

UDC 007.629.735 (045)

DOI: 10.18372/1990-5548.54.12293

¹A. Al-Ammouri,
²A. O. Degtiarova,
³H. A. Al-Ammori,
⁴A. E. Klochan,
⁵O. P. Tymchenko

ESTIMATION THE INFORMATION RESERVATION EFFECTIVENESS OF UNMANNED AERIAL VEHICLE INFORMATION-CONTROL SYSTEMS

^{1,2,4,5}Electronics and Computing Technics Department, National Transport University
Kyiv, Ukraine

³Department of International Road Transportation and Customs Control, National Transport University
Kyiv, Ukraine

E-mails: ¹ammourilion@ukr.net, ²degtjarova@gmail.com, ³ammourilion@ukr.net,
⁴Varsenchuk@gmail.com, ⁵elenatymchenko@ukr.net

Abstract—The paper deals with the questions of analysis and estimation the methods of information reservation efficiency increase for information-control systems of unmanned aerial vehicles. The methods of parallel, sequential, modular and combined information reservation are considered in the article. A mathematical model for estimating efficiency the various kinds of information reservation is obtained in the article. The information criterion in the form of entropy is used as a criterion for estimation the effectiveness of information reservation. The information criterion is calculated as the difference the information entropy in the case of information reservation and the information entropy of a single source of information. This criterion can be used as a general criterion for assessing the quality of various methods of information reservation for information-control systems of unmanned aerial vehicles. Mathematical modeling of parallel, sequential, combined information reservation, modular information reservation of the first and second hierarchy is carried out in the work, provided that information sources are characterized by low reliability and veracity of information. According to the results of mathematical modeling, it is shown that the most informative is the modular information reservation of the second hierarchy, as well as the modular information reservation of the first hierarchy and the combined information reservation.

Index Terms —Efficiency; information reservation; information criterion; information-control systems.

I. INTRODUCTION

It is known that the efficiency and quality of information-control systems (ICS) depends significantly on the validity of information that comes to the ICS input from various types of measuring device (so-called information sources (IS)), that monitor the condition and functionality parameters of the ICS. Information reservation is the main condition for ensuring the validity of data obtained from different sources of information, which include monitoring signal sensors and measuring device of all possible analog quantities. As a rule, each separate such source has insufficiently high characteristics that determine the degree of validity of data. Such characteristics include the probability of trustworthy report on the presence of a controlled phenomenon and the probability of errors of the I and II kind, that is, the probability of an error in the detection of a controlled phenomenon, if it actually is present, or the probability of a false signaling about the appearance of a controlled phenomenon, when in reality it is not present [1], [2]. Particular attention should be given to the issue of evaluating the performance of ICS of unmanned aerial vehicles (ICM UAVs), since the

quality of their operation significantly affects to the safety and efficiency of UAV's flights.

II. PROBLEM STATEMENT

There are three ways of information reservation: parallel, sequential and combined. The estimation of the quality the various types of information reservation is usually done by mathematical modeling and analysis of each model separately with subsequent comparative analysis. The obtaining of specific results in the comparison process is a complex mathematical procedure and requires a lot of computation. Therefore, is indispensable to develop an information criterion that would to allow a comparative analysis of various types of information reservation. That why is suggested to use of an information criterion that will allow us to determine, with the help of entropy, the amount of information of one or another type of information reservation and to give a comparative analysis on the basis of the obtained formulas and nomograms.

III. REVIEW

The analysis of ICS structures shows that their effectiveness depends on the reliability of the

information upon which the relevant decisions are made. Therefore, it is necessary to take adequate actions to increase the reliability of information in the ICS. Solutions to the problem of validating the validity of data during the transmission and processing of information in process control systems are proposed in [2], [3], where are considered the principles and methods of using statistic data redundancy in solving problems, related to control of information validity based on the minimum mean-square error criterion for different distribution laws of controlled parameters. This and other statistical methods stipulate the collection of a large array of data on the operation parameters of the ICS and don't allow to evaluate their effectiveness during operation. The use of information reservation allows to reduce the shortcomings of statistical methods and to shorten the evaluation time. But hereby a need arises to assess the quality of different ways for information reservation through the use of information criterion, which would allowed undertake the simultaneous assess of various types of reservation with high validity.

IV. PROBLEM SOLUTION

As is known, there are three ways of information reservation the UAV's information-control systems [1], [2]:

- parallel reservation, when instead of one source of information several sources are used and the decision on the validity of incoming data is determined by the majority principle: the controlled phenomenon or measurement value is present, when the m of n sources confirm its existence;

- sequential reservation when the same information source is queried sequentially with a certain time interval ν times, and if this source of information confirms " k of ν " times about the presence of a controlled phenomenon or measurement value, then such control is deemed validity;

- combined reservation, when each of n information sources is requested at a specified interval ν times, and after " k from ν " confirmations about the presence of a controlled phenomenon, the majority principle is also applied: the controlled phenomenon or measurement value is present, when the m of n sources confirm its existence.

