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TECHNOLOGY INTEGRATION OF EFFECTIVE ENCODING OF THE STREAM OF VIDEO FRAMES TO THE PROCESSING SYSTEM RESOURCES DYNAMIC VIDEO INFORMATION

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Проведено обґрунтування необхідності забезпечення безпеки відеоінформаційних ресурсів у системі об'єктивного контролю і управління стратегічно значущими об'єктами. Показано можливість підвищення доступності і цілісності відеоінформації шляхом ефективного кодування послідовності кадрів для відеопотоку. Обґрунтовано важливість питання щодо інтегрування процесів ефективного кодування у базові системи обробки динамічних відеоінформаційних потоків для зменшення їх бітової інтенсивності. Показано, що для побудови ефективного синтаксичного представлення потрібно використовувати підхід, який базується на усуненні міжкадрової надмірності з урахуванням форм представлення інформації на внутрікадровому рівні. Викладено основні етапи побудови технології інтеграції кодових конструкцій ефективного синтаксичного представлення нормованих інформативних диференційно-описаних спектрограм слотів Р-кадрів в структурі MPEG-потоку, що забезпечує: заданий рівень цілісності відеоінформації; скорочення службових даних, що використовуються для MPEG потоку; зниження бітової інтенсивності відеопотоку. У статті здійснюється побудова структури кодового представлення закритого кодового відеопотоку, що містить чотири комплексних рівнів пакетів Р-кадрів: рівень типового блоку; рівень інтегрованого макроблоку, рівень пакета Р-кадру і рівень відеопослідовності.

Ключові слова: безпека інформації, динамічний відеоінформаційний ресурс, кодування потоку кадрів, усунення міжкадрової надмірності, диференційно-описана спектрограма, градієнтний простір.

Reasons for need of safety of video information resources for system of objective monitoring and control of strategically significant objects are carried out. An opportunity to increase accessibility and integrity of video information by effective encoding of sequence of frames for a video stream is shown. Importance of a question concerning integration of processes of effective encoding in basic processing systems of dynamic video information flows for reduction of their bit intensity is justified. It is specified that for creation of effective syntax representation it is required to use approach which is based on elimination of interframe redundance taking into account data representation forms at the intraframe level. The main stages of creation of technology of integration of code constructions of effective syntax submission of the normalized of the informative differential described spectrograms of slots of P-frames to structure of a MPEG flow, providing are explained: the given level of integrity of video information; abbreviation of the service data used for flow MPEG; lowering of bit intensity of a video stream. In operation creation of structure of code representation of the closed code video stream including four complex levels of packets of P-frames is carried out: level of the standard unit; level of the integrated macrounit, level of a packet of the P-frame and level of video sequence.

Keywords: safety of information, a dynamic video information resource, coding of a stream of frames, elimination of interframe redundance, the differential described spectrogram, graded-index space.

Introduction

Reliable functioning of strategically significant objects and manufactories on the territory of Ukraine in many respects is defined by the solution of the questions connected to support of their safety. Considering the modern crisis factors, the important role in implementation of such requirements is laid to the organization of control systems and objective monitoring [1; 2]. The key component of such systems is video information exchange. The video information resource gains the status of the state information resource that responsible for safety of its component [1; 3].

The analysis of functioning of systems of video objective monitoring and control revealed existence of vulnerabilities and threats for loss of such categories of information security as accessibilities and integrity [3]. It becomes especially critical in case of need implementations of video information exchange or the organization of collection of video information from distant sensors; actions of malefactors; anthropogenous factors. Substantially such situation is caused by formation of high intensity of bit streams.

Use of technologies of processing of a video stream provides reduction of its bit intensity. Here it is used such technologies as MPEG with integration of technologies of effective syntax representation of video streams [4; 5]. In too time shortcomings are characteristic of the existing technologies of processing. Lowering of intensity of a bit flow is reached at the price of increase in time delays for the period of processing and loss of integrity of information.

The scope of researches concerning increase of safety of dynamic video information resources on the basis of use of effective encoding of a video stream means is actual.

In works [6–7] it is offered for effective syntax representation to use approach which is based on removing interframe redundance taking into account data representation forms at the intraframe level. For MPEG technologies processing of a flow of frames is carried out on groups with use of process of formation of P-frames, i.e. formations of slots of P-frames.

