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OPTIMIZATION OF JOINT SEARCH AND DETECTION OF OBJECTS IN TECHNICAL SURVEILLANCE SYSTEMS

Abstract. The **subject matter** of the article is joint search and detection of objects in technical surveillance system. The **goal** is solve the problem of optimizing joint search and detection of objects in technical surveillance system and develop a method for assessing the effectiveness of joint search and detection of objects for technical surveillance systems. **Results.** Introduced the current discrete area of view. The task of finding the optimal Bayes decision-making rule in the introduced current discrete area of view is posed and solved. The specified Bayes optimal decision rule is formulated. Proposes the efficiency estimation method of joint search and detection of objects for surveillance technical systems. An algorithm has been developed for calculating the unconditional probability of detecting an object of surveillance during a joint search and detection of objects in technical surveillance systems. **Conclusions.** Shown, that a joint search and detection of the objects of surveillance using a uniformly optimal search strategy provides a higher unconditional probability of the correct detection of the object of surveillance. In future research, it is necessary to assess the average time that is needed to detect the object of surveillance during the joint search and detection of objects and uniform distribution of the search potential of technical surveillance systems.

Keywords: technical surveillance system; area of view; joint search and detection of objects; minimum average risk criterion; optimal Bayes decision rule.

Introduction

Today, in the development of technical surveillance systems, the main issues are the joint optimization of the stages of search and detection of objects [1-3]. A number of significant scientific results were obtained in optimizing the search and detection of objects. However, existing optimization methods consider search as a single task to review space, process signals and make decisions only in the production plan.

Solutions are obtained only for individual components of the task. The solution to the problem as a whole has not been received. A unified approach to the selection of an efficiency criterion that adequately reflects the tasks of a technical system at the stage of searching and detecting objects of interest has not been formulated. The problem of optimization of joint discrete search and detection of objects of interest in technical systems is not solved [4].

Formulation of the problem. In [5, 6], the problem of joint search and detection optimization was solved as follows. For the case of a continuous a certain area of survey Ω, an improved Bayes rule for deciding on the detection of an object is formulated. This rule is as follows. When solving the task of testing a simple hypothesis against a simple alternative, the joint optimization of the search and detection of objects reduces to finding a uniformly optimal search strategy, calculating the maximum of the unconditional likelihood ratio in the current area of view and comparing it with the threshold. In [7], the results of joint search and detection of objects efficiency are briefly analyzed. The weight criterion of an optimality of detection in a zone of search elementary cell is formulated. The differential characteristics of Bayes criterion of a minimum of average risk are taken into account. The weight criterion of joint optimization of search and detection of objects in the current zone of search is specified. Expression for the ratio of likelihood in the current zone of search is received.

Consider the results obtained in [8-10] for the case of solving task of the discrete searching and detecting a

stationary single object. We solve the problem of optimizing joint search and detection of objects of interest in technical surveillance systems. We will develop a method for assessing the effectiveness of joint search and detection of objects for technical surveillance systems.

Results of researches

Consider the task of joint Bayesian optimization of discrete search and detection of objects. We will use the criterion of minimum average risk.

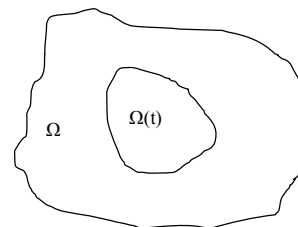Figure 1 shows the ratio of the current viewing area $\Omega(t)$ and the search area Ω.

Fig. 1. The ratio of the current viewing area $\Omega(t)$ and the search area Ω

where $\Omega(t)$ – current area of view that meets the conditions $\Omega(t) \to \Omega$ for $t \to T$; T – time of view of a given search area Ω.

Divide the area of search Ω into N subareas Ω_i ($\sum_{i=1}^{N} \Omega_i = \Omega$). The average risk in subarea Ω_j is denoted as R_j. Introduce the current area of search $\Omega(t_i) = \sum_{j(t_i)} \Omega_j$, where j – number of subarea of search and detection of an object at time t.