It is very important to find a common criterion for estimating the efficiency of each listed information reservation methods.

One of the effective methods for estimation the quality the various types of information reservation is the information criterion, in which the entropy of a single information source is determined, as well as the entropy obtained as a result of one information

reservation types. The difference between these two entropies determines the amount of information obtained as a result of this information reservation type. By the amount of information received, one can judge the effectiveness of one or another information reservation type and give comparative estimates of each listed types.

A. Entropy of the information sources

Let examine this for a specific example. Let three sources of information be given, each of which is characterized by three quality indicators [1], [3]: a is the probability of correct detection; b is the probability of false alarm; d is the probability of non-detection. Moreover, $a + b + d = 1$.

Let the probability a vary from 0.1 to 0.9: $a = 0.1, 0.2, \dots, 0.9$. Let the probabilities $b(a) = d(a)$ and

defined by the dependence $b(a) = d(a) = \frac{1-a}{2}$.

In this case, the entropy of such information source is expressed by the well-known formula [2]:

$$H(a) = -1.44[a \ln(a) + b(a) \ln(b(a)) + d(a) \ln(d(a))]. \quad (1)$$

B. Entropy with parallel information reservation

According to the physical representation of the IS's work, the real IS can be in one of three incompatible random states: correct detection, false alarm and non-detection, determined by probabilities a , b and d , respectively. Such system can be represented by using the trinomial probability distribution [1], [2], according to which the probability that n from m IS will not detect controlled phenomena at all, $m - k$ IS will work with false alarm, and $n - m$ IS will provide the correct information about the controlled phenomenon. The probability $p(n - m, m - k, k)$ is described by the following expression:

$$P_{(n-m, m-k, k)} = C_n^{n-m} a^{n-m} C_m^{m-k} b^{m-k} d^k. \quad (2)$$

Let the information system consisting of three IS and be executed in such a way that at its output there will be a signal $F_{2,3}$, when at the input by majority principle no less than two AI are triggered. Such system is shown in Fig. 1.

As is known [3], [4], with parallel information reservation for three sources of information in accordance with the majority principle "2 of 3" the probability of reliable detection of the controlled phenomenon P_1 , the probability of non-detection P_2 and the probability of false alarm P_3 are respectively, determined by the expressions:

$$\left. \begin{aligned} P_1 &= a^3 + 3a^2d(a) + 3a^2b(a) + 6ab(a)d(a), \\ P_2 &= d^3(a) + 3ad^2(a) + 3b(a)d^2(a), \\ P_3 &= b^3(a) + 3ab^2(a) + 3d(a)b^2(a). \end{aligned} \right\} (3)$$

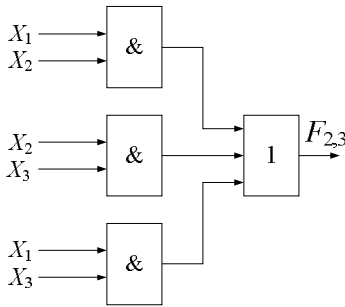


Fig. 1. Information system with the majority principle "2 of 3"

The entropy $H_1(a)$, which obtained as a result of parallel information reservation, in accordance with the majority principle "2 of 3" can be calculated according to the formula:

$$H_1(a) = -1.44 [P_1 \ln(P_1) + P_2 \ln(P_2) + P_3 \ln(P_3)]. \quad (4)$$

The amount of information $I(a)$, which obtained as a result of such parallel reservation, is defined as the entropy difference $H(a)$ and $H_1(a)$:

$$I_1(a) = H(a) - H_1(a). \quad (5)$$

Let the information system consisting of four IS and be executed in such a way that at its output there will be a signal $F_{2,4}$, when at the input by majority principle no less than two AI are triggered. Such system is shown in Fig. 2.

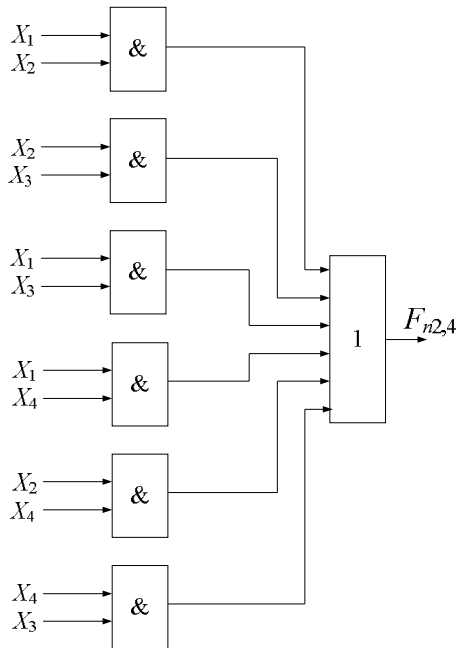


Fig. 2. Information system with the majority principle "2 of 4"