However integration in basic processing systems of video frames of technologies of effective encoding of dynamic video resources (DVR) ambiguously influences resultant efficiency of their functioning. Therefore the purpose of researches of article is creation of technology of integration of effective encoding of a stream of video frames into processing system of dynamic video information resources for support of the necessary security level of information.

Integration of effective syntax representation of slots of P-frames into structure of MPEG stream

In this case integration is understood as both conditions, and process of embedding of codegrams of the normalized of the informative differential described spectrograms belonging to slots of P-frames in MPEG-stream.

In the course of integration of the codegrams containing code values of the normalized the informative differential described spectrograms (NIDDS) into technology of processing of a video stream it is necessary to consider the following requirements:

1. The given quality level of regenerated images, i.e. integrable technology shan't reduce a level of reliability of information which is accepted for all system.

2. A possibility of abbreviation of service data due to implementation in structure of MPEG-stream of codegrams of the developed method.

3. An opportunity for lowering of bit intensity of a video stream as result of functioning of the implemented coder in the standard of the MPEG technology.

4. Necessary level of efficiency of formation and stability of code combinations, effective syntax representation of a stream of frames, to the errors arising in data transfer process on infocommunication networks.

For this purpose in the course of embedding it is necessary to consider the following features of effective encoding of the normalized informative DDS:

1. The differential described spectrograms are created on the basis of slots of the P-frames received by differential representation of the transformed frames. In this case structures of MPEG-stream will undergo the following changes:

– level of the description of a frame is excluded from code construction of a flow. This results from the fact that code representation is created initially for a packet of frames like P;

– frames of type B are absent;

– compensating of movement isn't carried out, therefore, there are no appropriate fields in control headings of the macrounit and unit;

– the quantization of components of transforms isn't carried out. It leads to an opportunity to exclude from control headings of video sequences, macrounits and units of the fields containing information on a step of quantization and type of scanning of a transformant;

– processing of units is carried out on the fixed technology. Means, the fields containing information on type of coding of the unit and the macrounit are excluded from the control heading of the unit.

In the same time the technology of differential representation assumes existence of information on an initial frame which is processed according to the selective diagram irrespective of others and is basic for the difference description of the subsequent frames. In this case code construction of an oblate stream shall contain a field under the compact provided basic frame.

2. Effective encoding of the normalized informative DDS assumes education in a code stream of own service fields caused by existence of the following unique control information:

– information about quantity of the informative and interpolated DDS elements;

– information about dynamic range of DDS;

– information about value of the generalized characteristic of graded-index space.

3. Code representation is created for the certain normalized informative DDS. For such option the bottom level of construction of a code flow will be built on the basis of the code words containing separate code NIDDS values.

4. Creation of a color format shall be carried out in the mode of quality support of video scenes. It assumes use of a format 4:2:2 — lateral dimensions of matrixes of Cb and Cr twice less than the size of a matrix of Y, and depth dimensions are identical. Then the structure of the macrounit will be the non-uniform and to consist of eight units, including: four units of brightness and four units of chromaticity (on two units Cb and Cr) in the following order:

Y1; Y2; Y3; Y4; Cb1; Cr1; Cb2; Cr2.

The composition of detection of interframe apertures shall be separated on macrounits. Interframe apertures will be created for four units on brightness component Y1; Y2; Y3; Y4, to two units on color components according to Cb and Cr.

Basic (indivisible) structural unit of a code video stream is the codegram $S(\overline{E}(\chi;\gamma)_{inf}^{(k,\ell)})_e$ effective syntax representation of the normalized informative DDS consisting of information and official parts. Information part of the codegram NIDDS comprises a code value $C(\overline{E}(\chi;\gamma)_{inf}^{(k,\ell)})_e$, the graded-index space created taking into account restrictions. The official part is built of two components, namely: dynamic range $\overline{d}_e^{(k,\ell)}$ and the generalized characteristic $g(max)^{(k,\ell)}$ graded-index space. On the basis of such indivisible structural units the lower complex components of a code stream are built — code construction $S(E(T-1)_{\chi,\gamma}^{(2)})$ slot of P-frames. Here according to the accepted color format there are three block types: unit of a brightness component, unit of color component Cb and unit of color component Cr. On the basis of four units of a brightness component $B(Y_1)$, $B(Y_2)$, $B(Y_3)$, $B(Y_4)$, two units of a Cb-component $B(Cb_1)$, $B(Cb_2)$ and two units of a Cr-component $B(Cr_1)$, $B(Cr_2)$ level of the integrated macrounit is created $M(i)$ slot of sequence of P-frames. Length V_{Mb} information part of the integrated macrounit is determined by a formula:

$$V_{Mb,\alpha} = \sum_{i=1}^{4} V(B(Y_i)) + \sum_{i=1}^{2} V(B(Cb_i)) + \sum_{i=1}^{2} V(B(Cr_i)).$$

In this formula the following designations are used: $V(B(Y_i))$ — length — i-th unit of a brightness component; $V(B(Cb_i))$ — length — i-unit of a Cb-component; $V(B(Cr_i))$ — length — i-unit of a Cr-component.

