaling data and quality indicators and parameters of their production, it is possible to carry out interstage optimization of airspace surveillance data processing based on Neumann-Pearson test. It will be possible to formulate the preparation of information messages faster within the current information, which will significantly affect the quality of the decision.

Keywords: *surveillance systems, Neumann-Pearson criterion, interstage optimization of data processing, methods of radar surveillance system, information security, information support*

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МІЖЕТАПНА ОПТИМІЗАЦІЯ ОБРОБКИ ДАНИХ РОЗПОДІЛЕНИХ СИСТЕМ СПОСТЕРЕЖЕННЯ ПОВІТРЯНОГО ПРОСТОРУ

В роботі проведено синтез та аналіз оптимальної структури обробки даних оглядових радіолокаційних систем спостереження. Завдяки створенню тимчасової інформаційної бази сигнальних даних на потрібну кількість оглядів радіолокаційної системи спостереження, в кожному елементі якої зберігаються сигнальні дані та показники якості та параметри їх отримання, вдається здійснити міжетапну оптимізацію обробки даних систем спостереження повітряного простору на основі критерія Неймана-Пірсона. З'явиться можливість швидше формулювати підготовку інформаційних повідомлень у

межах поточного інформування , що істотно вплине на якість прийнятого рішення.

Ключові слова: *системи спостереження, критерій Неймана-Пірсона, міжетапна оптимізація обробки даних, методика радіолокаційної системи спостереження, інформаційна безпека, інформаційне забезпечення*

Statement of the problem in general form and it's connection with important scientific or practical tasks

Information support of users of air control system space is carried out by radar surveillance systems usually compatible, which include the primary and secondary radars. Air Object (AO), which issued to consumers of information compatible surveillance systems includes spatial software coordinates and software identification on the basis of "own-foreign". Creating a temporary information database of signal data for the required number of reviews of the radar surveillance system makes it possible to carry out inter-stage optimization of data processing of airspace surveillance systems based on the Neumann-Pearson test.

Analysis of the latest research and publications

Various aspects of airspace control system are covered in the works Farina A., Studer F., X. Jianjuan, G. Xin., H. You, Yuan Xu, Yuriy S Shmaliy, Luchi Hua, Liyao Ma, X. Yang, H. Zhang, Q. Luo, G.A. Ybarra; S.M. Wu, G.L. Bilbro, S.H. Ardalan, C.P. Hearn; R.T. Neece., G. E. Zavolodko, I. I. Obod, I.V. Svyd, Siergiejczyk, M., Krzykowska, K. and Rosiński, A., study.

Highlighting the previously unresolved parts of the general problem

The airspace control system is significant to some extent ensures both the security of the country and security air traffic. To the main procedures of the system airspace control include: analysis air situation in the area of responsibility and making management decisions. The decision is made based on the analysis of information on the state of the air situation in the area of responsibility. The right decisions can be accepted only if available sufficiently complete, accurate, reliable and continuous information on the air situation in the control area laziness. Therefore, the quality of decision-making is determined both the quality and composition of the information on the basis of which decisions are made. The main source of information information on the air situation in the control system airspace is the primary survey radio locator (POR), data processing which is the basis for decision-making. This requires optimization ERP data processing, which determines the inter-stage optimization mitigation of the detection of the route of the air object (AO). In a significant number of scientific papers [1-12] raised there are issues of AO data processing optimization. IN these works carried out a systematic introduction to theory, development and presented the latest results research of radar data processing technology. They describe algorithms suitable for processing radar data that have common mathematical no basis: they are based on dynamic modeling no system, filtering, statistical solution, op- optimal management and management theory. In works [7-12] various aspects of op- thermal processing of radar signals and data. It is shown that the processing optimization approach signals and data offers a significant improvement characteristics compared to the existing approach to radar data processing. The algorithms proposed in [8-11] to optimize the performance of the radio processing system location signals allows you to predict the activity at the design stage, as well as for unification of probabilistic data associations for multi- targeted tracking using distributed tracking architecture. Works [12-13] dedicated to joint signal processing optimization data and primary processing data in the information network of primary radars. The aim of the work is the synthesis of the optimal structure inter-stage AO data processing and quality analysis the proposed structure, which allows to carry out inter-stage optimization of data processing

Statement of the main material

1. The structure of data processing survey radio- location surveillance systems.

Data Processing ERP is the conversion of information received from ERP, to the type possible for use. The system of AO data processing is directly related to the source - we signals and provides solutions to the following info- tasks:

- detection and measurement of parameters of received signals and noise elimination;
- disclosure - measurement and measurement of AO coordinates;
- "Strings" detected signals in the trajectory and determination of para- meters of trajectories;
- calculation of smoothed and biased for a fixed period of time the coordinates of the AO.

