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MEASURING OF IDENTIFICATON IN DIVERSITY RECOGNITON SYSTEMS

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Abstract: *This paper gives quantitive indexes for identification in the diversity recognition systems. The formulas for known coefficients, such coefficient of identification, coeficient of false alarm ratio are suggested. For this purpose a set theory is used. This makes it possible to evaluate and synthesize existing systems of recognition (including alarm systems) and to evaluate their quality and reliability. This can be differentiated by the two characteristics: probability of recognition, probability of erroneous identification and overall identification of the identification.*

1.Introduction

The Recognition Systems (RS) are often specialized in controlling certain types of events, called controlled events or CE. They can have different expressions, appear in different intensities and forms, but must be recognized by RS as soon as they have the parameters assigned to them in the system specification.

Each of the CE is manifested through multiple (set) of different parameters [1.2].

For the recognition of the event by RS serve the phenomena related to CE. For this purpose, detectors (sensors) are used which react to some of the parameters characterizing these phenomena. One of the known methods to improve identification is diversity. With it, CE is considered by two channels working on a different principle. The output results are compared by a specialized comparison scheme and when matched, the corresponding decision is taken.

In the identification are possible two inverse reactions of RS and these are related in general to its reliability in a different context [3]. (fig.1.)

- false alarms (registration of not held CE);
- no identification of the CAE (not registering of the held CE).

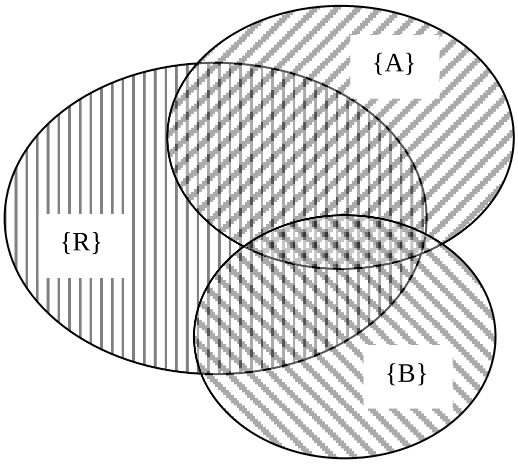

Fig.1.Ratios of sets of controlled alarming events (CAE) in the alarm system (AS)

The set {R} is the authentic space of CE, for example:

- intrusion or movement of an unauthorized person or object in an area;
- fire occurrence;
- defined natural disaster, etc.

The sets {A} and {B} are respectively the images of the CAE obtained in the two channels of the recognition system.

The signals received by the detectors form the images of CE (sets {A} and {B) at the input of the alarm system AS.

To identify CE in RS means it responds correctly to the appearance of the event. The reliability of its reaction can be measured with the degree of compliance between the authentic space of the CE (set {R}) and the images of CAE obtained through the technical resources in RS (sets {A} and {B}). Absolute authenticity means total overlapping of the three sets.

In addition to the lack of RS response, false recognition (false alarm) can be created. The difference between sets {(B∩A) -R} (fig.1) is the set of false alarms. In this case, the RS output has an alarm state, without the CE being held.

The aspiration for the construction of diversity recognition system is to increase the intersection {R∩A∩B} of the two sets (shadedin the drawing) and to reduce the areas of inadequacy [4]. In this priority, there is a solution to the problem of reducing the area {A-B} because it is linked to a dangerous state when the RS does not respond to CE (intrusion, fire, unauthorized access, etc.).

2. Identification indicators

On the basis of the above, a criteria system of indicators for assessing the adequacy of identification in RS is proposed.

When the CAE exists (set {A} in fig. 1) but the AS does not identify it, a danger may be occur - the object is vulnerable. {A - B} is a set of unidentified (and possibly dangerous) alarm situations. The main purpose in designing AS is that the sets {R}, {A} and {B} overlap to the maximum, $\{R-(A\cap B\}$ to be an empty set, so that there are no unidentified alarm situations. The requirement of absolute adequacy for the CAE identification can be formalized as:

$$A \equiv B \equiv R \text{ or } Card\{R-(A\cap B\}=0 \qquad (1)$$

The proposed criteria system includes three probability indicators:

1. ***Probability of detection of CAE - P_d***. The indicator assesses the ability of a diversity recognition system to register CAE. This probability can be formalised in the following formula:

$$K_d = \frac{Card\{R \cap (A \cap B)\}}{Card\{R\}}, \qquad (2)$$

where:

- {R} - a set of authentic CAEs;
- $\{R \cap (A \cap B)\}$ a set of correctly identified situations.

