Review on YCrCb color space optimization, TV images compression, Algorithm of Signals Sources Isolation and Optical Fiber

Sattarova Feruza Y. and Tai-hoon Kim

Hannam University, Daejeon, S.Korea
mymail6585@gmail.com, taihoonn@empal.com

Abstract

In this paper the latest researches on YCrCb color optimization, TV images compression basing on the dynamic objects selection, algorithms of signals sources isolation and examination of mechanical influence on an optical fiber by digital holographic interferometry methods are discussed.

In the new color space based on YCrCb every color has its own luminance value and there are no essential color tone changes and color distortion after the brightness editing.

In the article the scientific researches of the newest effective compression method for the video information are considered. Basic advantage of this method was displayed and testing comparison of the results was showed. Method of the interframe difference could be used for the video compression within single video-scene where the video camera movements almost immobile. Also, this method could be used in addition with other methods like parameter models. The main schemas algorithms were illustrated in detail. Also the basic requirement for this method implementation and its main defect were shown up and explored with possible solving for these problems. The main data from illustrated table shows that this method has an advantage in comparison with others only when the commutated video frames has static background. That makes this method useful only in specific video-scenes. The represented method was developed as an addition to the others methods that could be used in video-codec.

Also algorithms of separation of the source signals and showed the results of mathematical modeling of these algorithms are described.

The prospects for utilization of modern information technology achievements in the field of digital image processing for precision measurements of phase distortions arising in communication optical fiber under external mechanical influence are discussed. The measurement method based on two exposition digital holographic interferometer is proposed. The circuit of measurements and the programming algorithm of digital image processing are described. The measurement procedure and experimental results are presented. The opportunities of measurement method for monitoring of the telecommunication equipment are discussed.

1. Introduction

There are a lot of elbows, adapters between the cables of different sections, and connectors with available equipment in the modern fiber-optic data transfer lines and in the local network lines particularly. All this equipment endures by various continuous mechanical traffics and weather exposures, which can bring in distortions and additional noise to a flow of the transmitted information. For qualitative work securing the exact monitoring of fiber-optic data transfer lines is extremely necessary. To the present time the advanced methods of

Fiber-optic line diagnostics are reduced basically to measurement of losses and are not sensitive to small external perturbation.

As a problem «signals sources isolation» we will understand allocation of separate signals or one signal from the additive mix of signals measured in some point accessible to supervision. The decision of this problem is necessary for carrying out in many practical applications: signals receivers of various communications channels (radio, wire, rail, etc.), in technical and medical diagnostics, a radiolocation, seismic measurements, etc.

YCrCb color space is used in JPEG and MPEG standards [1-4]. YcrCb color space is also widely used in the contour analysis, color quantization, image binarization and restoration. These algorithms require to transform color image into grayscale and to increase the brightness of image. Due to the the particularities of this color space the transformation of color image into grayscale causes the loss of information important for the following analysis. The brightness increasing in this color space is also not correct. After the brightness increasing the inverse transformation from YcrCb into RGB color space is followed with essential distinctions of color tone. These particularities of YCrCb color space essentially complicate the algorithms of the contour analysis and image binarization.

In this paper the new color space is proposed. This color space considers that the object colors correlate. That's why it doesn't cause the upper problems.

There are codecs of Mpeg-4 standard got most distribution among great number of different types of video codecs, using the methods of TV images compression. This standard allows using of the newest segmentation algorithms for the dynamic objects with subsequent configuration of the media stages by segmented objects. There are two standards of the objects segmentation: context based segmentation and bitmap segmentation method. During implementation of the context based segmentation the system of the objects recognition is add up to searching contour of an object. In this case the contour of an object appears as the closed curve. Binary alpha map of an object is created by means of the object contour. In this case all pixels into the object contour equate to the one and become white, and pixels that out of contour border are equate to the zero and become black. As the result, binary presentation of an object, consists of two colors: black and white. This alpha map helps to find the local coordinates of the object contour into the frame.

2. YCrCb color space optimization

2. 1. YCrCb color space

This color space has three componenets: luminance – Y and non-negative chrominances – Cr and Cb.

The transformation from color space sRGB into YcrCb and vice versa according to the ITU BT.601 [5] and ITU BT.709 [6] recommendations is:

– direct ratio

$$\begin{pmatrix} Y \\ Cr \\ Cb \end{pmatrix} = \begin{pmatrix} Y \\ r-Y \\ b-Y \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.701 & -0.587 & -0.114 \\ -0.299 & -0.587 & 0.886 \end{pmatrix} \cdot \begin{pmatrix} r \\ g \\ b \end{pmatrix}$$

– inverse ratio

$$\begin{pmatrix} r \\ g \\ b \end{pmatrix} = \begin{pmatrix} 1 & 1 & 0 \\ 1 & -0.509369 & -0,194207 \\ 1 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} Y \\ Cr \\ Cb \end{pmatrix}$$

In this ratios the values r, g, b belong to sRGB color space and are evaluated as $r = R/255$, $g = G/255$, $b = B/255$, where R, G and B are RGB colors.

2.2 The transformation of color image into grayscale in YCrCb

Because of the particularities of this colorspace the transformation of color image into grayscale causes the loss of information important for the following analysis [7,8,9] . This particularities are related with the fact that in sRGB space are the subsets of such colors, which differ but have the same brightness. Some of this colors are shown on the figure 1.

The values of RGB and sRGB colors and their luminance value Y are put in table 1.

Table 1.

