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On Subband Embedding Resistance to Data Compression

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Abstract: In this operation stability of the information implemented in images containers based on methods of the subband analysis synthesis to its conversions by means of the shrinking algorithm of JPEG images which is a basis of one of the most widespread formats of storage of graphic data is researched.

Key words: Embedding, image, subband matrixes, latent vector, algorithm of JPEG, restoration error

INTRODUCTION

In case of information transfer in information telecommunication systems in some cases, it is necessary to realize both concealment of the contents of messages and the fact of their transmission. This requirement can be fulfilled in case of application of methods of a steganography for example, data encapsulation in low orders, Koch-Rao's Method, etc. (Cox and Ingemar, 2010; Lu and Chun-Shien, 2005). In development process of methods of a steganography essential attention is paid to support of resistance of information to different destroying influences (for example, application of shrinking algorithms).

For the analysis of stability of a steg-input on the basis of the subband analysis synthesis to influence of algorithm of JPEG beforehand, we will specify features of data transformation on the basis of this shrinking algorithm.

The algorithm of JPEG (Arjun and Nichal, 2013) is applied to compression of full-color images. This algorithm is based on application of the Discrete Cosine Conversion (DCC) to a matrix of the imag $\Phi = (f_{ik})$, $i = 1,2,..., N_1$, $k = 1,2,..., N$. DKP sequentially is applied to areas of 8×8 pixels of a separate color component of the source image. Further, quantization of conversion factors by their division into the appropriate elements of a normalizing matrix Z (Gonzalez *et al*., 2009) is executed. Actually, elements of a normalizing matrix, $Z = (z_{k_1k_2})$, $k_1 = 1, 2, ..., 8$, $k_2 = 1, 2, ..., 8$, apply to quantization of coefficients of DKP corresponding to the frequency domains $\Delta_{k_1k_2}$ which are formed in case of partition of the frequency domain on 64 equal-sized subareas of the Spatial Frequencies (SF). After quantization different shrinking algorithms without loss are applied.

In case of influence by algorithm of JPEG on the container essential losses of information happen to the implemented image at a quantization stage. In order that application of a shrinking algorithm of JPEG entered as little as possible distortions (error) to the information implemented in the container, it needs to be placed in subareas of an SF Δ_{13}, Δ_{12}, Δ_{21}, Δ_{22}, Δ_{32}, Δ_{23}, Δ_{31}, Δ_{41} and so on as increase in value of the appropriate normalizing coefficient which increase attracts growth of an error of recovery of the implemented information.

These recommendations can be implemented, applying methods of the subband analysis synthesis based on which information can be implemented in the given subareas of an SF.

MATERIALS AND METHODS

Main points

Method of data subband steg-input in the image: The image container W_0 dimensionalities $N_1 \times N_2$, we will set by means of a matrix of brightness $W_0 = (W_{ik}^0)$, $i = 1, 2, ..., N_1$, $k = 1, 2, ..., N_2$. In operation (Zhilyakov *et al*., 2011), it is shown that processing of the image container and the implemented image Y^0 on the basis of the subband analysis synthesis is executed on family of the centrally symmetric subareas of an SF formed in case of partition of the frequency domain $D_{2\pi}^2 = \{(u, v) \mid -\pi \le u, v < \pi\}$ on R_1R_2 equal-sized subareas $\Omega_{r_1r_2}$, $r_1 = 1, 2, ..., R_1$, $r_2 = 1, 2, ..., R_2$, a special look.

Implementation of subband conversions to subareas of an SF $\Omega_{r_1r_2}$, $r_1 = 1, 2, ..., R_1$, $r_2 = 1, 2, ..., R_2$ is carried out by means of subband matrixes (Zhilyakov *et al*., 2014a; Zhilyakov, 2015). The A_{r_1} and A_{r_2} corresponding to the given subarea of an SF.