As is known [3], [4], with parallel information reservation for four sources of information in accordance with the majority principle "2 of 4" the probability of reliable detection of the controlled phenomenon $P_{1,4}$, the probability of non-detection $P_{2,4}$ and the probability of false alarm $P_{3,4}$ are respectively, determined by the expressions:

$$\left. \begin{aligned} P_{1,4} &= a^4 + 4a^3b(a) + 6a^2b^2(a) \\ &\quad + 4ab^3(a) + 4a^3d(a) + 12a^2b(a)d(a) \\ &\quad + 12ab^2(a)d(a) + 6a^2b^2(a) + 12abd^2, \\ P_{2,4} &= d^4(a) + 4b(a)d^3(a) + 4ad^3(a), \\ P_{3,4} &= b^4(a) + 4b^3(a)d(a) + 6d^2(a)b^2(a). \end{aligned} \right\} (6)$$

The entropy $H_{1,4}(a)$, which obtained as a result of parallel information reservation, in accordance with the majority principle "2 of 4" can be calculated according to the formula:

$$H_{1,4}(a) = -1.44 [P_{1,4} \ln(P_{1,4}) + P_{2,4} \ln(P_{2,4}) + P_{3,4} \ln(P_{3,4})]. \quad (7)$$

The amount of information $I(a)$, which obtained as a result of such parallel reservation, is defined as the entropy difference $H(a)$ and $H_{1,4}(a)$:

$$I_{1,4}(a) = H(a) - H_{1,4}(a). \quad (8)$$

C. Entropy with parallel modular information reservation of the first hierarchy

On the basis of the module (Fig. 1), it is possible to build a more efficient information system $N_{6,9}$ (Fig. 3), which will combining 9 sources of information x_i and will implementing the majority principle "6 of 9". In this case, the scheme (Fig. 3) is executed on the modules $F_{2,3}$ (Fig. 1), and its probabilistic characteristics p_{1M}, p_{2M}, p_{3M} are determining the probability of reliable detection of the controlled phenomenon, the probability of non-detection and the probability of false alarm are respectively, determined by the expressions:

$$\left. \begin{aligned} p_{1M} &= p_1^3 + 3p_1^2p_3 + 3p_1^2p_2 + 6p_1p_2p_3, \\ p_{2M} &= p_2^3 + 3p_2^2p_3 + 3p_2^2p_1, \\ p_{3M} &= p_3^3 + 3p_3^2p_2 + 3p_3^2p_1. \end{aligned} \right\} (9)$$

Accordingly, the entropy of parallel modular information reservation $H_M(a)$ can be calculated according to the formula:

$$H_M(a) = -1.44 [p_{1M} \ln(p_{1M}) + p_{2M} \ln(p_{2M}) + p_{3M} \ln(p_{2M})]. \quad (10)$$

The amount of information $I_M(a)$, which obtained as a result of parallel modular information reservation, is determined by the formula:

$$I_M(a) = H(a) - H_M(a). \quad (11)$$

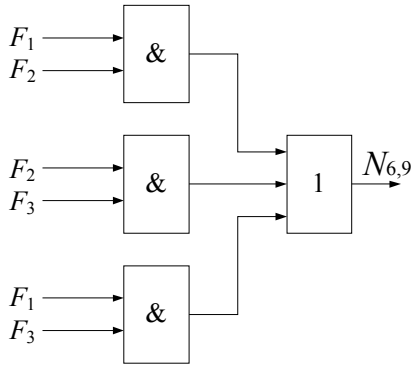


Fig. 3. Informational module $N_{6,9}$ for implementation the majority principle "6 of 9" to decision on the reliability of the message

At the same way on the basis of the module (Fig. 2), it is possible to build a more efficient information system $N_{12,24}$ (Fig. 4), which will combining 24 sources of information x_i and will implementing the majority principle "12 of 24". In this case, the scheme (Fig. 4) is executed on the modules $F_{2,4}$ (Fig. 2), and its probabilistic characteristics $p_{n1m}, p_{n2m}, p_{n3m}$ are determining the probability of reliable detection of the controlled phenomenon, the probability of non-detection and the probability of false alarm are respectively, determined by the expressions

$$\left. \begin{aligned} p_{n1m} &= p_{1,4}^4 + 4p_{1,4}^3 p_{3,4} + 6p_{1,4}^2 p_{3,4}^2 \\ &+ 4p_{1,4} p_{3,4}^3 + 4p_{1,4}^3 p_{2,4} + 12p_{1,4}^2 p_{2,4} p_{3,4} \\ &+ 12p_{1,4} p_{3,4}^2 p_{2,4} + 6p_{1,4}^2 p_{2,4}^2 + 12p_{1,4} p_{3,4} p_{2,4}^2, \\ p_{n2m} &= p_{2,4}^4 + 4p_{2,4}^3 p_{3,4} + 4p_{1,4} p_{2,4}^3, \\ p_{n3m} &= p_{3,4}^4 + 4p_{3,4}^3 p_{2,4} + 6p_{3,4}^2 p_{2,4}^2. \end{aligned} \right\} \quad (12)$$

