

The Video Stream Encoding Method in Infocommunication Systems

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Abstract—This paper substantiates the shortcomings of the methods of intraframe syntactic coding of predicted frames for information technologies of video stream processing and transmission. Basic approaches for improving technologies for syntactical coding of transformants with the formation of the space of identifiers of discrete positions of a two-dimensional structural-spectral description are substantiated. An effective syntactic representation of the transformed P-type frame segments is developed on the basis of one-dimensional two-base object-position coding under conditions of flexible pair-element inequality. The construction of the reconstruction method for the context-dependent nonuniform length of the ID vector of the compressed TSS space is described.

Keywords—video information resource; information intensity; two-component vector; video service; frame

I. INTRODUCTION

A key element of economic growth, social well-being of people and the National Security State is the systematic development of information processes. The information resource concept is a source for making sound key decisions and an object of the information security system [1].

In the process of providing information services in the interests of profile organizations, including in the process of functioning in crisis situations, it becomes necessary to use remote infocommunication technologies based on unmanned aerial complexes (UAC). At the same time over the past decade, the demand for video services has grown significantly.

The increased role of the UAC for the provision of video services is confirmed by the fact that the share of their use has increased by 50% over the past few years. Here the main advantages over other airmobile platforms are: the absence of an "expensive" crew; low cost and low operating costs; increased reliability, reduced weight and cost of the device due to the removal of many design limitations [2].

At the same time the transmission time of a frame with a high spatial resolution (which corresponds to the formats FullHD and 4K) reaches hundreds of seconds. Time delays drastically increase in the case of a dynamic video resource transmitting (as a stream) in real time [3].

The information intensity significantly affects the quality of providing video information services using platforms based on the UAC. The main reason here is the imbalance between: on the one hand, user requirements regarding the quality of the provided dynamic video resource, and on the other hand, the inadequate capabilities of airmobile platforms regarding the performance of information processing and transmission equipment [4].

The video stream information intensity growth trend leads to the fact that it outstrips the capabilities of networks built using airmobile platforms [5].

Therefore, improving the quality of providing video information services using on-board information and communication technologies is an urgent scientific task.

The main direction of scientific problem solving stated in the conditions required to ensure the integrity of the information is to reduce the imbalance between the video stream intensity growth and performance-board information and communication technologies. For this, it is proposed to use the stream processing and transmission information technologies (SPTIT) [6].

Standardized SPTITs use the concept of frame classification in local groups, depending on the provision of the weight component in the total balance between the encoded video stream intensity and the information integrity.

Estimation of the degree of reduction in the information intensity of the video stream per frame, depending on its type, showed that: the greatest compromise off between the integrity level (the PSNR value) and the information intensity level is achieved for P-type frames. In turn, the estimation of the

dependence of the information intensity of the coded video stream on the value of the peak signal-to-noise ratio for various types of codecs revealed that the existing information technologies for processing and transmitting the video stream do not provide a compromise between the growth of the information intensity of the dynamic video resource and the limited capacity of infocommunication technologies based on onboard unmanned complexes. With this in mind, the aim of the paper's research is to develop a technology for balancing video stream processing to reduce information intensity in infocommunication systems [7].

II. TECHNOLOGY DEVELOPMENT TO REDUCE INFORMATION INTENSITY IN INFOCOMMUNICATION SYSTEMS

Improvement of the stream processing and transmission information technologies is proposed to be implemented in the direction of the sequence of P-type frames encoding efficiency increasing. One of the promising methods are based on the formation of two-component vectors $\{\ell(\tau; \delta)_u; z(\tau; \delta)_u\}$. Here $\ell(\tau; \delta)_u$ - the length of a sequence of non-significant components preceding a significant component $z(\tau; \delta)_u$ for τ -th transform in the case of its quantization with the parameter δ .

Further processing technology consists in using the strategy of allocating the number of bits to components $\ell(\tau; \delta)_u$ and $z(\tau; \delta)_u$. Their comparative evaluation showed that the level of values η the decrease in information intensity of the transformed segments does not exceed 1.7 times on average. To eliminate systemic defects, it is required to develop approaches that are not related to the use of statistical models of informative transformants [8].

In this connection, consider the syntactic description of the transformant, given by a two-dimensional array $Y_2^{(1)}$:

$$Y^{(1)} \rightarrow Y_2^{(1)} = \{\ell(\tau; \delta)_u; z(\tau; \delta)_u\}, u = \overline{2, U-1}.$$

This array is considered as a two-dimensional structured-combinatorial object, the strings of which are permutations with repetitions on $U-2$ elements with two specifications, defined as constraints on the dynamic range, respectively $d(\ell; \delta)_\tau$, $d(z; \delta)_\tau$.