The complexity of the data processing structure of the ERP is not allows for formalization and analysis of its work in general, which requires the division of the ERP data processing system into several parts [1-3]. With It is important to note that a consistent EDP data lead to the impossibility of inter-stage optimization of data processing and how consequence, to reduced data quality.

Solving the problems of data processing ERP leads to the step-by-step processing of possible data streams divided into the following stages: processing of ERP signals, primary data processing (PID) and secondary processing bki data. The current vector of the state of theAO with the answer- bottom matrix of accuracy of measurement of coordinates is made after the end of PID. To perform PID tasks with POR on the device data processing receives signal data that carry information about the detection of signals, ie $x_i = 1$, when a temporary permission element has been raising the threshold; and if it did not happen - then $x_i = 0$.

For signal information processing, quality of information support can be the probability of correct detection of signals D_s

$$\boldsymbol{D_s = f[q_s, F_s = f(z_s) = const]}, \tag{1}$$

where q_s is the signal-to-noise ratio, F_s is the probability false alarm detection signal, z_s - analog signal detection threshold.

The optimality of the solution of the problem of signal detection is accepted, as a rule, according to the criterion of Neumann-Pearson, which comes down to maximizing the probability- correct detection of signals when on the probability of misdiagnosis. These two properties fidelity and are indicators of signal detection quality. Operations for estimating signal parameters in general case is optimized by the criterion of minimum day risk.

For POD under the quality of information consumer provision is the probability correct detection of AO

$P = D_1$, which is a function

$$D_1 = f(N, C, F_1 = f(N, C, z_s) = const, \tag{2}$$

where N is a packet of received signal data, C is a digital AO detection threshold.

The decision to identify AO with quality indicators those F_1 and D_1 are fed to the AO coordinate meter. Estimation of the coordinates of the instantaneous position of the AO simultaneously with the detection of AO. The task of the AO coordinator is to be based analysis of the obtained sequence of zeros and ones evaluate the optimal coordinates of the AO.

For secondary data processing, the quality indicator consumer information is likely the correct detection of the route of the AO $P = D_2$:

$$D_2 = f(k/R, F_2 = f(k/R, N, C, z_s) = const), \quad (3)$$

where k/R - the logic of the decision to detect AO tracks.

In AO route detection algorithms, is a method of accumulating input data. To decide solution of the formulated problem, the AO data detector received according to some algorithm. The AO route detection algorithm is reduced to test of hypothesis H_0 about the absence of the route of the AO you alternative hypothesis H_1 about its existence, ie to the formation of the likelihood ratio and comparing this relationship with some in advance a given number, which is selected based on the allowable the probability of incorrect detection of the AO path.

To solve the problem formulated in the work the AO coordinate detector must process the data which come in accordance with some algorithm- him. The optimal algorithm for measuring coordinates synthesized on the basis of the criterion of maximum similarity.

For secondary data processing, the quality indicator consumer information support are probable. the level of detection of the trajectory of the AO $P = D_2$.

These dependences (1-3) show that the stage- on the implementation of data processing complicates the end-to-end optimization of both detection and measurement of dinat PO. Really stabilize the probability of error AO detection must be analog signal detection threshold, which is difficult to provide you are in existing data processing systems.

2. Synthesis of the optimal processing structure data of survey radar systems observed solution.

Consumer information support the primary survey radar requires at all data processing (DP) stages of processing. Assume that the radar- tor has M elements of range resolution and has the ability to store data on R reviews. In this case, the overall optimal data processing POP can be carried out: when combining solutions on detection levels:

- when combining solutions at the level of AO detection;
- when combining solutions for equal detection of AO routes.

