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# Cascade Structural Encoding of Binary Arrays

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## Abstract

*The lacks of existent approaches come to light in relation to the compression of binary data for their use in digital diagnostics. It is grounded, that due to presentation of binary array as integral structure as a cascade structural number, satisfying limits on the number of carouses of units and on the dynamic range of cod-numbers of OFSN additional reduction of structural surplus is provided. The basic stages of binary of a two stage cascade structural encoding are expounded. Proved, that amount of digits on presentation of binary column examined as an element of cascade structural number less than, than amount of digits on presentation of that column, but examined as an one-dimensional floating structural number.*

## 1. Introduction

The features of treatment of diagnostic information consist of that: on treatment test sets, having an arbitrary structure and different statistical descriptions, are given; test information appears in a binary kind; the lead through of diagnostics of digital charts is carried out on the basis of the kept test sets. Digital diagnostics means related to the increase of volumes of test information. From here is ***the scientifically-applied task,*** consisting of diminishing of volumes of test information.

## 2. Formulation of problem

One of directions of decision of such task consists in compact presentation of tests.

For the increase of efficiency of processes of diagnostic it is required to provide the additional increase of degree of compression of data in the conditions of arbitrary binary structure. One of effective codes is one-dimensional structural encoding [1- 7]. However for such encoding there is failing, related to that amount $M$ digits on presentation of code-number $C_\nu$ in determined on a formula

$$M = [\ell og_2 V_{\nu,\eta}] + 1 . \qquad (1)$$

From other side for the value of code-number inequality can be executed

$$C_\nu <<< V_{\nu,\eta} . \qquad (2)$$

Then

$$\ell og_2 C_\nu <<< \ [\ell og_2 V_{\nu,\eta}] + 1 . \qquad (3)$$

Plenty of unmeaning digits, equal, appears in this case $[\ell og_2 V_{\nu,\eta}] + 1 - \ell og_2 C_\nu$ to the bats. It results in the decline of aspect of binary matrices ratio.

Consequently, the purpose of researches is creation of method of compression, taking into account the two cascade structure of binary arrays.

## 3. Basic material of researches

For the removal of failing, related to the choice of large length of codegram for presentation of code-number of one-dimensional structural number it is suggested to examine the aggregate of separate binary columns (OFS of numbers) taking into account additional limitations $\lambda_\nu$ on their dynamic ranges

$$C_\nu <<< \lambda_\nu . \qquad (4)$$

In this case binary arrays $G$ examined as integral structural objects.

***Determination 1.*** By a cascade structural number $G^{(2)}$ binary arrays are named $G = \{G^{(\ell)}\}_{\ell=\overline{1,n}}$ (sequence of columns, made from binary elements $g_{k\ell} \in [0;1]$), the columns of which are one-dimensional floating structural numbers which the number of carouses of units is certain for

$$G^{(\ell)} = \{g_{k\ell}\}_{k=\overline{1,n}} \to \eta_\ell \qquad (5)$$

and values $C_\ell$ code-numbers limited from above sizes $F(\eta,\lambda)_\ell$:

$$C_\ell < F(\eta,\lambda)_\ell = \min(V_{\ell,\nu,\eta} ; \lambda_\ell) , \ \ell = \overline{1,n} . \qquad (6)$$

***Determination 2.*** By a great number $\Omega^{(2)}_{n,\eta,\lambda}$ possible cascade structural numbers (CSN) a great number, consisting of binary arrays which terms are executed for, is named:

1) number of carouses of units for $\ell$ column of array equal $\eta_\ell$, $\ell=\overline{1,n}$;

2) size of code-number $C_\ell$, formed for $\ell$ OFSN, restrictedly from above a size $\min(V_{\ell,\nu,\eta};\lambda_\ell)$, $\ell=\overline{1,n}$.