Informative $V(Y_2^{(1)})$ syntactic representation of the transformants is estimated by the formula

$$V(Y_2^{(1)}) = \log_2 Q(Y_2^{(1)}) = (U-2) \log_2 (d(\ell; \delta)_\tau \cdot d(z; \delta)_\tau).$$

Here $Q(Y_2^{(1)})$ - the number of valid arrays $Y_2^{(1)}$ for the components of which the following constraints are satisfied:

$$\ell(\tau; \delta)_u \leq \begin{cases} d(\ell; \delta)_\tau = 1, & \rightarrow u = 1; \\ d(\ell; \delta)_\tau < \ell(\tau; \delta)_{\max}, & \rightarrow 2 \leq u \leq U; \\ d(\ell; \delta)_\tau = \ell(\tau; \delta)_{\max}, & \rightarrow u = U. \end{cases}$$

$$1 \leq z(\tau; \delta)_u \leq d(z; \delta)_\tau < z(\tau; \delta)_{\max}, u = \overline{2, U-1}.$$

Here the quantity $d(z; \delta)_\tau$ is defined as $d(z; \delta)_\tau = \max_{2 \leq u \leq U-1} \{z(\tau; \delta)_u\}$.

Appropriate amount $R(Y_2^{(1)})$ the potentially eliminated redundancy in the percentage is determined using the following expression:

$$\overline{R}(Y_2^{(1)}) = (1 - V(Y_2^{(1)}) / V(Y_2^{(1)})_{\text{beg}}) \cdot 100\%.$$

To further reduce the information intensity, it is suggested to take into account the new structural patterns that are created in the process of processing the transformed segments of P-type frames. Within this framework, it is proposed to transform the structural space transformants $\{L; Z\}$.

The essence of the vectors $\{\ell(\tau; \delta)_u; z(\tau; \delta)_u\}$ retransformation is to ensure the tendency of a proportional change in the values of its components $\ell(\tau; \delta)_u$ and $z(\tau; \delta)_u$. For this purpose, it is proposed to place the significant components of the linearized transformant in the reverse order [9]. In this case, the rearrangement of the DC is described by the following expression:

$$\tilde{p}_u : \{\ell(\tau; \delta)_u; z(\tau; \delta)_{U-u+1}\}, \quad (1)$$

Where \tilde{p}_u - u -th reconstructed discrete position of a two-dimensional structural space (TSS) $\{L; Z\}$ transformants.

As a result, a transformed vector $\tilde{P}(U-2)$ discrete positions of the DSP space, which in the coordinate form will adopt the following form:

$$\tilde{P}(U-2) = \{\tilde{p}_2; \dots; \tilde{p}_u; \dots; \tilde{p}_{U-1}\}.$$

Taking into account what is proposed to form the syntactic representation of transformants Y in two-dimensional structure space $\{L; Z\}$ on an object principle. Here, a single code value is constructed for the coordinates $\{\ell(\tau; \delta)_u; z(\tau; \delta)_{U-u+1}\}$ with discrete position \tilde{p}_u TSS space, both for individual objects [10]. Such code values are proposed to be called identifiers $I(\tau; \delta)_u$, which is given by the formula:

$$\tilde{p}_u : \{\ell(\tau; \delta)_u; z(\tau; \delta)_{U-u+1}\} \rightarrow I(\tau; \delta)_u.$$

It is necessary to consider the following aspects:

1. The number of discrete samples of TSS space is uneven context-dependent, i.e. $U = \text{var}$.

2. The two-dimensional space $\{L; Z\}$ is densified by significant components of the spectrum, which is given by inequality $U < n^2$.

3. Maximum values of elements of vectors L and Z are bounded respectively by the quantities $d(\ell; \delta)_\tau$ and $d(z; \delta)_\tau$ i.e.

$$\ell(\tau; \delta)_u \in [0; d(\ell; \delta)_\tau] \text{ and } z(\tau; \delta)_u \in [0; d(z; \delta)_\tau].$$

4. Items excluded from processing p_u TSS space with coordinates $u=1$ and $u=U$.

5. The two-dimensional structural spectral space of a transformant is transformed in accordance with the unidirectionality of the gradient of the values of the elements of two-component vectors, which is given by formula (1).