	R	G	B	r	g	b	Y
1	150	191	200	0,59	0,75	0,78	0,71
2	85	232	160	0,33	0,91	0,63	0,71
3	230	178	60	0,90	0,70	0,24	0,71
4	50	244	190	0,20	0,96	0,75	0,71

Figure 1. The luminance in the YCrCb
a) input image; b) luminance

2.3 The brightness increasing in YCrCb

It’s also very useful to edit the image brightness in the YcrCb color space, because in this case you have to change only the value of luminance component Y. But the brightness increasing in this color space is not correct. After the brightness increasing the inverse transformation from YcrCb into RGB color space is followed with essential distinctions of color tone. It reduces the quality of image visual perception (figure 2).

Figure 2. Linear brightness increasing in YcrCb color space.
a) input image b) increased brightness

The luminance value from table 1 linearly increased and RGB and sRGB colors values after inverse transformation are put in table 2.

Table 2.

	Y	R	G	B	r	g	b
1	0,96	214	255	264	0,84	1,00	1,03
2	0,96	149	296	224	0,58	1,16	0,88
3	0,96	294	242	124	1,15	0,95	0,49
4	0,96	114	308	254	0,45	1,21	1,00

2.3. Proposed color spaces

It's known that object color on scene is formed not only with the reflected from it light but also with the scattered light and reflected from other objects light. Thereby object colors correlate. On purpose to consider this fact the new color space was invented [10]. In this color space the luminance is evaluated as vector

$$B = \lambda_r \cdot r + \lambda_g \cdot g + \lambda_b \cdot b,$$

where coefficients λr ,λg ,λb contain the information about correlation of r, g,b components in formed image and match the ratio $\lambda r + \lambda g + \lambda b = 1$.

Since the luminance definition changes the color space changes accordingly. Taking into account equation we can obtain such ratios:

— direct ratio

$$\begin{pmatrix} B \\ Xr \\ Xb \end{pmatrix} = \begin{pmatrix} B \\ r - B \\ b - B \end{pmatrix} = \begin{pmatrix} \lambda_r & \lambda_g & \lambda_b \\ 1 - \lambda_r & -\lambda_g & -\lambda_b \\ -\lambda_r & -\lambda_g & 1 - \lambda_b \end{pmatrix} \cdot \begin{pmatrix} r \\ g \\ b \end{pmatrix},$$

– inverse ratio

$$\begin{pmatrix} r \\ g \\ b \end{pmatrix} = \begin{pmatrix} 1 & 1 & 0 \\ 1 & -\frac{\lambda_r}{\lambda_g} & -\frac{\lambda_b}{\lambda_g} \\ 1 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} B \\ Xr \\ Xb \end{pmatrix},$$

where Xr , Xb are the chrominance components.

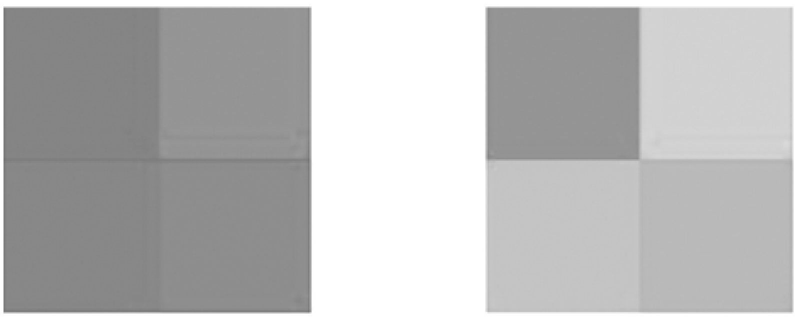
2.3.1 The transformation of color image into grayscale in proposed color space

Such luminance specification allows saving all the image details at grayscale image (figure 3). It affirmatively effects the quality of contour allocation algorithms and simplifies the development of text blocks on color image recognition systems because there is no need to consider every RGB component apart now.

a) b)

Figure 3. Brightness in proposed color space
a) input image; b) brightness.

2.3.2 The brightness editing in proposed color space



a) b)

Figure 4. The result of nonlinear brightness increasing
a) input image; b) increased brightnness

The results of brightness editing in proposed color space are shown at figure 4.
As it shown at figure now the brightnes increasing is not followed with essential distinctions of color tone.

At figure 5 the results of brightness editing for some realistic images are presented. Notice that image restoration procedure is much simplified in proposed color space.

Also notice that there is no whiten effect with brightness increasing (figure 5 d) and color distortion with brightness decreasing (figure 5 c) in proposed color space.

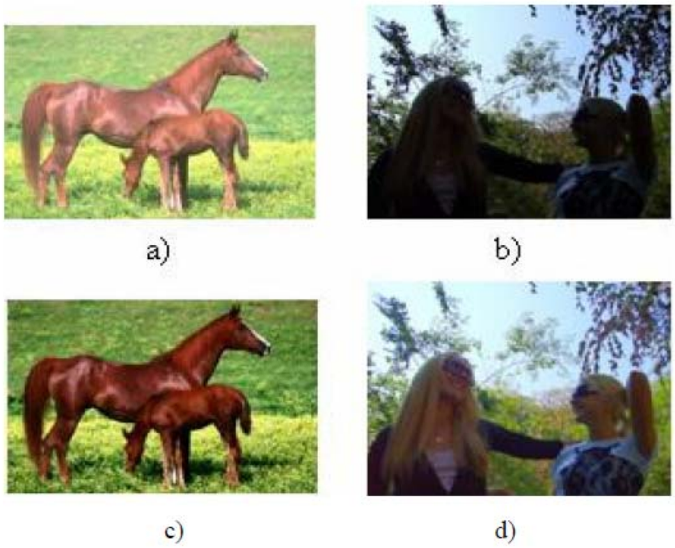


Figure 5. Brightness editing
a), b) input images; c) decreased brightness; d) increased brightness

The personal evaluation of quality of grayscale images, linear brightness increasing and nonlinear brightness increasing was carried out. The personal evaluation was made according to the rules for photographic pictures. Two hundred test realistic images with some mandatory images were evaluated during this procedure.