Further on the basis of code sendings of the integrated macrounits the level of sequence of P-frames in group is formed. This level consists from:

1) the information part containing code constructions of the integrated macrounits;

2) the official part including code representation:

- start a code — a marker of the beginning of level of sequence of P-frames in group;
- the code description according to the selective diagram of a basic frame of I-type;
- information about signs of elements of P-frames;
- interpolation mode parameters of DDS.

Summary length V_p code representation of level of a packet of the P-frame is defined on the basis of the following expression:

$$V_p = V_{marker} + V(I) + V(S) + V(\Theta) + \sum_{\alpha=1}^{W_{row}\ W_{col}/256} V_{Mb,\alpha},$$

where V_{marker} — length start of a code of sequence of P-frames in group; $V(I)$ — length of code representation of the closed basic frame; $V(S)$ — length of code information representation about signs of differential frames in a video stream; $V(\Theta)$ — length of code representation of parameters of the mode of approximation of an aperture; $W_{row}\ W_{col}/256$ — the number of macrounits in one frame of the image when the size of one macrounit is equal 16×16.

Video sequence level is created of separate code constructions of sequence of P-frames. This level forms code construction of all encoded closed video stream. The amount of video sequences depends on amount of sequence of P-frames created for the initial video stream. If the number of frames per second is equal ν_k, packet length (length of an interframe aperture) is equal r, that in time equal t seconds it is created $\nu_k \cdot t/r$ video sequences.

Based on the above, we can conclude the following:

1. The technology of integration of code constructions of effective syntax representation of the normalized informative DDS of slots of R-frames into structure of a MPEG-stream providing is constructed: the given level of integrity of video information; abbreviation of the service data used for MPEG-stream; lowering of bit intensity of a video stream.

2. The structure of code representation of the closed code video stream includes four complex levels of packets of P-frames: level of the standard unit; level of the integrated macrounit, level of a packet of the P-frame and level of video sequence. In comparison with six the level structure of MPEG-stream excludes such levels as: level of group of frames, frame level, section level. Instead of them the level of a packet of P-frames is added.

The closed code video stream on the basis of effective syntax encoding of NIDDS in two-component graded-index space of local and structural regularities in comparison with MPEG-stream has less difficult structure; abbreviation of the redundant control footing and levels of a flow is provided; single-digit identification of structure of a code stream is reached.

Conclusions

1. The technology of integration of code constructions of the normalized informative DDS as a part of slots of sequence of the differential described transformed frames in structure of a MPEG-stream is constructed. The structure of code representation of effective code representation of a video stream includes four complex levels of sequence of P-frames: level of the standard unit; level of the integrated macrounit, level of sequence of the P-frame and level of video sequence.

Here the following features of effective encoding of NIDDS are considered:

1) the differential described spectrograms as a part of slots are created for sequence of the P-frames received by differential representation of the transformed frames;

2) effective encoding of the normalized informative DDS in graded-index space assumes education in a code stream of own service fields;

3) code representation is created for the separate DDS considered as a combination in two-component graded-index space of local structural constraints;

4) creation of a color format shall be carried out in the mode of quality support of video scenes. It assumes use of a format 4:2:2.

Here it is provided: the given level of integrity of dynamic video information resources; abbreviation of the service data used for MPEG-stream; lowering of bit intensity of a video stream.

Scientific novelty

The technology of integration of codegrams of effective syntax representation of the normalized informative DDS in graded-index space as a part of the slot of P-frames of a packet in structure of a MPEG-stream standard is for the first time developed. Differences are that the standard unit of a four-level flow of sequence of P-frames in group is created on the basis of uneven codegrams of slots of sequence of P-frames. It provides an exception of loss of integrity of a dynamic video information resource and increase of its availability.

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