Accordingly, the entropy of parallel modular information reservation $H_{Mn}(a)$ can be calculated according to the formula:

$$H_{Mn}(a) = -1.44 [p_{n1m} \ln(p_{n1m}) + p_{n2m} \ln(p_{n2m}) + p_{n3m} \ln(p_{n3m})]. \quad (13)$$

The amount of information $I_{nM}(a)$, which obtained as a result of parallel modular information reservation, is determined by the formula:

$$I_{nM}(a) = H(a) - H_{Mn}(a). \quad (14)$$

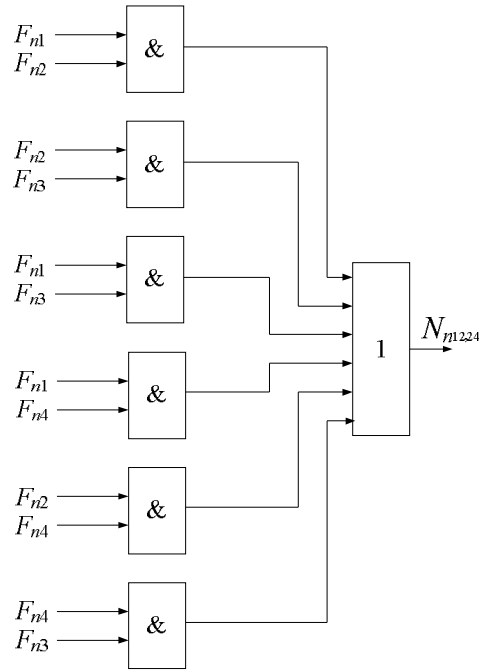


Fig. 4. Informational module $N_{12,24}$ for implementation the majority principle "12 of 24" to decision on the reliability of the message

D. Entropy with parallel modular information reservation of the second hierarchy

On the basis of the module (Fig. 3), in accordance with the modular principle of implementing the parallel redundancy schemes, it is possible to build a more efficient information system $L_{18,27}$, which is depicted in the Fig. 5, which will combining 27 sources of information x_i and will implementing the majority principle "18 of 27".

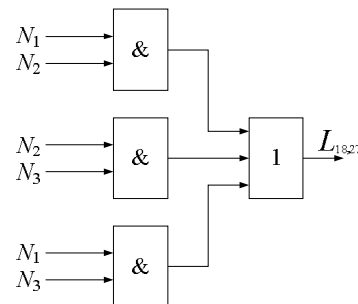


Fig. 5. Informational module $L_{18,27}$ for implementation the majority principle "18 of 27" to decision on the reliability of the message

In this case, the scheme (Fig. 5) is executed on the modules $N_{6,9}$ (Fig. 3), and its probabilistic characteristics $p_{1Mn}, p_{2Mn}, p_{3Mn}$ are determining the probability of reliable detection of the controlled phenomenon, the probability of non-detection and the probability of false alarm are respectively, determined by the expressions:

$$\left. \begin{aligned} p_{1M_{II}} &= p_{1M}^3 + 3p_{1M}^2 p_{3M} + 3p_{1M}^2 p_{2M} \\ &\quad + 6p_{1M} p_{2M} p_{3M}, \\ p_{2M_{II}} &= p_{2M}^3 + 3p_{2M}^2 p_{3M} + 3p_{2M}^2 p_{1M}, \\ p_{3M_{II}} &= p_{3M}^3 + 3p_{3M}^2 p_{2M} + 3p_{3M}^2 p_{1M}. \end{aligned} \right\} (15)$$

Accordingly, the entropy of parallel modular information reservation $H_{M_{II}}(a)$ can be calculated according to the formula:

$$H_{M_{II}}(a) = -1.44 \left[p_{1M_{II}}(a) \ln(p_{1M_{II}}(a)) + p_{2M_{II}}(a) \ln(p_{2M_{II}}(a)) + p_{3M_{II}}(a) \ln(p_{3M_{II}}(a)) \right]. \quad (16)$$

The amount of information $I_{M_{II}}(a)$, which obtained as a result of parallel modular information reservation, is determined by the formula:

$$I_{M_{II}}(a) = H(a) - H_{M_{II}}(a). \quad (17)$$

At the same way on the basis of the module (Fig. 4), in accordance with the modular principle of implementing the parallel redundancy schemes, it is possible to build a more efficient information system $L_{48,96}$, which is depicted in the Fig. 6, which will combining 96 sources of information x_i and will implementing the majority principle "48 of 96". In this case, the scheme (Fig. 6) is executed on the modules $N_{32,64}$ (Fig. 4).