The result of $\tilde{W}_1$ subband implementations of data in a separate subarea of an SF of $\Omega_{r_1r_2}$ images containers W_0 can be calculated based on the following ratio:

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$$\tilde{W}_1 = W_0 - Y_{r_1 r_2} + K_0 \frac{tr(A_{r_1}^T W_0 A_{r_2} W_0^T)}{tr\left(W_{r_1 r_2} W_{r_1 r_2}^T\right)} Q_1^{r_1} Y_0 (Q_1^{r_2})^T$$

Where:

$Y_{r_1 r_2}$ = Result of filtering images (Zhilyakov and Chernomorets, 2008)

W_0 = The selected SF subarea

$Q_1^{r_1}$ and $Q_1^{r_2}$ = Matrixes which columns are made of latent vectors of the subband matrixes

A_{r_1} and A_{r_2} = Corresponding to single own numbers of the considered subband matrixes

K_0 = The general coefficient of implementation providing uniformity of change of energy the implemented images in different subareas of an SF (Zhilyakov *et al*., 2007)

tr = A matrix trace

For receiving result of restoration $\tilde{Y}_1$, it is necessary to execute conversion:

$$\tilde{Y}_1 = \left(Q_1^{r_1}\right)^T \tilde{W}_1 Q_1^{r_2}$$

RESULTS AND DISCUSSION

Computing experiments: The purpose of computing experiments is determination of errors of (Zhilyakov *et al*., 2014b) representations of the container image with the implemented information and errors of recovery of the implemented image under different conditions.

As the image container images are used by dimensionality of 512×512 pixels (Fig. 1a). The implemented image is provided by dimensionality of 25×25 pixels in a Fig. 1b. Dimensionalities are selected according to quantity of single own numbers of the appropriate subband matrixes.

When carrying out computing experiments of the SF area $D_{2\pi}{}^2$, it was broken into 8×8 equal-sized subareas of an SF ($R_1 = R_2 = 8$). Implementation of the image Y_0 sequentially was executed in different subareas of an SF of the container W_0.

Values of an error (mean squared deviation) of representation of the container $\tilde{W}_1$ containing, the implemented image and errors of the regenerated image $\tilde{Y}_1$ in case of implementation in separate subareas of an SF $\Omega_{r_1 r_2}$ are given in Table 1 (value of coefficient of implementation $K_0 = 0.9$).

The values given in Table 1 show that in case of implementation of the image Y_0 with coefficients $K_0 = 0.9$ in a subarea of an SF Ω_{13} (the frequency domain is broken into 8×8 subareas of an SF) and the subsequent file recording of the JPEG format with the parameter of quality of Quality = 75 insignificant errors of representation of the container and recovery of information are received. In case of implementation of the image Y_0 in other subareas of an SF and in case of application of algorithm of JPEG (Quality = 75) rather big errors that is explained by different values of coefficients of quantization of a normalizing matrix of Z are received. In case of implementation in low-energy subareas of spatial

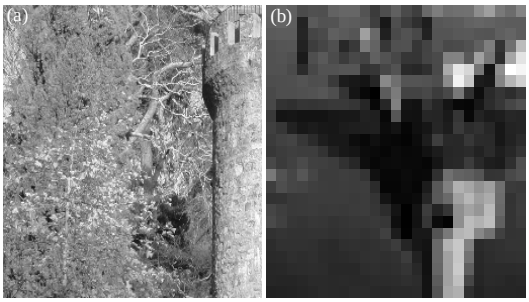

Fig. 1: a) The initial image container W_0; b) The implemented image Y_0

Table 1: Errors of representation of the container $\tilde{\omega}_1$ and error of recovery of the implemented image ($R_1 = R_2 = 8$, $K_0 = 0.9$)