When searching for an optimal Bayes decision rule in the current discrete search area $\Omega(t_i)$, additional optimization parameters appear. These are the current dimensions and position of the discrete area $\Omega(t_i)$ in the common area Ω. Conditions are created for finding the optimal strategy for joint search and detection of an

object in the search area of a discrete structure. A solution to such a problem was previously absent.

The average risk in the current area of search $\Omega(t_i)$ can found as expression (1):

$$R(t_i) = \sum_{\Omega(t_i)} R_j = R_0 - ((I_{10} - I_{11});$$
$$\sum_{\Omega(t_i)} P_{1j}(\gamma_1, t_i) - (I_{01} - I_{00}) \sum_{\Omega(t_i)} P_{0j}(\gamma_1, t_i)), \quad (1)$$

where $P_{0j}(\gamma_1, t_i)$ – the current value of the unconditional probability of false alarm in the j-th subarea at a time t; $P_{1j}(\gamma_1, t_i)$ – the current value of the unconditional probability of the correct detection of objects in the j-th subarea at a time t; R_0 – a non-negative constant for the current area of search $\Omega(t_i)$ at time t. Write the Bayes rule for testing simple hypothesis H_0 against simple alternative H_1 in the current discrete sub-area $\Omega(t_i)$ of area Ω as follows:

$$\frac{\sum_{\Omega(t_i)} P_{1j}(\gamma_1, t_i)}{\sum_{\Omega(t_i)} P_{0j}(\gamma_1, t_i)} \mathop{\gtrless}_{\gamma_0}^{\gamma_1} \frac{I_{01} - I_{00}}{I_{10} - I_{11}}, \quad (2)$$

Passing to the unconditional likelihood ratio write expression (2) as follows:

$$l(t_i) = \frac{\sum_{\Omega(t_i)} P_{1j}(\gamma_1, t_i)}{\sum_{\Omega(t_i)} P_{0j}(\gamma_1, t_i)}; \quad l(t_i) \mathop{\gtrless}_{\gamma_0}^{\gamma_1} \frac{I_{01} - I_{00}}{I_{10} - I_{11}}. \quad (3)$$

Thus, the optimal Bayes rule (3) for testing a simple hypothesis against a simple alternative, which was obtained on the basis of expressions (1) and (2), is to maximize the unconditional likelihood ratio $l(t_i)$ in the current discrete area $\Omega(t_i)$ and compare it with the threshold (4):

$$c_b = \frac{I_{01} - I_{00}}{I_{10} - I_{11}}. \quad (4)$$

If $l(t) \geq c_b$, then decision γ_1 is made (the hypothesis H_0 is rejected). If $l(t) < c_b$, then decision γ_0 is made (hypothesis H_0 is accepted).

In accordance with (2) optimization should be carried out by:

parameters of conditional probability of correct detection of $P(\gamma_1 / H_1, x)$ in sub-areas Ω_j;

parameters of the current discrete area of search $\Omega(t_i)$.

Consider an important special case. Assume that, similarly to the Neumann-Pearson criterion, the value of the unconditional probability of false alarm in subarea Ω_j at a time t is fixed at a constant level – $P_{0j}(\gamma_1, t_i)$. Then, according to expression (2), finding the maximum of the unconditional likelihood ratio reduces to finding the maximum of the unconditional probability of the

correct detection of the object in the current discrete subarea $\Omega(t_i)$.

Thus, to find the optimal Bayes decision rule in the current discrete area $\Omega(t_i)$ of the common area Ω, along with the solution of the hypothesis testing problem in this area, the problem of finding the optimal object search strategy (using the Bayes criterion of minimum average risk) must be solved.

Search strategy $\lambda(\Omega_j, t_i)$ is a rule that at any moment of time t_λ establishes in which subarea Ω_j of the area the search should be carried out and with what energy costs.