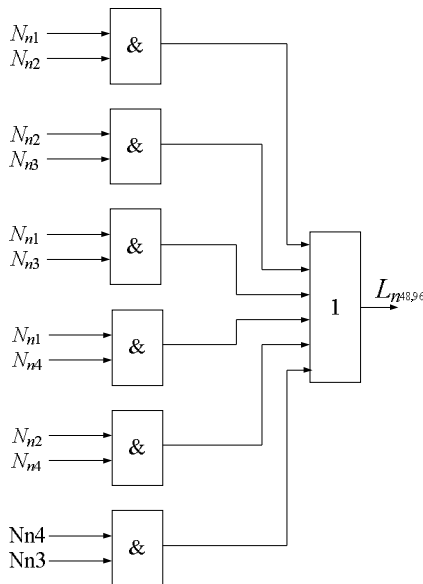


Fig. 6. Informational module $L_{48,96}$ for implementation the majority principle "48 of 96" to decision on the reliability of the message

The probabilistic characteristics $p_{n1M_{II}}, p_{n2M_{II}}, p_{n3M_{II}}$ are determining the probability of reliable

detection of the controlled phenomenon, the probability of non-detection and the probability of false alarm are respectively, determined by the expressions:

$$\left. \begin{aligned} P_{n1M_{II}} &= p_{n1m}^4 + 4p_{n1m}^3 p_{n3m} + 6p_{n1m}^2 p_{n2m}^2 \\ &\quad + 4p_{n1m} p_{n3m}^3 + 4p_{n1m}^3 p_{n2m} \\ &\quad + 12p_{n1m}^2 p_{n2m} p_{n3m} + 12p_{n1m} p_{n3m}^2 p_{n2m} \\ &\quad + 6p_{n1m}^2 p_{n2m}^2 + 12p_{n1m} p_{n3m} p_{n2m}^2, \\ P_{n2M_{II}} &= p_{n2m}^4 + 4p_{n2m}^3 p_{n3m} + 4p_{n1m} p_{n2m}^3, \\ P_{n3M_{II}} &= p_{n3m}^4 + 4p_{n3m}^3 p_{n2m} + 6p_{n3m}^2 p_{n2m}^2. \end{aligned} \right\} (18)$$

Accordingly, the entropy of parallel modular information reservation $H_{nM_{II}}(a)$ can be calculated according to the formula:

$$H_{nM_{II}}(a) = -1.44 \left[p_{n1M_{II}}(a) \ln(p_{n1M_{II}}(a)) + p_{n2M_{II}}(a) \ln(p_{n2M_{II}}(a)) + p_{n3M_{II}}(a) \ln(p_{n3M_{II}}(a)) \right]. \quad (19)$$

The amount of information $I_M(a)$, which obtained as a result of parallel modular information reservation, is determined by the formula:

$$I_{nM_{II}}(a) = H(a) - H_{nM_{II}}(a). \quad (20)$$

E. Entropy with sequential information reservation

As is known [2], in sequential information reservation, next parameters are entered: the quality factor of the information source $\gamma(a)$, as the ratio of the false alarm probability $b(a)$ or the non-detection probability $d(a)$ to the reliable detection probability, i.e. $\gamma(a) = b(a)/a$, and also entered a data apriority coefficient $\beta(a)$ in accordance with the formula: $\beta(a) = (1 - \alpha) / \alpha$, where α is the a priori probability of a controlled phenomenon.

It is known [1], [3] that if are in evidence two confirmations at serial query of the same source, then the probabilities of reliable detection $P_{01}(a)$, non-detection $P_{02}(a)$ and false alarm $P_{03}(a)$ are respectively determined by the formulas:

$$\left. \begin{aligned} P_{01}(a) &= \frac{1}{1 + \gamma^2(a)\beta(a)}, \\ P_{02}(a) &= \frac{\gamma^2(a)}{2(\beta(a) + \gamma^2(a))}, \\ P_{03}(a) &= \frac{\beta(a)\gamma^2(a)}{2(1 + \gamma^2(a))}. \end{aligned} \right\} (21)$$

Ordinarily, the a priori probability of a controlled phenomenon α is unknown and is accepted as $\alpha=0.5$, then $\beta(a)=1$ and the formulas (10) are simplified.