The personal evaluation was made by 80 experts using worsening scale with 5 reference points: worsening is unnoticeable; worsening is noticeable, but doesn't disturb; worsening disturbs a little; worsening disturbs; worsening disturbs very much. These meanings were converted into the values at five-point scale. There the highest point 5 corresponds to the meaning 'worsening is unnoticeable'. Total point was defined as average point and evaluates 4,8.

3. TV images compression basing on the dynamic objects selection

One of newest methods for the dynamic objects selection is interframe difference. The couses of choosing this method are related to that the dynamic objects contour could changes from a frame to the frame, that makes the segmentation and recognition of such objects an serious problem. In the case of implementation of the interframe difference the static areas of background (background of the video stage) that remains unchanges during some time in the video are disappear. Those areas in the frame that changes during motion of an object, shows up as a canculation result of the interframe difference.

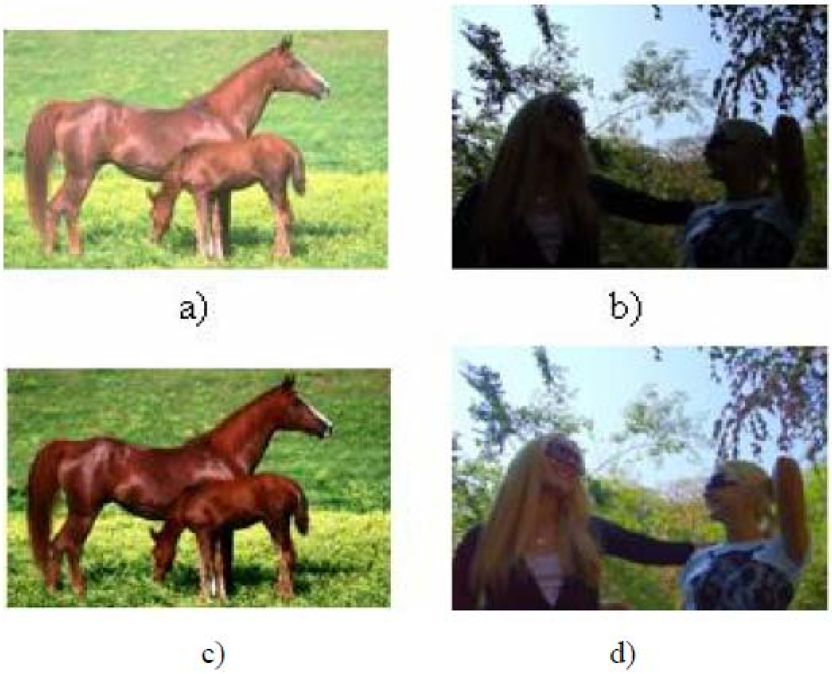


Figure 6. Display of the moving object by a difference of it's two subsequent positions (a) and interframe difference of an object moved on the 3 pixels (b).

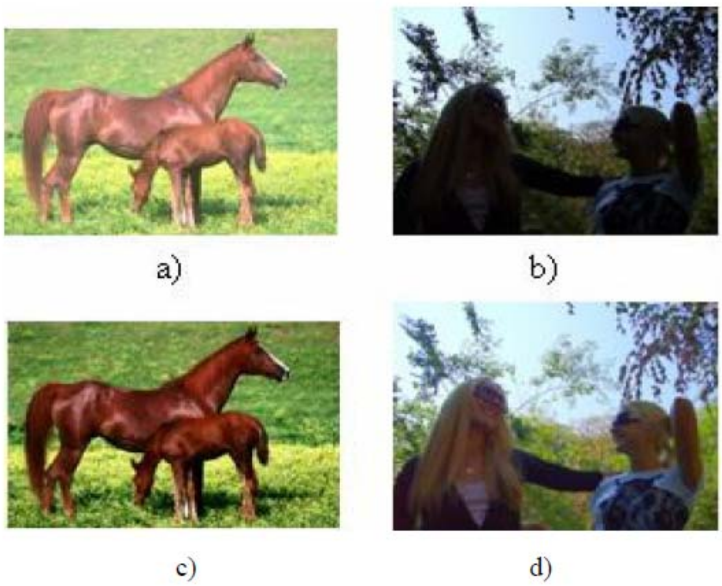


Figure 7. Structural diagram of the developed video-codec.

However, applying the interframe difference method is effective in those cases, when moving objects are situated on a stationary background. In the real video it is rarely case when the background is absolutely immobile. It is related to motion of the vedio camera. Therefore, comfortably to apply the interframe difference method to the frame sequence only after it will be processing by means of the parameter models. Structural diagram of the generalized algorithm of the developed video-codec that allows to apply interframe difference method is presented on a Pic. 2.

