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S.S. Antsyferov, K.E. Rusanov
Moscow State Technical University Mirea, Russia
Russia, 119454, c. Moscow, Vernadsky ave., 78

Estimation of Processing Speed of Intellectual Systems in the Conditions of Multivariance and Uncertainty

С.С. Анцыферов, К.Е. Русанов
Московский государственный технический университет МИРЭА, Россия
Россия, 119454, г. Москва, пр. Вернадского, 78

Оценка быстродействия интеллектуальных систем в условиях многовариантности и неопределенности

С.С. Анциферов, К.Є. Русанов
Московський державний технічний університет МІРЕА, Росія
Росія, 119454, м. Москва, пр. Вернадського, 78

Оцінка швидкодії інтелектуальних систем в умовах багатоваріантності і невизначеності

The analytical relations allowing to obtain the approximate estimates of the time of decision in the successive processing algorithms of fuzzy information for different values of the probability of making right or wrong decisions are established.
Key words: probability, decision making, processing algorithm, fuzzy information, uncertainty, multivariance, intellectual system.

Установлены аналитические соотношения, позволяющие получать приближенные оценки времени принятия решения в последовательных алгоритмах обработки нечеткой информации для различных значений вероятностей принятия правильного или ошибочного решений.
Ключевые слова: вероятность, принятие решения, алгоритм обработки, нечеткая информация, неопределенность, многовариантность, интеллектуальная система.

Встановлено аналітичні співвідношення, що дозволяють отримувати наближені оцінки часу прийняття рішення в послідовних алгоритмах обробки нечіткої інформації для різних значень ймовірностей прийняття правильного чи помилкового рішень.
Ключові слова: ймовірність, прийняття рішення, алгоритм обробки, нечітка інформація, невизначеність, багатоваріантність, інтелектуальна система.

Introduction

As a rule, the operation of intellectual systems (IS) occurs under conditions of ambiguity and uncertainty. In these circumstances, special importance is the problem of providing high quality decisions. For example, in the adaptive information-recognition systems – AIRS [1-6] – there is a processing sequence of two-dimensional implementations of space-time fields to assess the state of the objects, in particular, the diagnosis of complex diseases. The decisions about the state of the object are often contradictory, and they can be both correct and incorrect. In such situations, effective as close to optimal, are so-called moving decision-making algorithms. According to these algorithms for each of the variants of decisions occurs parallel accumulation of information in cycles sequential processing implementations by counting the number of identical solutions (number of units for each alternative solutions for each parallel channel – b_k, where k – number of channels), up to a total cycles equal to n. A processing ends in case of exceeding the number of units of a predetermined threshold. If the excess is not the case, the information of the first cycles is reset performed adaptive correction parameters processing algorithms and processing information comes last cycle. Thus, in the memory of the algorithm, all the information being held last n cycles. Decision time for such algorithms to determine exactly quite difficult, so assessment can wear only approximate.

The purpose of work – to establish the analytical relations, allowing to receive approximate estimates of the time of decision in successive processing algorithms fuzzy information.

Estimation of the Time of Decision

The time of the decision relies function of the number of units received by the k-th channel in the last n cycles (for simplicity of exposition index k omitted):

$$T(b) = p_0 P_1 T(b-1) + p_1 P_0 T(b+1) + p_0 P_0 T(b) + p_1 P_1 T(b), \qquad (1)$$

where p_0 – the probability of getting of zero;

p_1 – the probability of getting of unit;

P_0 – the probability of zero in the first cycle;

P_1 – the probability of unit in the first cycle;

$p_0 + p_1 = 1; \quad P_0 + P_1 = 1;$

$p_0 P_1 T(b-1)$ – the average time when dropping the first cycle unit lost, and in the last cycle passed zero, i.e. the average time when the number of units of one less than the original;

$p_1 P_0 T(b+1)$ – the average time, when in the first discarded cycle was zero and the latter accepted the new unit;

$p_0 P_0 T(b)$ – the average time corresponding to the loss of the first zero and the emergence of zero in the last cycle;

$p_1 P_1 T(b)$ – the average time corresponding to the loss of the first unit and the acquisition unit at the end.

At presence b units in the n positions:

$$P_0 = \frac{C_{n-1}^b}{C_n^b} = 1 - \frac{b}{n}; \quad P_1 = \frac{b}{n}. \qquad (2)$$

After entering the variable

$$A(b) = T(b) - T(b-1) \qquad (3)$$

the relation (1) takes the following form

$$A(b) p_0 \frac{b}{n} - A(b+1) p_1 \left(1 - \frac{b}{n}\right) = 1. \qquad (4)$$

The solution of this equation

$$A(b) = -\frac{1}{p_1}\frac{\sum_{l=0}^{b-1} C_n^l \left(\frac{p_0}{p_1}\right)^{b-1-1}}{\mathrm{C_n^{b\text{-}1}}\left(1-\frac{b-1}{n}\right)}. \tag{5}$$

If $p_0 / p_1 << 1$, then

$$A(b) \approx -\frac{1}{p_1}\frac{1}{\left(1-\frac{b-1}{n}\right)}, \tag{6}$$

If $p_0 / p_1 >> 1$, then

$$A(b) \approx -\frac{1}{p_1}\frac{\left(\frac{p_0}{p_1}\right)^{b-1}}{C_n^{b-1}\left(1-\frac{b-1}{n}\right)} = -\frac{n}{p_1 b_1}\frac{\left(\frac{p_0}{p_1}\right)^{b-1}}{C_n^{b-1}}. \tag{7}$$

From (3), (6) and (7)

$$T(b) \approx \left\{\frac{n}{p_1}\sum_{l=n-m+1}^{n-b}\frac{1}{l}\right\}\tau, \tag{8}$$

where m – the threshold for the number of recruited units;

τ – the time interval between a sequence of observations.