Amount $V^{(2)}_{n,\eta,\lambda}$ cascade structural numbers, satisfying limitations (5) and (6) equal

$$V^{(2)}_{n,\eta,\lambda}=\prod_{\ell=1}^{n}F(\eta,\lambda)_\ell\,, \qquad (7)$$

$$F(\eta,\lambda)_\ell=\min(V_{\ell,\nu,\eta};\lambda_\ell)\,,\ \ell=\overline{1,n} \qquad (8)$$

$$V_{\ell,\nu,\eta}=\frac{(\nu+1)!}{(2\eta_\ell)!\ (\nu+1-2\eta_\ell)!}\,, \qquad (9)$$

where $\eta_\ell$ - value of number of carouses of units for $\ell$ OFSN of binary array;

$\nu$ - length of OFSN, in special case equal $\nu=n$.

Investigation flows out from here.

***Investigation 1.*** For any set sizes $\eta_\ell$, $\ell=\overline{1,n}$ inequality between the maximal total amount of digits is executed $\sum_{\ell=1}^{n}\ell og_2 V_{\nu,\eta_\ell}$ on presentation of sequence of OFSN examined as separate numbers and by the maximal amount of digits $\ell og_2 V^{(2)}_{n,\eta,\lambda}$, expended on presentation of that sequence of OPSCH, but examined as a cascade structural number

$$\ell og_2 V^{(2)}_{n,\eta,\lambda}\le\sum_{\ell=1}^{n}\ell og_2 V_{\nu,\eta_\ell}\,. \qquad (10)$$

Means as a result of forming of cascade number from separate OFSN reduction of amount of digits is provided on their presentation in relation to an initial variant. This condition is executed by virtue of account of situations when

$$C_\nu <<< V_{\nu,\eta}\,.$$

For forming of code-number a cascade structural number must develop the proper process of numeration of possible binary combinations, belongings a great number $\Omega^{(2)}_{n,\eta,\lambda}$.

***Determination 3***. Cascade structural numeration of information is name the process of calculation of sequence number, which occupies a cascade structural number in a possible great number $\Omega^{(2)}_{n,\eta,\lambda}$. For a binary array $G=\{g_{k\ell}\}$, $k=\overline{1,n}$, $\ell=\overline{1,n}$, $g_{k\ell}\in\{0;1\}$, the elements, it is possible to form a code-number $C^{(2)}$, calculated on the basis of expressions:

$$C^{(2)}=\sum_{\ell=1}^{n}\Big(\sum_{k=1}^{n}g_{k\ell}\,p_{k\ell}\Big)\prod_{\phi=\ell+1}^{n}F(\eta,\lambda)_\ell\,; \qquad (11)$$

$$g_{0\ell}=0\,,\ \beta_{0\ell}=2\eta_\ell\,,\ \beta_{k\ell}=\beta_{k-1,\ell}-\left|g_{k-1,\ell}-g_{k\ell}\right|, \qquad (12)$$

where $p_{k\ell}$ - value of gravimetric coefficient of element $g_{k\ell}$ one-dimensional floating structural number;

$n$ - an amount of binary elements is in OPSCH;

$\beta_{k\ell}$ - recurrent parameter, equal to the amount of binary overfalls (transitions between «0» and «1») for a sequence, consisting of $(n-k+1)$ untilled elements.

For forming of cascade code constructions $C^{(2)}_\psi$ it is required to build arrays, consisting of values of code-numbers $C_\nu$ separate OFSN and to conduct the selection of dynamic ranges on the lines of array $C$.

The construction of the second cascade of code constructions is carried out in other words.

***Determination 4.*** The cascade code constructions of OFSN are name a code constructions which are formed as a result of construction of code-numbers for the aggregate of one-dimensional floating structural numbers.

Array $C$ has a next kind:

$$C=\begin{vmatrix}C_{11} & \ldots & C_{1\psi} & \ldots & C_{1\Psi}\\ C_{\ell 1} & \ldots & C_{\ell\psi} & \ldots & C_{\ell\Psi}\\ C_{n1} & \ldots & C_{n\psi} & \ldots & C_{n\Psi}\end{vmatrix}, \qquad (13)$$

where $C_{\ell\psi}$ - code-number of one-dimensional floating structural number, formed on a base $\ell$ column $\psi$ of binary array;

$\Psi$ - amount of binary arrays for which formed cascade code constructions.

The process of the cascade structural encoding plugs in itself the followings stages:

1. One-dimensional structural floating numbers are built taking into. In this case $\nu=n$. It is suggested to utilize $n=8$.