This algorithm works by the next way: load of the two subsequent frames in the program buffer memory is realized. The first frame fixs as a supporting frame, and next frame becomes intermediate frame. Thus, a supporting frame is a first frame of the videostream by means of that the further processing of images is produced. That less the difference between supporting and intermediate frame is, then more certain the object contour will be distinguished.

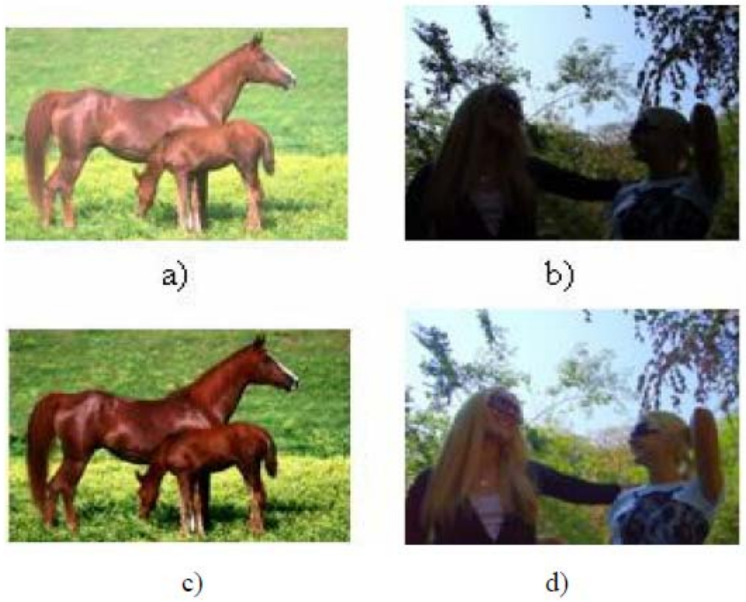


Figure 8. Two subsequent frames choosed for the processing by the video-codec.

The next step of the realization of this method is loading this two subsequent frames into RGB convertor that allows to get YUV(black and white) images. This process is necessary, because the work with the interframe difference of the black and white images far easier, otherwise, after interframe difference of the coloured images could be gotten varicolored contour, that changes it's colour from one group of pixels to other. This operation is carried out by the following algorithm:

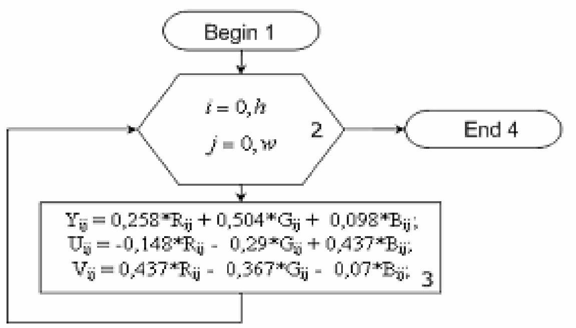


Figure 9. Algorithm of the transformation of the RGB images into the YUV images.

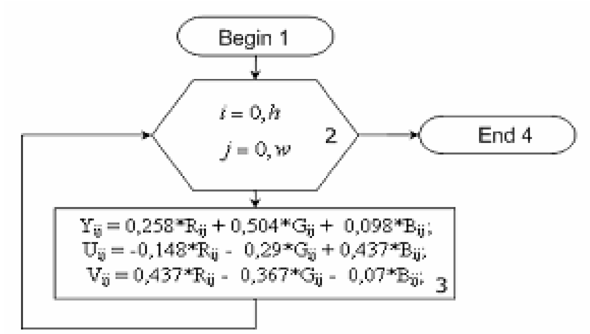


Figure 10. Transformation of the RGB image into the YUV image.

Then, an interframe difference is realizing during which from every pixel of the first frame substract the proper pixel with the same local coordinates into the second frame with help of the algorithm on the Pic. 6.

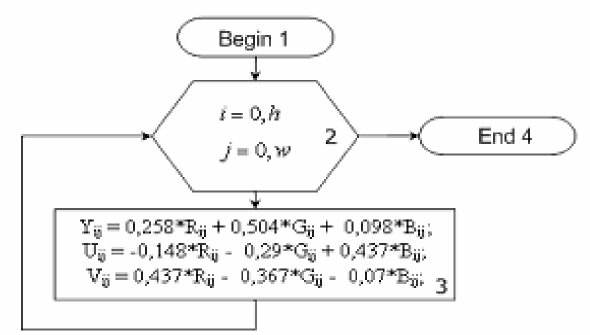


Figure 11. Algorithm of the interframe difference.

In the resulting program window appears produced interframe difference as some contour, representing the difference of two subsequent positions of the moving object. However, the contour brightness could vary from one group of pixels to other that makes brightness limited transform necessary to use. Brightness limited transform produces interframe difference consists of the following: a program user put some threshold value that is most acceptable to this type video. As a result of it, all pixels that have brightness value higher than threshold value equates to the maximal value (255), and other that less than threshold value are equtes to the zero. Thus, a binary image is formed having only two values of brightness – 0 or 1. Nevertheless, in a resulting binary image it is uttery rarely posible to get the clear contour of the dynamic object. More frequent cases when there is a noise that appears because of the casual background trembling that demonstrates as some single pixcels or their small groups. Appearance of that kind of noise is related to the defects of the work of the parameter models. Also, there is a lot of contours appears because of the presence of great number of areas with bright gradation transitions and difficult textures. To remove this defects the two filters are used. After the brightness limited transform of the interframe difference the first filter starts it's work– Filter for removal of the casual noises. With help of this filter all single pixels are equated to a zero (becomes black). Then, the implementation of the casual noises removal filter resulting image processing by the next filter – Single contour forming filter based on nonstationary equation for the heat conductivity that used in the field of Thermodynamics.