The averaging (8) by the number of units b, which may arrive up to n cycles of accumulation of information, i.e. in all $0 \le b \le m-1$, and considering we obtain an expression for the average time decision

$$\begin{aligned} T \approx & \sum_{k=0}^{n-m}(m+k)P_\text{П}^m(1-P_\text{П})^k C_{m+n}^k + \\ & + \sum_{b=0}^{m-1}\left(n + \sum_{l=n-m+1}^{n-b}\frac{n}{lP_\text{П}}\right) C_n^b P_\text{П}^b [1-P_\text{П}]^{n-b}, \end{aligned} \tag{9}$$

$P_\text{П}$ – the probability of a correct decision.

If we set $m \approx nP_\text{П}$, we obtain

$$T \approx n + \frac{1}{\sqrt{2\pi}}\sqrt{nP_\text{П}(1-P_\text{П})} + \frac{n}{2P_\text{П}[n - nP_\text{П} + 1]}. \tag{10}$$

It is important to determine n the link between T and the frequency of decision of false solutions $f_\text{Л} = P_\text{Л} / n$, $P_\text{Л}$ – the probability of making a false decision. Accumulated statistics has the following form

$$L = b\ln\frac{P_\text{П}}{P_\text{Л}} + (n-b)\ln\frac{1-P_\text{П}}{1-P_\text{Л}}. \tag{11}$$

A comparison of these statistics with the threshold R equivalent in the model number of units b compared with a threshold m

$$m = \frac{R - n\ln\left[\left(1-P_{п}\right)/\left(1-P_{л}\right)\right]}{\ln\left(P_{п}/P_{л}\right) - \ln\left[\left(1-P_{п}\right)/\left(1-P_{л}\right)\right]}. \tag{12}$$

In this case

$$f_{Л} \approx \frac{\left(1-P_{Л}\right)d}{d-P_{Л}} \cdot \frac{1}{\sqrt{2\pi n d\left(1-d\right)}} e^{-nG\left(P_{Л},P_{П}\right)}, \tag{13}$$

where $d = \frac{m}{n}$, $G\left(P_{Л},P_{П}\right) = -P_{П}\ln\frac{P_{Л}}{P_{П}} - \left(1-P_{П}\right)\ln\frac{1-P_{Л}}{1-P_{П}}$.

The real interest are small values $f_{Л}$, so next value $\ln f_{Л}$ is introduced, and the expression n takes the following form

$$n \approx -\ln f_{Л} G\left(P_{Л},P_{П}\right)\left[1+\frac{1}{\sqrt{2\pi}}\sqrt{P_{П}\left(1-P_{П}\right)} \times \frac{1}{-\ln f_{Л}/\sqrt{G\left(P_{Л},P_{П}\right)}}\right]. \tag{14}$$

For example, for $P_{Л} = 0{,}001$ and $P_{П} = 0{,}95$, $n = 50$, and for $P_{Л} = 0{,}0001$, $P_{П} = 0{,}99$, $n = 100$.

The time before a false decision

$$T_{Л} \approx \frac{\left(p_0/p_1\right)^{m-1}}{p_1 C_{n-1}^{m-1}}. \tag{15}$$

At $m = nP_{П}$, $p_0 = 1 - P_{Л}$, $p_1 = P_{Л}$, $n >> 1$, $P_{Л} << 1$.

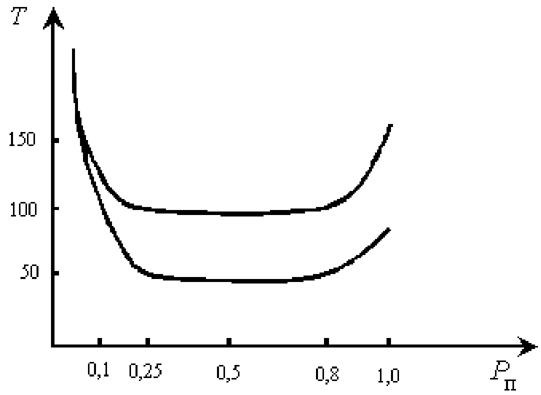

Figure 1 – The average time of the decision: n = 50; 100

Abstracts

∗ The analytical relations allowing to obtain the approximate estimates of the time of decision in the successive processing algorithms of fuzzy information for different values of the probability of making right or wrong decisions are established.

∗ The obtained relationships allow us to optimize the structure of fuzzy information processing algorithms.

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RESUME

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