Accordingly, the entropy $H_2(a)$ of the sequential information reservation can be calculated according to the formula:

$$H_2(a) = -1.44 [P_{01}(a) \ln(P_{01}(a)) + P_{02}(a) \ln(P_{02}(a)) + P_{03}(a) \ln(P_{03}(a))] \quad (22)$$

The amount of information $I_2(a)$, which obtained as a result of sequential information reservation after two checks of the controlled phenomenon can be determined according to the formula:

$$I_2(a) = H(a) - H_2(a) \quad (23)$$

F. Entropy with combined information reservation

Now, let's consider the combined information reservation. In this case the majority principle of decision by criterion "2 of 3" is applied after each from 3 sources was requested successively two times.

In this case, the probabilities of reliable detection $P_{11}(a)$, probabilities of non-detection the controlled phenomenon $P_{12}(a)$ and the probability of false alarm $P_{13}(a)$ are determined according to the following expressions [3]:

$$\left. \begin{aligned} P_{01}(a) &= P_{01}^3(a) + 3P_{01}^2(a)P_{02}(a) + 3P_{01}^2(a)P_{03}(a), \\ P_{02}(a) &= P_{02}^3(a) + 3P_{02}^2(a)P_{01}(a) + 3P_{02}^2(a)P_{03}(a) + 6P_{01}(a)P_{02}(a)P_{03}(a), \\ P_{03}(a) &= P_{03}^3(a) + 3P_{03}^2(a)P_{01}(a) + 3P_{03}^2(a)P_{02}(a). \end{aligned} \right\} \quad (24)$$

Accordingly, the entropy $H_3(a)$ of the combined information reservation can be calculated according to the formula:

$$H_3(a) = -1.44 [P_{11}(a) \ln(P_{11}(a)) + P_{12}(a) \ln(P_{12}(a)) + P_{13}(a) \ln(P_{13}(a))] \quad (25)$$

The amount of information $I_3(a)$, which obtained as a result of combined information reservation, is determined by the formula:

$$I_3(a) = H(a) - H_3(a) \quad (26)$$

V. RESULTS OF RESEARCH

Based on formulas (5), (8), (11), (14), (17), (20), (23), (26) were plotted dependency graph the amount of information, which obtained as a result of sequential, parallel, modular and combined information reservation, on the probability of reliable data, which are shown in Fig. 7.

The analysis of the graphs shows that the most informative is the modular information reservation of the second hierarchy (module $L_{48,96}$), which provides obtaining the greatest amount of information $I_{nM_{II}}(a)$, even if the quality of information sources, characterized by the probability of reliable detection of a controlled phenomenon by one source, will be lower than for information sources with parallel and sequential information reservation. It should also be noted that the modular information reservation of the first hierarchy and combined information reservation is also characterized by high results compared to parallel and sequential information reservation.

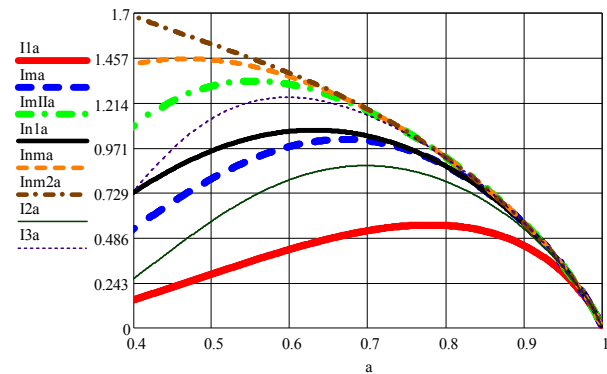


Fig. 7. Dependency graph the amount of information, which obtained as a result of sequential, parallel, modular and combined information reservation, on the probability of reliable data

VI. CONCLUSIONS

The article deals with analyzes of evaluation the information reservation effectiveness of UAV's information and control systems. Also, the article presents a mathematical model for estimating the efficiency of information reservation and the information criterion in the form of entropy for estimating the efficiency of reservation the UAV's information and control systems is proposed. The algorithm for assessing the quality for various methods of information reservation is, also, proposed. It implemented with the help of a generalized information criterion for estimating the amount of information. Also, the article presents the results of the evaluation the various types of information reservation. In the evaluation it was shown that one of the most effective criteria for assessing the quality for various methods of information reservation is the information criterion. Such generalized criterion makes it possible to simple and easy evaluate the effectiveness of using "m of n" for parallel information reservation and "k of v" for sequential information reservation. As a

result of the research it was shown that the most informative methods of information reservation are modular and combined reservation.