The condition of compulsory viewing of area Ω during the search T must be fulfilled. It's obvious that:

$$\lambda(\Omega_j, t_i) > 0, \quad for \quad \Omega_j \in \Omega(t_i); \quad (5,a)$$

$$\lambda(\tilde{\Omega}, t_i) = 0, \quad for \quad \tilde{\Omega} \in \Omega / \Omega(t_i). \quad (5,b)$$

Assume that the search strategy should be constant for all subareas that are viewed at a fixed moment of time t_i. The measure of the current area $\Omega(t_i)$ consists of the sub-areas Ω_j viewed at the moment t_i.

$$\Omega(t_i) = \sum_j \Omega_j. \quad (6)$$

In addition to the above properties of the search strategy, require that it satisfy the optimality condition. This condition is that if each T-truncated strategy $\lambda(\Omega_j, t_i)$ has a functional $P(\lambda(\Omega_j, t_i))$, then strategy $\lambda_{opt}(\Omega_j, t_i)$ will be optimal if:

$$P(\lambda_{opt}(\Omega_j, t_i)) = \sup P(\lambda(\Omega_j, t_i)), \quad (7)$$

where $P(\lambda(\Omega_j, t_i))$ – unconditional probability of correct detection of an object at time t_i at strategy $\lambda(\Omega_j, t_i)$.

From the analysis of the results for the selection of search strategies that are studied in the theory of search, of all the strategies, the class of uniformly optimal search strategies most fully satisfies expressions (5)–(7).

Strategy $\lambda(\Omega_j, t_i)$ is uniformly optimal if any T-truncated strategy is optimal, i.e.

$$P(\lambda(\Omega_j, t_i)) = P(\lambda_{opt}(\Omega_j, t_i)), \quad \forall t_i \leq T. \quad (8)$$

Thus, when solving the problem of finding, according to the Bayes criterion of the minimum of the average risk of the search strategy and object detection, the uniformly optimal search strategy is optimal. In accordance with which the current sizes and position of sub-area $\Omega(t_i)$ in the common search area Ω should be selected.

In accordance with expression (2) with a value of the unconditional probability of false alarm fixed at a constant level, the optimization task is formulated as follows:

$$P_1(\gamma_1, t_i) \to \max;$$

$$\lambda(\Omega_j, t_i) \ge 0, \quad t_i > 0;$$

$$\sum_{\Omega(t_i)} \lambda(\Omega_j, t_i) = L_0, \quad t_i > 0; \qquad (9)$$

$$\sum_j \lambda(\Omega_j, t_i) = \varphi(t_i);$$

$$\sum_{\Omega(t_i)} \varphi(t_i) = L_0 t_i,$$

where $P_1(\gamma_1, t_i)$ – the unconditional probability of detecting an object at time t_i in the discrete area of search $\Omega(t_i)$; L_0 – characterizes the power of a search engine; $\varphi(t_i)$ – search effort in search area Ω at t_i.

Based on the studies performed, the following refined optimal Bayes decision rule can be formulated. When solving the task of testing a simple hypothesis against a simple alternative, the joint optimization of discrete search and object detection is reduced to: finding a uniformly optimal search strategy; calculating the maximum unconditional likelihood ratio in the current discrete area $\Omega(t_i)$; comparing it with a threshold.

To optimize the decision rule in detection systems, along with the Bayes criterion of minimum average risk, the maximum likelihood criterion is widely used [11]. The synthesis of the optimal decisive rule of deciding on the detection of the object by the criterion of maximum likelihood in the interests of joint search optimization and detection of objects in technical surveillance systems.

The weight criterion is clarified in the joint search and detection of objects in the current area of view.

Optimized two-alternative solutions according to this criterion. Synthesis of the decision rule was carried out during a two-alternative test of hypotheses in the current area and joint optimization of the search and detection of objects by the criterion of maximum likelihood.