The same information is also given by the inverse indicator - probability of non-recognition - P_{nd}.

$$P_{nd} = \frac{Card\{R - (B \cap A)\}}{Card\{R\}} \qquad (3)$$

2. ***Probability of False Recognition (P_f)*** is an indicator that evaluates the possibility that the identification is wrong. It is proposed here to be recorded as a ratio:

$$P_f = \frac{Card\{(A \cap B) - R\}}{Card\{A \cap B\}} \qquad (4)$$

Obviously, with adequate identification $P_f = 0$.

It can be argued that if $P_d = 1$ and $P_f = 0$ there is a maximum identification. Both P_d and P_f coefficients describe the adequacy of the identification, but do not give complete information about it. Therefore, a generic indicator is introduced - a K_i coefficient.

3. ***The coefficient K_i*** is defined as:

$$K_i = \frac{Card\{R \cap A \cap B\}}{Card\{R \cup A \cup B\}} \qquad (5)$$

It includes the indicators for both inverse situations - non-recognition and false alarm. This coefficient has the most unfavorable value in the extreme case when the two sets A and B do not intersect ($K_i = 0$) and the most favorable ($K_i = 1$) when they fully coincide. But when he does not carry enough information: its value can be obtained under different ratios of non-recognition and false activations in the AS. Therefore, this coefficient alone is not sufficient to assess the identification.

Unlike single-channel systems, in diversity systems, different cases are possible. The essence of the diversity processing of the information is to perform logical AND from the outputs of the two channels. But there are cases in which logical OR the output of the two channels would give better identification. This stems from the fact that the two channels, due to their different nature, "see" the object of recognition for different signs.

Depending on the application are possible both combinations between the two channels. For example, when a warning event is to be generated, the output function is used logical function OR, and in the case of alarm – function AND.

In fig. 1 is visible, that both channels of the recognizing system cannot fully identify the CAE, because they do not fully cover the set of {A}. Maximum good recognition would have, if the system can read where the intersections {R ∩ A} and {R ∩ B}, i.e. $Card\{(R \cap A) \cup (R \cap B)\}$ is the maximum that can be recognized by both channels.

If the ratio between diversity and maximum recognition is taken, a coefficient is obtained which gives a quantitative estimate, to what extent the diversity may reduce the P_d coefficient.

$$K_e = \frac{Card\{R \cap (A \cap B\}}{Card\{(R \cap A) \cup (R \cap B)\}} = \frac{Card\{R \cap (A \cap B\}}{Card\{(R \cap (A \cup B))\}}$$

For example, if the two sets intersect (Fig.1) и Card{R}=50, Card{A}=20, Card{B}=30, Card{R∩A}=10, Card{R∩B}=10, Card{R∩A∩B}=5, Card{A∩B}=10, Card{R∪A∪B}=75, the K_i factor will be $K_i = \frac{5}{75} = 0{,}066$, the possibility of detection will be $P_d = \frac{5}{50} = 0{,}1$ and the probability of misidentification will be $P_f = \frac{5}{10} = 0{,}5$. The coefficient of efficiency of the diversity processing will be $K_{ed} = \frac{5}{15} = 0{,}333$.

By means of the above-defined criteria (the P_d, P_f, and K_i coefficients), an identification of the CAE in the AS can be made.

3. Conclusion

Preparations have been made from which the main scientific and technical problem in the academic recognition systems can be derived - the problem of the adequacy of the identification of the controlled events.

The research has found that in the scientific and technical literature this problem is not explicitly formulated as a problem of identification but has been essentially solved by different authors over the years in various ways and by different means.

Indicators are introduced to identify the CAE, which quantify the correct response of an alarm system. Thanks to the proposed criteria system, the existing recognition system (alarms) can be analyzed and their quality and reliability assessed, with two distinct features: detection and false alarms.

In the synthesis and design of new detection systems, detectors, or design of devices in specific applications, it is possible to search for and evaluate design solutions for which the most favorable set of criteria values is created $K_i = 1$, $P_d = 1$ and $P_f = 0$.

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ПОКАЗАТЕЛИ ЗА ОТЧИТАНЕ НА АДЕКВАТНОСТТА НА ИДЕНТИФИКАЦИЯТА В ДИВЕРСИТЕНИ СИСТЕМИ

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Ключови думи: *диверситет, излишък, детектори, разпознаване на образи, детекция, фалшива аларма, идентификация*

Резюме: *В статията се дават количествени показатели за оценка на идентификацията при разпознаващите системи в диверситетна (двуканална) обработка на информацията. За целта е използвана критериална система, основана на теория на множествата. Това дава възможност да се извърши оценка и послеващ синтез на съществуващи диверситетни разпознаващи (в т.ч.алармени) системи и да се оценяват тяхното качество и надежжност, при това диференцирано по двете характеристики: вероятност за разпознаване, вероянтост за грешно разпознаване и цялостна оценка на идентификацията.*