We will synthesize and analyze the structure of DP POR for the data processing options under consideration. At this we will assume that there is signal data coming from the ERP for R circular space reviews.

In the POR signals are received after the optimal linear processing and detection are compared in threshold device with a threshold voltage which determines the probability of false alarms. After the threshold- of the device for further processing solution ie signaling data. Thus, with POR the consumer is given a set of signal data x_i , with indicators of the quality of detection which is determined threshold and signal-to-noise ratio of the signal that accepted.

In this formulation, the question of the observer has an R signal matrix with data $\vec{X} = \|x_{ijr}\|$, where$\|x_{ijr}\| = 1$, when in the element time division $i = (\overline{1,M}), j = (\overline{1,N}), r = (\overline{1,R})$, which corresponds to the spatial division under consideration the threshold has been exceeded; when not occurred - $x_{ijr} = 0$.

To decide on the detection of AO when compatible processing at the level of signal data is a set of zeros and ones x_{ijr} It turned out that x_{ijr} is a random variable that corresponds to gives the Bernoulli distribution:

$$P(x_{ijr}) = P_{ijr}^{x_{ijr}}(1 - P_{ijr})^{1-x_{ijr}},$$

where P_{ijr} – is the probability of exceeding the threshold in the i-th time processing channel. In the absence of a signal $P_{ijr} = F_{rjr}$- the probability of false alarm, and if present $P_{ijr} = D_{ijr}$- the probability of signal detection in the POR.

We will assume that the input of the device is compatible processing of the whole array of previous decisions that there is an incoming set of the above probable values. Compatible probability distribution all possible combinations of xijr both in the absence and in the presence of a signal (hypotheses H_0 and H_1), ie $P(x_{ijr}|H_0)$ and $P(x_{ijr}|H_1)$ are arbitrary but known. For of each specific set x_{ijr} we will form plausibility:

$$\Lambda = P(x_{ijr}|H_1)/P(x_{ijr}|H_0) . \quad (4)$$

Comparison of the relationship of plausibility Λ with threshold which is determined by the allowable probability false alarm, provides the optimal for Neumann-Pearson criterion of the decision on the presence or no x_{ijr} signal.

Since the noise in the channels time processing independent it is possible to write:

$$P(x_{ijr}|H_0) = \Pi_{j=1,i=1,r=1}^{N,M,R} P(x_{ijr}|H_0) = = \Pi_{j=1,i=1,r=1}^{N,M,R} F_{ijr}^{x_{ijr}}(1 - F_{ijr})^{1-x_{ijr}} . \quad (5)$$

When the signal exceeds the thresholds in the processing channels - independent events. Then (4) can be written as follows:

$$P(x_{ijr}|H_1) = \Pi_{i=1,j=1,r=1}^{M,N,R} P(x_{ijr}|H_1) = = \Pi_{i=1,j=1,r=1}^{M,N,R} D_{ijr}^{x_{ijr}}(1 - D_{ijr})^{1-x_{ijr}} . \quad (6)$$

Given expressions (5) and (6), expression (4) is possible. write in the following form

$$\Lambda = \frac{\Pi_{i=1,j=1,r=1}^{M,N,R} D_{ijr}^{x_{ijr}}(1-D_{ijr})^{1-x_{ijr}}}{\Pi_{i=1,j=1,r=1}^{M,N,R} F_{ijr}^{x_{ijr}}(1-F_{ijr})^{1-x_{ijr}}} . \quad (7)$$

Logarithmizing expression (7), we obtain:

$$L = ln\,\Lambda = \sum_{i=1,j=1,r=1}^{M,N,R} x_{ijr}\left(ln\,D_{ijr} - ln\,F_{ijr}\right) +$$
$$+(1 - x_{ijr})\left[\left(1 - ln\,D_{ijr}\right) - \left(1 - ln\,F_{ijr}\right)\right].$$

When the factors xijr denote as

$$Q_{ijr} = ln\,D_{ijr} - ln\,F_{ijr} - ln(1 - D_{ijr}) + ln(1 - F_{ijr}) =$$
$$= ln\left(\frac{D_{ijr}(1 - F_{ijr})}{(1 - D_{ijr})F_{rjr}}\right)$$

and discard the terms that do not depend on x_{ijr}, then we obtain the optimal, according to the Neumann criterion- Pearson, the algorithm for detecting the route of the AO when combining previous decisions of all temporal and spatial processing channels:

$$L = \sum_{i=1,j=1,r=1}^{M,N,R} Q_{ijr} x_{ijr} \underset{>}{\overset{<}{}} C\,, \tag{8}$$

where C the detection threshold of the route, which is determined by fidelity of erroneous detection of the AO path.