Let us consider an algorithm for calculating the unconditional probability of the correct detection of an object and the average time for detection of this object.

We will calculate the unconditional probability of the correct identification of the object and the average time to detect the object in a joint search and detection in two coordinates for a particular case. Namely, when the a priori probability density of the location of the object is set in the form of a truncated normal law, and the viewing area is a circle with a radius of S.

We assume that the amplitude of the signal that is received is distributed according to the Nakagami distribution.

Define function $\lambda(x, t)$ of search strategy

$$\lambda_1(x_1, x_2; t) =$$

$$= \begin{cases} L_0 / z(t); & for \quad x_1^2 + x_2^2 < r^2(t); \\ 0; & for \quad x_1^2 + x_2^2 \ge r^2(t), \end{cases} \qquad (10)$$

where $z(t)$ – a measure of the current search area.

This search strategy function will be distributed in a circle centered in the center of the viewing area and the current radius $r(t)$.

This will happen until the scope of the search strategy becomes equal to the size of the viewing area.

We define this moment of time t_1 on condition that the dimensions of the current viewing area are equal to the dimensions of the entire area of view. We get the expression (11):

$$\sigma\sqrt{2\pi L_0 t} = \pi S^2, \qquad (11)$$

where σ – standard deviation in the a priori law of the location of the object. from expression (11) we obtain:

$$t_1 = \frac{\pi S^4}{4\sigma^2 L_0}. \qquad (12)$$

In the points of the viewing area where the search strategy is distributed, the search potential will be accumulated over time $[0, t_1]$. This search potential is proportional to the detection parameter, which can be calculated according to expression (13):

$$\varphi_1 = \int_{t(x_1, x_2)}^{t_1} \lambda(x_1, x_2) dx, \qquad (13)$$

where $t(x_1, x_2)$ – function that matters the start time of viewing the points of the viewing area.

We find this function $t(x_1, x_2)$ under condition:

$$x_1^2 + x_2^2 = 2\sigma\sqrt{\frac{L_0 t(x_1, x_2)}{\pi}}, \qquad (14)$$

From (14) we obtain the expression (15):

$$t(x_1, x_2) = \frac{\pi(x_1^2 + x_2^2)^2}{4\sigma^2 L_0}. \qquad (15)$$

We substitute (10), (12) and (15) into (13). Take the integral (13) and get the expression (16):

$$\varphi_1(x_1, x_2) = \begin{cases} \dfrac{S^2 - x_1^2 - x_2^2}{2\sigma^2}; & for \quad x_1^2 + x_2^2 < S^2; \\ 0; & for \quad x_1^2 + x_2^2 \ge S^2. \end{cases} \qquad (16)$$

To find function $\varphi_1(x_1, x_2)$ at any moment of time, we replace in (13) the upper integration boundary for the current time t.

As a result we get the expression (17):

$$\varphi_1(x_1, x_2) = \int_{t(x_1, x_2)}^{t} \lambda_1(x_1, x_2; t) dt. \qquad (17)$$

After time moment t_1 at the accepted density of a priori probability, the search strategy will be distributed under conditions of uniform distribution density (base).

While the current viewing area $\Omega(t)$ will completely coincide with the entire viewing area, and

$$\Omega(t) = \pi S^2. \qquad (18)$$

In this case, taking into account expression (18), the search strategy has the following form:

$$\lambda_2(x_1, x_2; t) = \begin{cases} \dfrac{L_0}{\pi S^2}; & for \quad x_1^2 + x_2^2 < S^2; \\ 0; & for \quad x_1^2 + x_2^2 \geq S^2. \end{cases} \quad (19)$$

In time interval $[t_1, T]$, the search potential, taking into account expression (19), can be determined according to expression (20):

$$\varphi_2(x_1, x_2) = \int_{t_1}^{T} \lambda_2(x_1, x_2; t) dt. \quad (20)$$

We substitute (19), (12) into (20). As a result we get the expression (21):

$$\varphi_2(x_1, x_2) = \frac{L_0(T - t_1)}{\pi S^2}, \quad (21)$$

where T – time to view the entire viewing area.