This filter consider resulting image as the thermal map of environment, where a white color corresponds to the strongly heated areas, and black – to the cold areas. After it, by using the relation of the parameters of “heating” and “cooling” limits entered an user, starts the simulation process of cooling and heating environment according to the nonstationary equalization. As a result of “cooling” process all white pixels little by little equating to a zero. Speed of this process depends with the pixels concentration. The small groups of pixels disappears quickly (“becomes cool”). The large groups of pixels disappear far slower. Then, after some threshold value that had been achieved, the process of “heating” was starting, and the all white pixels groups that didn’t have enough time to disappear processing with the next process of approximation during which all black pixels are equated to the value of nearby white pixels around. After the time when the threshold value had been achieved the pixels concentration was increased. As the result the clear single contour filled with a white color appers and could be concedered as the binary alpha map of an object.

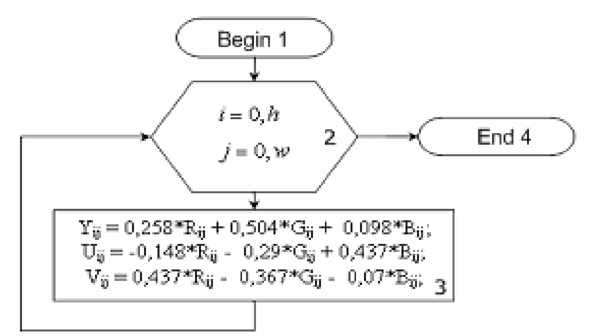


Figure 12. Binary alpha map of an object

Then, the program memorizes the position place of the all extreme points of an object (extreme white pixels). Thus, with help of the extreme points of a selected object contour the dynamic object is segmented in the second subsequent frame. The selected object is the coloured image. Besides an object some areas of the background are selected too. These areas of a background also needs to be transmitted, because, during the movement an object will close the new area of background, but will free the area of a background, which it closed by itself before as it illustrated on the Figure 8.

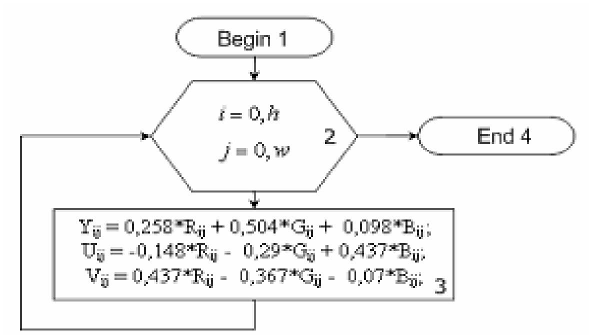


Figure 13. The relations between an moving object and static background of an image

These emptying areas should be filled with an areas of background, which are transmitted together with the dynamic object contour as a one file and memorized into the buffer of the interframe memory. The next step of the process is loading the supporting frame and the segmented dynamic object with the local coordinates of his placing in the frame into the output stream former. All areas of the second subsequent frame that have not been transmitted remain stationary and could be copied from the first frame. And all changed areas transmitted as a one file. Thus, a frame video stream that have been compressed with a coder becomes ready to be transmitted by the connection channels. In result, it is possible to get enough great compression coefficients using relatively simple algorithms for the dynamic object segmentation.

Table 3. Test results of the efficiency compression comparison of a videostream consists of the 18 frames 1050x623 with a size 1.87 Mbyte.

The name of the used video-codec	File size forming as a result of the 18 frames compression (BMP 24 bit)	Compression coefficients
Without compression	33, 660 Mbit	Cc=1;
MPEG-2	5,320 Mbit	Cc=6;
MPEG-4	3,130 Mbit	Cc=11;
Testing object - oriented codec	2,020 Mbit	Cc=17;
MJPEG	11 Mbit	Cc=3;

The parameter models as a method of the motion compensation mechanism allows to compensate the video camera motion. After, the implementation of the dynamic objects segmentation method becomes efficient expedient by means of interframe difference. The general defect of the interframe difference is segmentation redundance, because not only the contour is selected during deduction one frame from another but also the parts of a background that have been changed as a result of an object movement will be selected too. Therefore for the more exact object contour determination comfortably to use gradation algorithms distinguish a background from an object basing on the brightness difference. Along other methods this method will allow to do next: to localize the finded areas with dynamic objects and produce rapid segmentation of the all changing areas, moving objects and changing background areas. Then, it is becomes possible to separate the selected object and extrapolate extreme object pixels for the receipt of an clear contour. Basic advantage of this method is that this method does not depend on complication of an object shape and represents all changes that occur in the frame in detail. However, this method application requires the previous videostream processing with other algorithms - especially the implementation of the parameter models for a motion stabilizing of the video camera.