To ensure the integrity of information, it is required to provide a one-to-one functional transformation $F(I)$ to convert the TSS space transformants into the space of identifiers and vice versa. In this case, taking into account the retransformation of coordinate objects \tilde{p}_u TSS space is proposed to generate identifiers $I(\tau; \delta)_u$ their positions \tilde{p}_u , as code values of biadic numbers under conditions of gradient unidirectionality. Then the functional transformation $F(I)$ for identification will be given by the relation

$$I(\tau; \delta)_u = (\ell(\tau; \delta)_u (d(z; \delta)_\tau - 1) + z(\tau; \delta)_{U-u+1}).$$

The justification of the conditions for a one-to-one identity is based on the following statement.

Statement on the interdependence of the identification of a compressed TSS space over coordinate objects. For the selected coordinate object \tilde{p}_u identification rule, under the conditions (3) of the given restrictions on the values of its components $\ell(\tau; \delta)_u$ and $z(\tau; \delta)_{U-u+1}$, construct only one identifier. Conversely, for the given constraints in magnitude $I(\tau; \delta)_u$ identify only one discrete position \tilde{p}_u TSS space.

Taking this into account, in order to construct the inverse functional $F(I)^{(-1)}$ need and sufficient to use information about the dynamic number of values $d(\ell; \delta)_\tau$ and $d(z; \delta)_\tau - 1$, which respectively take the elements of vectors L and Z transformants. Then, based on the principle of bi-decoding in the conditions of gradient one-directionality, the reconstruction of the coordinate components $\ell(\tau; \delta)_u$ and $z(\tau; \delta)_{U-u+1}$ by the corresponding value of the identifier, is given by the relations:

$$\begin{aligned} \ell(\tau; \delta)_u &= [I(\tau; \delta)_u / (d(z; \delta)_\tau - 1)] - \\ &- [I(\tau; \delta)_u / ((d(z; \delta)_\tau - 1) \cdot d(\ell; \delta)_\tau)] d(\ell; \delta)_\tau; \\ z(\tau; \delta)_{U-u+1} &= I(\tau; \delta)_u - [I(\tau; \delta)_u / (d(z; \delta)_\tau - 1)] (d(z; \delta)_\tau - 1). \end{aligned}$$

Creating an effective syntactic representation of the sequence $I(\tau; \delta)$ identifiers of coordinate objects of the TSS space must be carried out taking into account the presence of two regularities.

The first structural regularity consists in the presence of restrictions on the allowable number $Q(\tilde{p}_u; \delta)$ values that the identifier takes for the coordinate object, which is given by inequality

$$I(\tau; \delta)_u \leq Q(\tilde{p}_u; \delta) - 1 = d(\ell; \delta)_\tau \cdot (d(z; \delta)_\tau - 1), \quad u = \overline{2, U-1}.$$

The second structural regularity is that the values of the coordinate components of the DSP space have a gradient unidirectionality. This property of coordinate objects \tilde{p}_u creates conditions for the existence of a tendency of flexible inequality of pair identifiers. By paired identifiers we mean identifiers at neighboring positions in the vector $I(\tau; \delta)$, eg $u -$

th the pair will be written as follows $\{I(\tau; \delta)_u; I(\tau; \delta)_{u+1}\}$, $u = \overline{2, U-2}$.

The concept of the flexibility of the inequality is introduced in connection with the fact that there are cases when the values of the pair identifiers will be the same. i.e.

$$I(\tau; \delta)_\gamma = I(\tau; \delta)_\xi, \quad \text{where } \gamma \neq \xi, \quad \gamma = \overline{2, U-1}, \quad \xi = \overline{2, U-1}.$$

To mark a such pairs serves administered syndrome vector $S(\tau; \delta)$, elements $s(\tau; \delta)_u$ of which are the following Formulas system:

$$s(\tau; \delta)_u = \begin{cases} 0 & \rightarrow I(\tau; \delta)_u \neq I(\tau; \delta)_{u+1}; \\ 1 & \rightarrow I(\tau; \delta)_u = I(\tau; \delta)_{u+1}. \end{cases}$$

In this case the vector $I(\tau; \delta)$ IDs described by two components, namely the vector $\hat{I}(\tau; \delta)$ IDs under restrictions on inequality pair of elements and the corresponding syndrome $S(\tau; \delta)$. This makes it possible to give the following interpretation of the sequence $\hat{I}(\tau; \delta)$.

Definition. Vector $\hat{I}(\tau; \delta)$ identifiers under restrictions on inequality paired elements is called the one-dimensional positional object number with a base $Q(\tilde{p}_u; \delta)$, for which the condition of the flexible elements of (syndrome paired inequalities $S(\tau; \delta)$).

Therefore, effective syntactic coding of the vector of the TSS ID space should be carried out taking into account additional use of the syndrome $S(\tau; \delta)$ object position number in terms of having a flexible inequality its paired elements.