We calculate the unconditional probability of the correct detection of the object during the search T when continuously searching for objects in two coordinates in a circular viewing area.

In this case, we will take into account the proportional dependence of the detection parameter and the calculated value of the search potential. We restrict ourselves to the case of detecting a signal with an amplitude that is distributed according to the Nakagami distribution with coefficient m.

If $m = 1$, the Nakagami distribution is converted into a Rayleigh distribution.

If $m = 2$, the Nakagami distribution is converted into a Swerling distribution.

For the convenience of subsequent calculations, we introduce a polar coordinate system.

Then, taking into account the transition to the polar coordinate system and the transition in both parts of the expression to dimensionless quantities by multiplying by the search time, expressions (10) and (19) will have the form (22):

$$\lambda(\rho_1, \beta, s)T = \begin{cases} \dfrac{k^{1/2}}{2(\pi s)^{1/2}}; & s \in [0, s_1]; \\ & \rho_1 < h; 0 \leq \beta \leq 360^0; \\ \dfrac{k}{\pi h^2}; & s \in [s_1, 1]; \\ & \rho_1 < h; 0 \leq \beta \leq 360^0, \end{cases} \quad (22)$$

where k – value that determines the total search potential of the surveillance technical system; h – value that determines the size of the entire viewing area.

And for the search potential when changing the value of s in the interval of expression (16), expression (17) is converted to the next expression (23):

$$\varphi(\rho_1, \beta) = \frac{h^2}{4} + \frac{k^2}{\pi h^2} - \frac{\rho_1^2}{2};$$
$$\rho_1 < h; \quad (23)$$
$$0 \leq \beta \leq 360^0.$$

Thus, the expressions for the unconditional probability of the correct detection of the object of surveillance:

for $m = 1$

$$P_1(\gamma_1, T) = 1 / \left(1 - e^{-h^2/2}\right) \times$$
$$\times \int_0^h \exp\left(-\frac{\ln(1/F)}{1 + \dfrac{h^2}{4} + \dfrac{k^2}{\pi h^2} - \dfrac{\rho_1^2}{2}} - \frac{\rho_1^2}{2}\right) \rho_1 d\rho; \quad (24)$$

for $m = 2$

$$P_1(\gamma_1, T) = 1 / \left(1 - e^{-h^2/2}\right) \times$$
$$\times \int_0^h \left(\left(1 + \frac{\dfrac{h^2}{8} + \dfrac{k^2}{2\pi h^2} - \dfrac{\rho_1^2}{4}}{\left(1 + \dfrac{h^2}{8} + \dfrac{k^2}{2\pi h^2} - \dfrac{\rho_1^2}{4}\right)^2} \mp \right) \times \ln(1/F) \right) \rho_1 d\rho;$$
$$\times \exp\left(-\frac{\ln(1/F)}{1 + \dfrac{h^2}{8} + \dfrac{k^2}{2\pi h^2} - \dfrac{\rho_1^2}{4}} - \frac{\rho_1^2}{2}\right) \quad (25)$$

We calculate the unconditional probability of correct detection according to obtain expressions (24) and (25).

Fig. 2 and 3 show the dependences of the calculated values on a value that characterizes the speed and time of viewing the entire viewing area.