4. Recursive Algorithm of Signals Sources Isolation

Let a signal $\xi_u^p(t;l)$ in some point *p* accessible to measurement representing the sum of unrelated signals $\xi_\lambda^s(t), s=\overline{1,k}$ with overlapped spectrum, generated *k* by sources. Each of S , $s=\overline{1,k}$ signals by transfer from a source to receiving point *p* undergoes distortions which are described by impulse transition function $h_{ps}(t,l)$ or frequency transfer ratio $H_{ps}(\omega,l)$ of some equivalent channel of conversion and the transfer (information channel), connecting *s* -th source and *p* -th signals receiver. Generally dynamic behaviors of information channels are not stationary, and depend on various parameters - time, characteristics of environment, etc., on what specifies parameter l . Then the model of formation of the observed (measured) signal $\xi_u^p(t,l)$ in a point p of object can be described the integral equation

$$\sum_{s=1}^{k}\int_0^l \xi_\Gamma^s(\tau)\cdot h_{ps}(t-\tau;l)d\tau = \xi_u^p(t,l).$$

For definition of one of signals $\xi_\lambda^s(t)$ it is necessary to measure signals $\xi_\lambda^s(t)$ $s=\overline{k}-\overline{l}$ in a point of generation, generated by other sources, otherwise the problem becomes incorrect. Therefore for reception of correct statement of a problem it is necessary to have number of receivers d of not less number of signals sources k , i.e. $d \geq k$. It is necessary to have signals receivers in such points of the object, measured signals in which would contain signals from all k sources.

Thus, each of d signals $\xi_u^p(t,l)$, $p=\overline{1,d}$ receivers can be presented as linear superposition (sum) k of signals $\xi_\Gamma^s(t)$, $s=\overline{1,k}$ the sources acting to the receiver on k information channels. Then model of signals formation $\xi_u^p(t,l)$, $p=\overline{1,d}$ in receivers it is possible to describe following system of integral equations:

$$\sum_{s=1}^{k}\int_0^l \xi_\Gamma^S(\tau)\cdot h_{ls}(t-\tau;l)d\tau = \xi_u^p(t,l), \sum_{s=1}^{k}\int_0^l \xi_\Gamma^S(\tau)\cdot h_{ds}(t-\tau;l)d\tau = \xi_u^d(t,l),\ldots$$

As division of signals will understand definition of signals $\xi_\lambda^s(t)$, $s=\overline{1,k}$ sources inaccessible to direct measurements, on measured in accessible places to signals $\xi_u^p(t,l), p=\overline{1,d}$, receivers and impulse transition functions $h_{ps}(t,l)$. Thus, the decision of problem of signals isolation is reduced to the decision of system (2). Methods of the decision of this system define classes of algorithms of the problem decision of signals sources isolation [2], one of which - recursive - is concerned below.

For reception of the unique decision of system of equations (2) we will set $d = k$.
Then in frequency domain the system of equations (2) looks like

$$\sum_{s=1}^{k}\Xi_\Gamma^s(\omega)\cdot H_{ls}(\omega,l) = \Xi_u^l(\omega,l), \sum_{s=1}^{k}\Xi_\Gamma^S(\omega)\cdot H_{ds}(\omega,l) = \Xi_u^d(\omega,l),\ldots$$

The decision of system of the equations (3) can be presented as follows:

$$\Xi_\Gamma^k(\omega) = \sum_{S=1}^{\max}\Delta_{S,k}(\omega,l),$$

Where the first and the subsequent elements of iteration are defined so:

$$\Delta_{l,k}(\omega,l) = \left\| \begin{matrix} \Xi_u^l(0)/H_{1l}(0) \\ \ldots\ldots \\ \Xi_u^d(0)/H_{dd}(0) \end{matrix} \right\| \quad A_{S,k}(\omega,l) = \left\| \begin{matrix} 0 & \ldots & H_{lk}(0)/H_{1l}(0) \\ \vdots & \vdots & \vdots \\ H_{dl}(0)/H_{dd}(0) & \ldots & 0 \end{matrix} \right\|,$$

Where $\Delta_{S,k}(\omega,l) = A_{S,k}(\omega,l) \cdot \Delta_{Sl,k}(\omega,l), S = 2...\max$ - number of iterations;

$$H(0) = H(\omega,l), \Xi(0) = \Xi(\omega,l).$$

4.1. The results of mathematical modellig

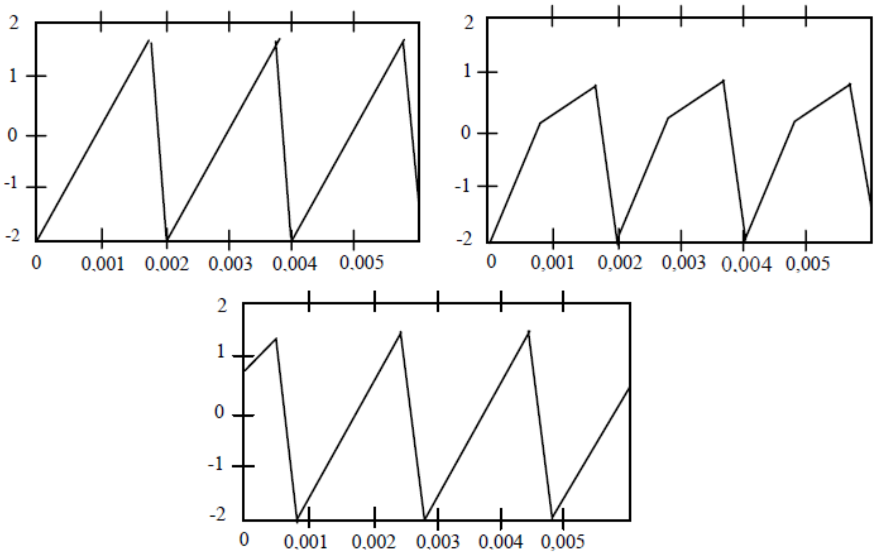


Figure 14. Signals of the first source (from left to right): initial, in additive mix with other signals, allocated from a mix of signals sources