		Error without file recording		Error in case of file recording without compression (Bmp)		Error in case of file recording JPEG shrinking algorithm Quality quality of conversion JPEG 75		85		95	
r_1	r_2	Container	Picture	Container	Picture	Container	Picture	Container	Picture	Container	Picture
1	2	3	4	5	6	7	8	9	10	11	12
1	1	9.133	3.20E-11	9.134	0.0007	9.146	0.0058	9.143	0.0036	9.143	0.0017
1	2	0.071	8.79E-06	0.071	0.0028	0.108	0.018	0.091	0.011	0.075	0.0055
1	3	0.035	1.49E-05	0.035	0.0056	0.078	0.044	0.059	0.026	0.039	0.012
1	4	0.023	1.78E-05	0.023	0.0097	0.071	0.098	0.051	0.065	0.028	0.025
1	5	0.018	2.85E-05	0.018	0.016	0.069	0.248	0.048	0.156	0.024	0.055
2	1	0.118	7.88E-06	0.118	0.0017	0.146	0.012	0.133	0.0072	0.121	0.0033
2	2	0.056	1.26E-05	0.056	0.0034	0.094	0.025	0.076	0.015	0.059	0.0067
2	3	0.031	3.13E-05	0.031	0.0071	0.075	0.066	0.056	0.039	0.035	0.015
2	4	0.02	3.91E-05	0.02	0.013	0.07	0.174	0.049	0.104	0.026	0.039
2	5	0.016	4.26E-05	0.016	0.019	0.068	0.382	0.047	0.232	0.023	0.084

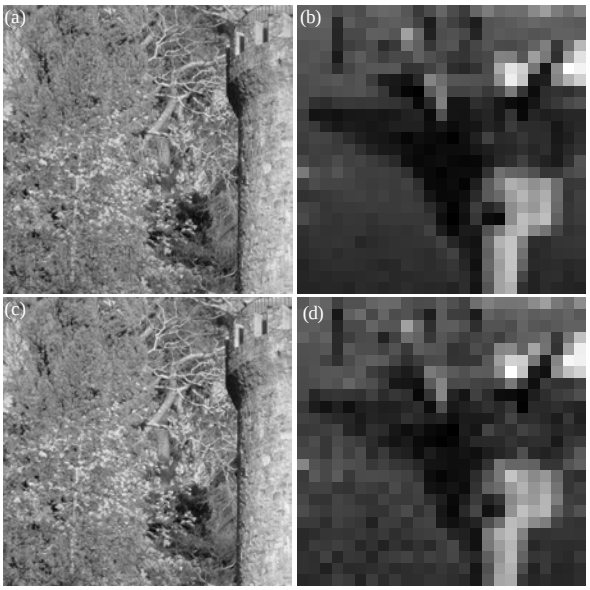

Fig. 2: a, c) Container $\tilde{w}_1$; b, d) Regenerated image $\tilde{y}_1$ in case of different parameters of conversions

frequencies the error of recovery of the image increases. In case of application of algorithm of JPEG with the high parameter of quality of Quality = {85, 95} insignificant values of analysable errors are received.

In Fig. 2a-d examples of representation of the container containing the implemented image in subareas of an SF Ω_{13} (K_0 = 2.0) and Ω_{23} (K_0 = 1.0) in Fig. 2b are given and 2 g examples of the images recovered from these subareas of an SF (after application of algorithm of JPEG are given in case of quality = 75). It is visually visible that in Fig. 2a-d of distortion of images containers and regenerated data aren't considerable.

The results given in Table 1 and in Fig. 2 show the considerable resistance of subband implementation to influence by algorithm of JPEG.

Similar computing experiments were made for different images containers and the implemented data in case of different partitions of area of frequencies on a subarea. Their results also showed unessential distortions of the implemented data in case of impact on the container JPEG shrinking algorithm.

Summary: Results of the made computing experiments showed resistance of algorithm of subband implementation to the considered type of the external destroying influences. It is necessary to mark that one of the directions of increase of stability of a steg-input on the basis of methods of the subband analysis synthesis is implementation of the useful information in separate fragments of the selected subarea of spatial frequencies.

CONCLUSION

In operation, it is shown that subband implementation of images in separate subareas of an SF of the image container allows to receive insignificant errors of representation of the container containing the implemented information and insignificant distortions of the implemented images in case of different parameters of compression by algorithm of JPEG in case of different parameters of subband conversions.

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