Fig. 2 and 3 show the dependence of the unconditional probability of correct detection on a value of k for the values of the conditional probability of false alarm $F = 10^{-2}$ (upper curve) and $F = 10^{-4}$ (lower curve).
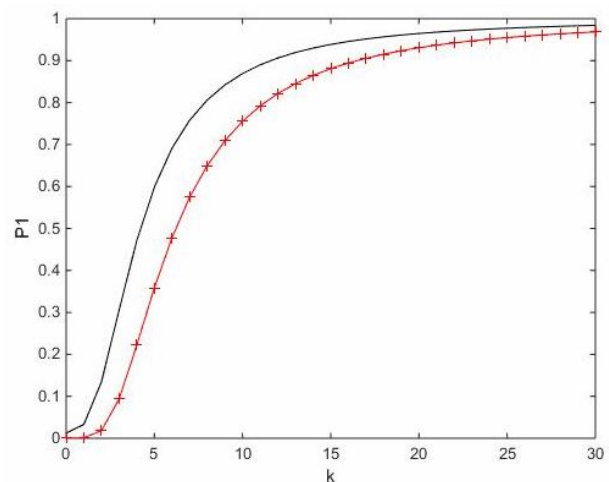

Fig. 2. The dependence of the unconditional probability of correct detection on the value of ($m = 1, h = 1$)
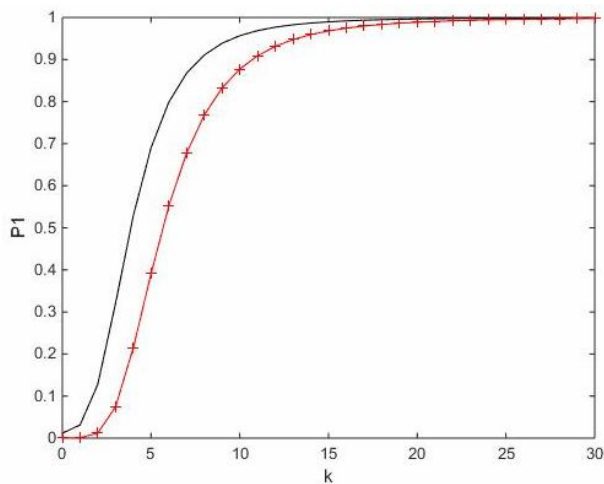
Fig. 3. The dependence of the unconditional probability of correct detection on the value of k ($m = 2, h = 1$)

The minimum value of the value, which is proportional to the value of the total search potential of the surveillance system, is selected subject to mandatory viewing of the entire viewing area.

To assess the effectiveness of the search algorithm and object detection using a uniformly optimal search strategy, we will compare this algorithm with the known algorithms of the space-temporal distribution of search efforts in surveillance systems.

Provided that the known algorithms assume a uniform distribution of the search potential across the viewing area. With a uniform distribution, the expression for the detection parameter, and, consequently, for the search potential, has the following form:

$$\varphi(x_1, x_2) = \frac{L_0 T}{\pi S^2}, \qquad (26)$$

which, taking into account the introduced notation, has the form:

$$\varphi(x_1, x_2) = k / (\pi h^2). \qquad (27)$$

The expressions for the conditional probability of the correct surveillance of the object under surveillance with a uniform distribution of the search potential over the search area, taking into account expression (27), have the following form:

for $m = 1$

$$P_1(\gamma_1 / H_1, x_1, x_2) = F^{1/(1+k/\pi h^2)}, \qquad (28)$$

for $m = 2$

$$P_1(\gamma_1 / H_1, x_1, x_2) = F^{\frac{1}{1+k/\pi h^2}} \times$$

$$\times \left(1 + \frac{k}{\left(2\pi h^2 \left(1 + k/(\pi h^2) \right)^2 \right)} \cdot \ln(1/F) \right). \qquad (29)$$

Using expressions (28) and (29) we get the unconditional probability of the correct detection of the object with a uniform distribution of the search potential across the viewing area. We will use the notation introduced earlier:

for $m = 1$

$$P_1(\gamma_1, T) = F^{1/(1+k/\pi h^2)} \times$$

$$\times \frac{\int_0^h \exp\left(-\rho_1^2/2\right)\rho_1 d\rho_1}{1 - e^{-h^2/2}}. \qquad (30)$$

for $m = 2$

$$P_1(\gamma_1, T) = F^{1/(1+k/\pi h^2)} \times$$

$$\times \int_0^h \exp\left(-\rho_1^2/2\right)\rho_1 d\rho_1 \times \qquad (31)$$

$$\times \frac{(1 + k\ln(1/F)) / \left(2\pi h^2 \left(1 + \frac{k}{2\pi h^2} \right)^2 \right)}{1 - e^{-h^2/2}}.$$