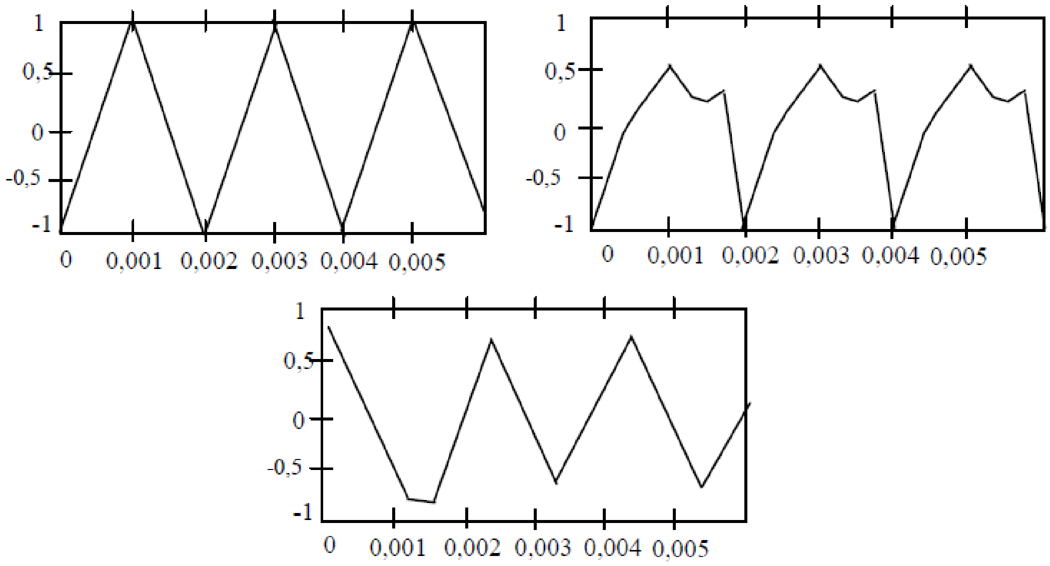


Figure 15. Signals of the second source: initial, in additive mix with other signals, allocated from a mix of signals

On Figure 14 - 16 are resulted results of modeling in MATLAB environment the signals sources isolation considered above recursive algorithm. Three sources of the signals were used, two of which were impulses of the triangular form, and the third - harmonious. The recursive algorithm considered in work in comparison with not recursive algorithms has smaller computational complexity. Besides advantage of this algorithm is the opportunity of its realization on parallel computing systems.

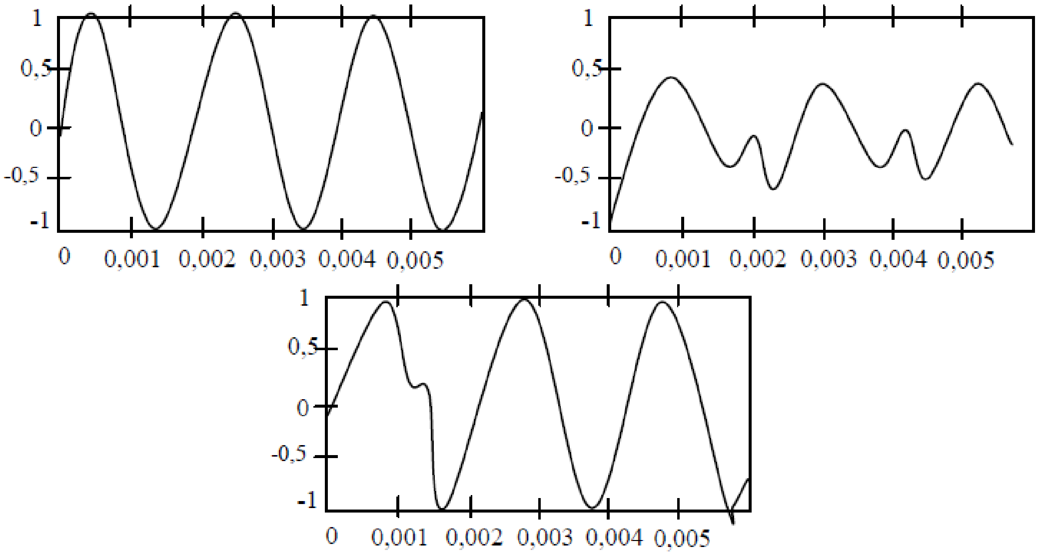


Figure 16. Signals of the third source: 1 - initial, 2 - an additive mix, 3 - allocated from a mix of signals