To this must be integrated into the encoding system vector $\hat{I}(\tau; \delta)$ identifiers syndrome $S(\tau; \delta)$ object position number.

In this case the sequence $\hat{I}(\tau; \delta)$ identity can be treated as one-dimensional dibasic $\{Q(\tilde{p}_u; \delta); \hat{Q}(\tilde{p}_u; \delta)\}$ object-point number based on the availability of flexibility inequality conditions adjacent elements, i.e. considering syndrome $S(\tau; \delta)$.

Then the system of relations for a one-dimensional object dibasic positional encoding, in a pair of flexible elements of inequality takes the following form:

$$\begin{aligned} \hat{E}(s; \tau; \delta) &= \sum_{u=2}^{U-1} \theta'(\tau; \delta)_u Q'(s; \tau; \delta)_{U-u-1} = \\ &= \sum_{u=2}^{U-1} \theta'(\tau; \delta)_u Q(\tilde{p}_u; \delta)^{v_u} \cdot \hat{Q}(\tilde{p}_u; \delta)^{\hat{v}_u}. \end{aligned}$$

Here $\hat{E}(s; \tau; \delta)$ - dimensional code value dibasic object position number in a flexible inequality paired elements, i.e. considering syndrome $S(\tau; \delta)$; v_u and \hat{v}_u - the number of identifiers, the remaining not treated in u -th encoding step,

and, respectively, for which the condition of equality, and vice versa;

$Q'(s; \tau; \delta)_{U-u-1}$ - weighting of the auxiliary element $\theta'(\tau; \delta)_u$ with the additional information, taking into account the magnitude $s(\tau; \delta)_u$.

Vector reconstruction method identifier is organized by the following process steps.

The first process step determine the number v_2 and \hat{v}_2 identifiers in the initial processing step, $u=2$ for which, respectively, the condition of equality, ie $s(\tau; \delta)_u = 1$ and vice versa, i.e., $s(\tau; \delta)_u = 0$. For this purpose, information on the relevant aspects of the syndrome, i.e.:

$$s(\tau; \delta)_u = \begin{cases} 0, & \rightarrow I(\tau; \delta)_u \neq I(\tau; \delta)_{u+1}, \\ \theta'(\tau; \delta)_u = \theta(\tau; \delta)_u ; \\ 1, & \rightarrow I(\tau; \delta)_u = I(\tau; \delta)_{u+1}, \\ \theta'(\tau; \delta)_u = I(\tau; \delta)_u. \end{cases}$$

In the second process step is carried out to establish base types.

The third process step is the direct recovery of elements $I(\tau; \delta)_u$ and $\theta(\tau; \delta)_u$ dibasic object-point number.

At the beginning of using the formula $\hat{I}(\tau; \delta)_0 = Q(\tilde{p}_u; \delta) = d(\ell; \delta)_\tau \cdot (d(z; \delta)_\tau - 1)$ is formed by information element $\hat{I}(\tau; \delta)_0$, which is conventionally preceded by the identifier $\hat{I}(\tau; \delta)_2$.

Then, based on the amount of available information $\hat{E}(s; \tau; \delta)$ reconstruction process implemented by the weighted decoding dibasic object positional space under conditions of use syndrome $S(\tau; \delta)$ to identify the presence of disparities between the paired elements.

For the method developed for efficiently encoding predicted frame segment gain is achieved by decreasing the degree of intensity information relative to known approaches for implementing encoding transformant standardized information technology, namely, to middle information video segments mode PSNR at 35 dB, and is 19 %.

III. CONCLUSIONS

1. Created-balanced video processing technology to reduce the intensity of the information in the info-communication systems. This technology is based on two conceptual components, namely:

a) coding method predicted frames of the video stream, which is based on an efficient syntactic segments by coding the transformed basis dimensional dibasic object positional

identifiers encoding the space based on the availability of paired inequalities syndrome vector elements;

b) reconstruction method identifier compressed TSS vector space based on its two-stage identification by dibasic object positional decoding under the presence of disparities between the paired elements, the number of which is uneven and context-dependent.

2. In case of constructing an information processing technology standardized stream of frames based on the use of the technology better standard platforms by information intensity level [9]. This is manifested in the following: the level of information further decreases the intensity of an average of 17 % for PSNR 35 dB and 14 % for PSNR 25 dB; to create conditions to ensure a balance between the level of information intensity of HD quality and level of preservation of the integrity of information for bandwidth info-communications network, starting from the level of 5 Mbit/s; to an acceptable level of integrity information corresponding to the value PSNR 25 dB, a balance is achieved with the level of information intensity HD quality by frame size, ranging from the level of info-communication network bandwidth 1 Mbit/s[10].

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