Fig. 4 and 5 show graphs of the dependence of the unconditional probability of detecting an object:

the lower curve – when a uniform distribution of the search potential across the viewing area, which are calculated by the expressions (30) and (31) versus the value of k ;

the upper curve – when searching and discovering objects together, which are calculated by the expressions (24) and (25) versus value of k .

The value of the conditional probability of false alarm was taken equal to $F = 10^{-3}$.

From these graphs it can be concluded that a joint search and detection of the object of surveillance using a uniformly optimal search strategy provides a higher unconditional probability of the correct detection of the object of surveillance.
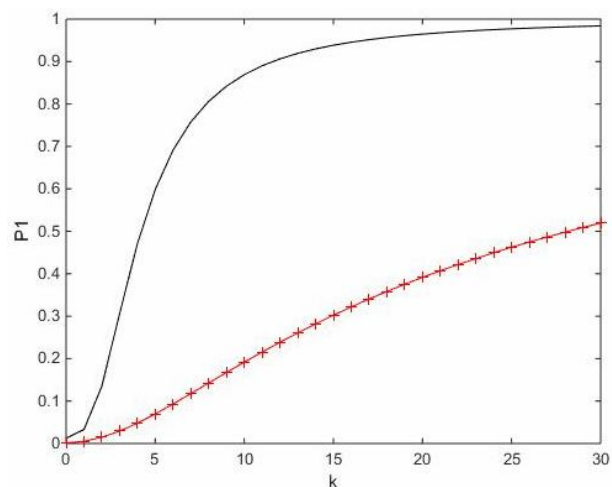

Fig. 4. The dependence of the unconditional probability of correct detection on the value of k ($m = 1, h = 1$)
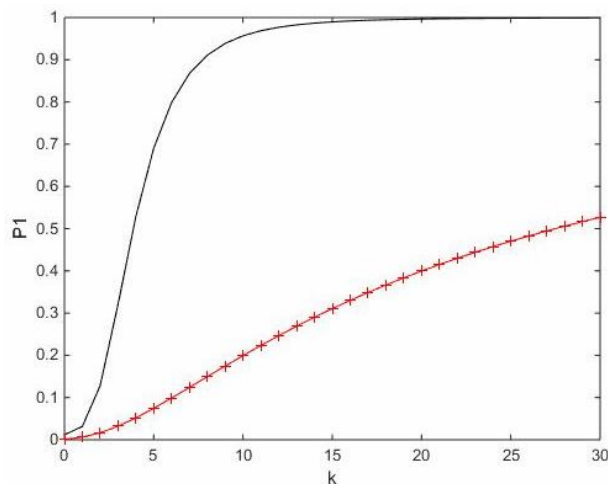
Fig. 5. The dependence of the unconditional probability of correct detection on the value of k ($m = 2, h = 1$)

This is especially noticeable provided that there is a strict restriction on the value of k.

Conclusions

Introduced the current discrete area of view. The task of finding the optimal Bayes decision-making rule in the introduced current discrete area of view is posed and solved. The specified Bayes optimal decision rule is formulated. When solving the task of testing a simple hypothesis against a simple alternative, the joint optimization of discrete search and object detection is reduced to: finding a uniformly optimal strategy for finding an object in discrete cells of the search area; calculating the maximum unconditional likelihood ratio in the current group of search subdomains; comparing it with a threshold.

Proposes the efficiency estimation method of joint search and detection of objects for surveillance technical systems. The differential characteristics of the Bayes criterion of minimum average risk, a priori probabilities of hypotheses about the absence of an object and its presence are taken into account in the calculations.