Algorithm (8) is obtained for the combination case at the level of AO detection.

For the case of a combination of solutions at the level of The algorithm can be written as In both versions of data processing probability detection of AO paths is optimized by compatible optimization of signal detection, AO detection and detection of AO routes, ie optimization is carried out all stages of data processing.

$$L_1 = \sum_{i=1,r=1}^{M,R} Q_{ir} x_{ir} + \sum_{j=1}^{N} Q_j x_j \underset{>}{\overset{<}{}} C\,. \tag{9}$$

To do this, you must be to create an information base for radio storage location data for the required number of circular radar reviews, in each element of which signal data with indicators must be stored the quality of their receipt.

It is possible to calculate by expressions (8) and (9) the probability of detecting the AO path for different values appropriate values and the corresponding decisive rules.

It should be noted that for the implementation- inter-stage optimization of data processing in response to algorithms (8) and (9) should be created on a temporary information database of signal data, which will formulate the preparation of information- messages within the current information. For its functioning the structure of storage is necessary. and quick access to general data the amount of memory is equal to

$$P = M \cdot N \cdot R \cdot k,$$

where k is the bit weight of Qjr.

3. Analysis of the optimal processing structure data of survey radar systems observed

Figures 1 and 2 show the dependences of the probability of detection of AO path $D = f(q, C, k/R, N = 15)$ for both methods of data processing (curves marked l it should be noted that the processing) and different AO detection thresholds and route detection rules AO in case of probability of false alarm of route detection AO which is equal to 0.001.

The presented dependences show that when ma- threshold values of AO detection C = 5) kra- existing algorithm for processing primary data survey radars. So when for the logic of processing 2/3 gain in the probability of AO detection is 0.1 percent, and for logic 3/5 gain in probability detection rate is 0.3 percent compared to the second gim algorithm. However, with increasing digital decision threshold for AO detection (C = 8) the second detection optimization method is better, because it allows you to get a hig $q = 1.28$ probability of AO route detection for both the logic of data processing increases.

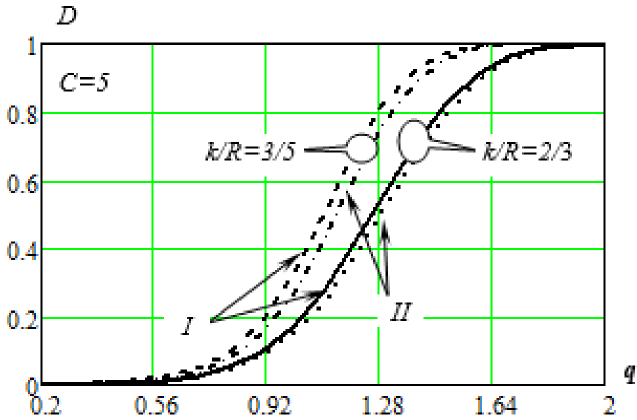

Fig. 1. The probability of detecting the AO path

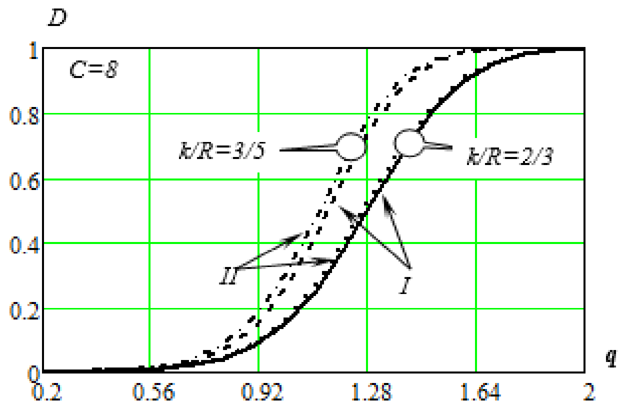

Fig. 2.. Probability of AO path detection