REFERENCES

- [1] A. Al-Ammory, "Technique for evaluating information reservation of the dangerous flight situation alarm systems," *Artificial Intelligence*, Donetsk, no. 1, pp. 61–67, 2008. (in Russian)
- [2] F. E. Temnikov, V. A. Affonin, and V. I. Dmitriev, *Theoretical basis of information technique*, Moscow: Energy, 1971, 410 p. (in Russian)
- [3] A. Al-Ammouri, A. Kasyanenko, H. Al-Ammouri, and A. Degtiarova, "Optimization of onboard navigation systems," *Proceedings 2016 IEEE 4th International Conference "Methods and Systems of Navigation and Motion Control (MSNMC)"*, October, 18-20, 2016, Kyiv, Ukraine, 2016, pp. 288–290.
- [4] T. T. Abezgaus, A. P. Tron, Yu. N. Kopenkin and et al. *Handbook on probability calculations*, Moscow: Military Publishing, 1989, 656 p. (in Russian)

Received September 20, 2017

Al-Ammouri Ali. Doctor of Engineering Science. Professor.
Electronics and Computing Technics Department, National Transport University, Kyiv, Ukraine.
Education: Kyiv Civil Aviation Engineers Institute, Kyiv, Ukraine, (1992).
Research area: avionics, information technology, transport processes, flight safety, reliabilities.
Publications: over 200.
E-mails: ammourilion@ukr.net.
orcid.org/0000-0002-0375-6108.

Degtiarova Anastasia. Post-graduate student.
Electronics and Computing Technics Department, National Transport University, Kyiv, Ukraine.
Education: National Transport University, Kyiv, Ukraine, (2015).
Research area: information technology, reliabilities.
Publications: 4.
E-mail: degtjarova@gmail.com.
orcid.org/0000-0001-5883-6060

Al-Ammori Hasan. Post-graduate student.
Department of International Road Transportation and Customs Control, National Transport University, Kyiv, Ukraine.
Education: Kyiv National University of Technologies and Design, Kyiv, Ukraine, (2013).
Research area: information technology, reliabilities.
Publications: 5.
E-mail: hasan.ammori@gmail.com.
orcid.org/0000-0002-1371-2205

Klochans Arsen. Post-graduate student.
Electronics and Computing Technics Department, National Transport University, Kyiv, Ukraine.
Education: National Aviation University, Kyiv, Ukraine, (2015).
Research area: avionics and optoelectronics.
Publications: 9.
E-mail: VArsechuk@gmail.com
orcid.org/0000-0002-4225-9382

Tymchenko Olena. Teaching Fellow.
Electronics and Computing Technics Department, National Transport University, Kiev, Ukraine.
Education: National Transport University, Ukraine, (1984).
Research area: information technology.
Publications: 3.
E-mail: elenatymchenko@ukr.net

Алі Аль-Амморі, А. О. Дегтярьова, Х. А. Аль-Амморі, А. Є. Клочан, О. П. Тимченко. Оцінка ефективності інформаційного резервування інформаційно-керуючих систем безпілотних літальних апаратів

Статтю присвячено розгляду питання аналізу та оцінки методів підвищення ефективності інформаційного резервування інформаційно-керуючих систем безпілотних літальних апаратів. Розглянуто методи паралельного, послідовного, модульного та комбінованого інформаційного резервування. Отримано математичну модель оцінки ефективності різних видів інформаційного резервування. В якості критерію для оцінки ефективності інформаційного резервування використовується інформаційний критерій, який представляє собою різницю ентропії інформації при інформаційному резервуванні та ентропії одиничного джерела інформації. Даний

критерій може бути використаний як загальний критерій оцінки якості різних методів інформаційного резервування для інформаційно-керуючих систем безпілотних літальних апаратів. Проведено математичне моделювання паралельного, послідовного, комбінованого інформаційного резервування, модульного інформаційного резервування першої та другої ієрархії за умови, що джерела інформації характеризуються низькими показниками надійності та достовірності інформації. За результатами математичного моделювання показано, що найбільш інформативним є модульне інформаційне резервування другої ієрархії, а також модульне інформаційне резервування першої ієрархії та комбіноване інформаційне резервування.

Ключові слова: ефективність; резервування інформації; інформаційний критерій; інформаційно-керуючі системи.

Аль-Амморі Алі. Доктор технічних наук. Професор.

Кафедра електроніки та обчислювальної техніки, Національний транспортний університет, Київ, Україна.

Освіта: Київський інститут інженерів цивільної авіації, Київ, Україна (1992).

Напрямок наукової діяльності: авіоніка, інформаційні технології, транспортні процеси, безпека польотів, надійність.

Публікації: понад 200.

E-mails: ammourilion@ukr.net.

orcid.org/0000-0002-0375-6108.

Дегтярєва Анастасія Олегівна. Аспірантка.

Кафедра електроніки та обчислювальної техніки, Національний транспортний університет, Київ, Україна.

Освіта: Національний транспортний університет, Київ, Україна, (2015).