An algorithm has been developed for calculating the unconditional probability of detecting an object of surveillance during a joint search and detection of objects in technical surveillance systems.

Shown, that a joint search and detection of the objects of surveillance using a uniformly optimal search strategy provides a higher unconditional probability of the correct detection of the object of surveillance.

In future research, it is necessary to assess the average time that is needed to detect the object of surveillance during the joint search and detection of objects and uniform distribution of the search potential of technical surveillance systems.

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Оптимізація спільного пошуку та виявлення об'єктів в технічних системах спостереження

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Анотація. **Предметом** статті є оптимізація спільного пошуку та виявлення об'єктів в технічних системах спостереження. **Мета** - вирішити проблему оптимізації спільного пошуку та виявлення об'єктів в технічних системах спостереження та розробити метод оцінки ефективності спільного пошуку та виявлення об'єктів для систем технічного спостереження. **Результати.** Була введена у розгляд поточна дискретна зона огляду. Поставлена і вирішена задача пошуку оптимального байєсовського правила прийняття рішення у введеній поточній дискретній зоні огляду. Сформульовано уточнене оптимальне байєсовське правило прийняття рішення. Проведений синтез оптимального правила прийняття рішення про виявлення об'єкту при сумісному пошуку та виявленню в технічних системах спостереження по критерію максимальної правдоподібності. Запропоновано метод оцінки ефективності спільного пошуку та виявлення об'єктів в технічних системах спостереження. Розроблено алгоритм обчислення безумовної вірогідності виявлення об'єкта спостереження під час спільного пошуку та виявлення об'єктів у системах технічного спостереження. **Висновки.** Показано, що спільний пошук та виявлення об'єктів спостереження з використанням рівномірно-оптимальної стратегії пошуку забезпечує більш високу безумовну ймовірність правильного виявлення об'єкта спостереження. У майбутніх дослідженнях необхідно оцінити середній час, необхідний для виявлення об'єкта спостереження під час спільного пошуку та виявлення об'єктів та рівномірного розподілу пошукового потенціалу систем технічного спостереження.

Ключові слова: технічна система спостереження; зона огляду; спільний пошук та виявлення об'єктів; критерій мінімуму середнього ризику; оптимальне байєсовське правило прийняття рішення.

Оптимизация совместного поиска и обнаружения объектов в технических системах наблюдения

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Аннотация. **Предметом** статьи является оптимизация общего поиска и обнаружения объектов в технических системах наблюдения. **Цель** - решить проблему оптимизации совместного поиска и обнаружения объектов в технических системах наблюдения и разработать метод оценки эффективности совместного поиска и обнаружения объектов для систем технического наблюдения. **Результаты.** Была введена в рассмотрение текущая дискретная зона обзора. Поставлена и решена задача поиска оптимального байесовский правила принятия решения в введенной текущей дискретной зоне обзора. Сформулировано уточненное оптимальное байесовский правило принятия решения. Проведенный синтез оптимального правила принятия решения об обнаружении объекта при совместном поиске и выявлению в технических системах наблюдения по критерию максимального правдоподобия. Предложен метод оценки эффективности совместного поиска и обнаружения объектов в технических системах наблюдения. Разработан алгоритм вычисления безусловной вероятности обнаружения объекта наблюдения во время совместного поиска и обнаружения объектов в системах технического наблюдения. **Выводы.** Показано, что совместный поиск и выявление объектов наблюдения с использованием равномерно-оптимальной стратегии поиска обеспечивает более высокую безусловную вероятность правильного обнаружения объекта наблюдения. В будущих исследованиях необходимо оценить среднее время, необходимое для обнаружения объекта наблюдения во время совместного поиска и обнаружения объектов и равномерного распределения поискового потенциала систем технического наблюдения.

Ключевые слова: техническая система наблюдения; зона обзора; совместный поиск и выявление объектов; критерий минимума среднего риска; оптимальное байесовский правило принятия решения.