2. The redistribution of official information is conducted depending on values $V_{\nu,\eta}$ volumes of possible great numbers of OPS of numbers.

3. For arrays the exposure of limits is carried out on dynamic ranges $\lambda_\ell$, which are utilized for the calculation of gravimetric coefficients $F(\eta,\lambda)_\ell$:

$$\lambda_\ell = \max_{1 \le \psi \le \Psi} \{C_{\ell\psi}\} + 1, \quad (14)$$

where $\lambda_\ell$ - limit on the range of sizes $C_{\ell\psi}$ in $\ell$-é to the line.

4. Forming of code-numbers is conducted $C_\psi^{(2)}$ second cascade level, formed for $\psi$ column of array $C$ on the basis of parameters, $\psi = \overline{1, \Psi}$ :

$$C_\psi^{(2)} = \sum_{\ell=1}^{n} \left(\sum_{k=1}^{n} g_{k\ell}^{(\psi)} p_{k\ell}^{(\psi)}\right) \prod_{\phi=\ell+1}^{n} F(\eta,\lambda)_\phi ; \quad (15)$$

$$g_{0\ell} = 0, \ \beta_{0\ell} = 2\eta_\ell, \ \beta_{k\ell} = \beta_{k-1,\ell} - \left| g_{k-1,\ell} - g_{k\ell} \right|, \quad (16)$$

where $g_{k\ell}^{(\psi)}$ - $(k;\ell)$-é element $\psi$ of cascade structural number $p_{k\ell}^{(\psi)}$ - gravimetric coefficient of element $g_{k\ell}^{(\psi)}$.

Next investigation follows from the features of forming of cascade code structures.

***Investigation 2.*** Value of code-number $C_\psi^{(2)}$ cascade structural number there will be a less size $V_{n,\eta,\lambda}^{(2)}$,

equal to the total amount of CSN:

$$C_\psi^{(2)} < V_{n,\eta,\lambda}^{(2)} = \prod_{\ell=1}^{n} F(\eta,\lambda)_\ell . \quad (17)$$

On the basis of the well-proven investigation 2 flows out, that for preset a parameter , $\lambda_\ell$ and $\{\eta_1,...,\eta_\ell,...,\eta_n\}$ by the high bound of amount of digits, taken on presentation of cod-number $C_\psi^{(2)}$ cascade structural number, there is a size $(\ell og_2 V_{n,\eta,\lambda}^{(2)} + 1)$:

$$\ell og_2 C_\psi^{(2)} < 1 + \ell og_2 V_{n,\eta,\lambda}^{(2)} . \quad (18)$$

***Investigation 3.*** For the set values of sizes: lengths of OFSN $n$, vector of limitations $F = \{F(\eta,\lambda)_\ell\}_{\ell=\underline{1,n}}$ and vector $\{\eta_1,...,\eta_\ell,...,\eta_n\}$ limits on the number of carouses of units inequality is executed in the binary columns of cascade structural number

$$\ell og_2 \underline{C}_\psi^{(2)} \le \sum_{\ell=1}^{n} \ell og_2 C_{\ell\psi} / n , \quad (19)$$

where $\ell og_2 \overline{C}_\psi^{(2)}$ - middle on an amount $n$ binary columns, entering in CSN, value of amount of digits, expended on presentation of size $C_\psi^{(2)}$:

$$\ell og_2 \overline{C}_\psi^{(2)} = \frac{\ell og_2 C_\psi^{(2)}}{n} ; \quad (20)$$

$\ell og_2 \sum_{\ell=1}^{n} C_{\ell\psi} / n$ - middle amount of digits, expended on presentation of one column, examined as a separate one-dimensional floating structural number.

## 4. Conclusions

1. It is grounded, that due to presentation of binary array as integral structure as a cascade structural number, satisfying limits on the number of carouses of units and on the dynamic range of code-numbers of OFSN additional reduction of structural surplus is provided.

2. A theorem is well-proven about forming of code-number for a cascade structural number. On the basis of the well-proven theorem a high bound is exposed for amount of digits, taken on presentation of code-number of CSN.

3. It is well-proven that amount of digits on presentation of binary column examined as an element of cascade structural number less than, than amount of digits on presentation of that column, but examined as an one-dimensional floating structural number.

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