Напрямок наукової діяльності: інформаційні технології, надійність.

Публікації: 4.

E-mail: degtjarova@gmail.com.

orcid.org/0000-0001-5883-6060

Аль-Амморі Хасан Аліївич. Аспірант.

Кафедра міжнародних перевезень та митного контролю, Національний транспортний університет, Київ, Україна.

Освіта: Київський національний університет технологій та дизайну, Київ, Україна, (2013).

Напрямок наукової діяльності: інформаційні технології, надійність.

Публікації: 5.

E-mail: hasan.ammori@gmail.com.

orcid.org/0000-0002-1371-2205

Клочан Арсен Євгенійович. Аспірант.

Кафедра електроніки та обчислювальної техніки, Національний транспортний університет, Київ, Україна.

Освіта: Національний авіаційний університет, Київ, Україна, (2015).

Напрямок наукової діяльності: авіоніка та оптоелектроніка.

Публікації: 9.

E-mail: VArsechuk@gmail.com.

orcid.org/0000-0002-4225-9382.

Тимченко Олена Петрівна. Асистент.

Кафедра електроніки та обчислювальної техніки, Національний транспортний університет, Київ, Україна.

Освіта: Національний транспортний університет, Київ, Україна, (1984).

Напрямок наукової діяльності: інформаційні технології.

Публікації: 3.

E-mail: elenatymchenko@ukr.net

Али Аль-Аммори, А. О. Дегтярева, Х. А. Аль-Аммори, А. Е. Клочан, Е. П. Тимченко. Оценка эффективности информационного резервирования информационно-управляющих систем беспилотных летательных аппаратов

Статья посвящена рассмотрению вопроса анализа и оценки методов повышения эффективности информационного резервирования информационно-управляющих систем беспилотных летательных аппаратов. Рассмотрены методы параллельного, последовательного, модульного и комбинированного информационного резервирования. Получена математическая модель оценки эффективности различных видов информационного резервирования. В качестве критерия для оценки эффективности информационного резервирования используется информационный критерий, представляющий собой разницу энтропии информации при информационном резервировании и энтропии единичного источника информации. Данный критерий может быть использован как общий критерий оценки качества различных методов информационного резервирования

для информационно-управляющих систем беспилотных летательных аппаратов. Проведено математическое моделирование параллельного, последовательного, комбинированного информационного резервирования, модульного информационного резервирования первой и второй иерархии при условии, что источники информации характеризуются низкими показателями надежности и достоверности информации. По результатам математического моделирования показано, что наиболее информативным является модульное информационное резервирование второй иерархии, а также модульное информационное резервирование первой иерархии и комбинированное информационное резервирование.

Ключевые слова: эффективность; резервирования информации; информационный критерий; информационно-управляющие системы.

Аль-Аммори Али. Доктор технических наук. Профессор.

Кафедра электроники и вычислительной техники, Национальный транспортный университет, Киев, Украина.

Образование: Киевский институт инженеров гражданской авиации, Киев, Украина (1992).

Направление научной деятельности: авионика, информационные технологии, транспортные процессы, безопасность полетов, надежность.

Публикации: более 200.

E-mails: ammourilion@ukr.net.

orcid.org/0000-0002-0375-6108.

Дегтярева Анастасия Олеговна. Аспирантка.

Кафедра электроники и вычислительной техники, Национальный транспортный университет, Киев, Украина.

Образование: Национальный транспортный университет, Киев, Украина, (2015).

Направление научной деятельности: информационные технологии, надежность.

Публикации: 4.

E-mail: degtjarova@gmail.com.

orcid.org/0000-0001-5883-6060

Аль-Аммори Хасан Алиевич. Аспирант.

Кафедра международных перевозок и таможенного контроля, Национальный транспортный университет, Киев, Украина.

Образование: Киевский национальный университет технологий и дизайна, Киев, Украина, (2013).

Направление научной деятельности: информационные технологии, надежность.

Публикации: 5.

E-mail: hasan.ammori@gmail.com.

orcid.org/0000-0002-1371-2205.

Клочан Арсен Евгеньевич. Аспирант.

Кафедра электроники и вычислительной техники, Национальный транспортный университет, Киев, Украина.

Образование: Национальный авиационный университет, Киев, Украина, (2015).

Направление научной деятельности: авионика и оптоэлектроника.

Публикации: 9.

E-mail: VArsenchuk@gmail.com.

orcid.org/0000-0002-4225-9382.

Тимченко Елена Петровна. Ассистент.

Кафедра электроники и вычислительной техники, Национальный транспортный университет, Киев, Украина.

Образование: Национальный транспортный университет, Киев, Украина, (1984).

Направление научной деятельности: информационные технологии.

Публикации: 3.

E-mail: elenatymchenko@ukr.net