5. Examination of Mechanical Influence on an Optical Fiber by Digital Holographic Interferometry Methods

5.1. Basis of Method

In the work the diagnostics of optical communication lines developed on the basis of modern information technology achievement of registration and processing of digital information is described. The offered technique is based on a supersensitive method of digital double-exposed holographic intreferometry [1]. In contrast to traditional holography [2,3] where the electromagnetic field wavefront record and reconstruction are occurred in an analog form (using a photoplate, thermoplastic, photorefractive materials), the digital holography is a way of wavefront record in a digital form with the subsequent its retention, measurement, transformation, and reconstruction by mathematical methods in computers [4,5]. In digital holographic interferometry, two wave fronts reconstructed from two digital holograms Γ1 and Γ2 are compared (numerically interfere). In this case Γ1 is the hologram of the unperturbed object and Γ2 is the hologram of object with induced optical heterogeneousness. As a result of two wave front summing the interferogram is obtained. It is possible to determine the phase changes arisen at the temporal interval between records of Γ1 and Γ2 holograms in the investigated objects on basis of analysis of curvatures and locations of fringes at the obtained interferogram. Each digital hologram is recorded in the field of pulse or cw laser radiation using a CCD matrix of the digital chamber. At this case the shot time is specified by digital chamber control gate or laser pulse durations. The idea of application of computer processing for wave-front reconstruction using the images written down holographically was offered for the first time by J.W.Goodman and R.W.Lawrence [6], and also by R.W.Kronrod with co-workers [7]. The development of information technologies and solid-state radiation detectors has allowed writing down the holograms with the help of photosensitive matrixes on basis of charge-transfer devices (CCD chambers) in a digital form. In these cases the processes of retention and processing of the holograms are completely digital ones and were called as digital holography. The application of digital holography opens great potentialities for qualitative and moreover exact quantitative analysis of object properties such as precision displacement of surface points at the deformation and fault analysis, definition of the object shape, measurement of refraction index in transparent media, study of microparticle trajectories, and so on.

The numerical reconstruction of the hologram written down by a digital image is carried out according to the scalar diffraction theory in the Fresnel approach for the Rayleigh-Sommerfeld diffraction integral [8,9]. This technique serves as a starting point for numerical reconstruction of the images in the digital holography in paraxial approximation. The resulting field is determined by twofold Fourier transform of intensity distribution product in the obtained hologram. At accounts the quantization is entered taking into account the pixel sizes of a CCD matrix.

5.2. Algorithm Description

In the measurements of induced phase heterogeneities in optical fibers the algorithm of digital intreferogram reconstruction under the recorded holograms was similar to algorithm submitted in [4]. The intensity distribution in a plane of hologram record *I (x, y)* is determined by summing of a module squares of complex amplitudes of object O(x, y) and background R(x, y) waves:

$$I(x,y) = |R(x,y)|^2 + |O\ (x,y)|^2 + R(x,y)\ O^*(x,y) + R^*(x,y)\ O(x,y)$$

The last two terms of the Eq. (1) contain the information appropriate to amplitude and a phase of the object wave. This information can be discriminated by the Fourier transform method. If the hologram is recorded by a light source with the restricted output aperture (in our case, the restricted light beam), after transformation we receive a Fourier spectrum of the hologram with four located areas of spatial frequencies, which correspond to the various terms of the Eq. (1). First two terms of Eq. (1) form the zero order of the spectrum, which is located at the centre of two-dimensional Fourier plane. The third and fourth terms of Eq. (1) form two connected spectral areas located symmetrically concerning the centre and correspond to the complex amplitude of object wave. If one of these located spectrum areas is separated and then the inverse Fourier transform is applied, the phase front of object wave (real or imaginary ones depending on the chosen separation area) can be reconstructed in the object image plane.

Thus the following algorithm the recording and reconstruction was used. In the beginning the hologram Γ1 (non-loaded optical fiber) is recorded, then in the next light pulse the hologram Γ2 (loaded optical fiber) is recorded. Then the two-dimensional Fourier spectrum is constructed under the obtained holograms. In this spectrum the area for reconstruction is selected. Under this selected area the digital phase fronts Γ1 and Γ2 are reconstructed by inverse Fourier transform and their interferogram is calculated. Then the algorithm of a phase unwrapping similar to [4] is used. The real surface of the indignant phase of radiation transmitted through deformable optical fiber is reconstructed.

5.3. Experimental Arrangements

For record and analysis of induced optical heterogeneities in optical fibers the traditional schemes of Young and Michelson interferometers were used. The interferometer was assembled using two pieces of single-mode fiber for optical telephony. The diameter of fiber core was 125 μm. The lengths of each optical fiber pieces were 2 m. The cable sheath was removed from the fiber input and these cable inputs incorporated together in parallel for input of laser radiation in the interferometer. At the interferometer input the He-Ne laser beam with wavelength of 0.63 μm and radiation power of 3 mW are transmitted without focusing optics.

The cable sheath was also removed from the fiber end and these cable ends incorporated together in parallel at the spatial interval Δ. The interferometer optical fibers were rolled by rings with diameter of about 30 cm and were situated in the free (unfixed) conditions on an optical table. In such scheme, two optical fibers formed object and background light beams. In Figure1 and Figure2 the meter schemes assembled by the Young and Michelson interferometers are shown.

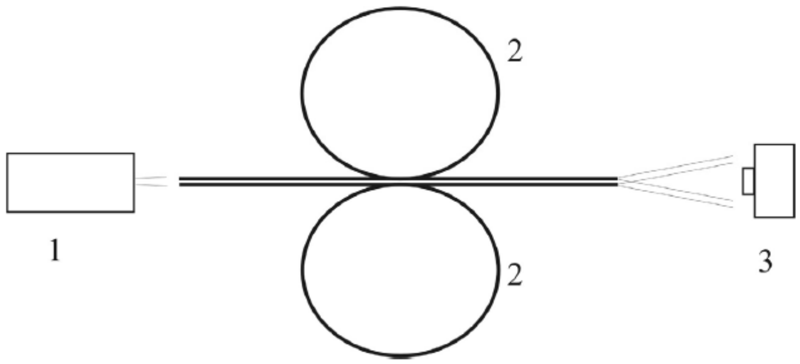


Figure 17. Meter scheme based on the Young interferometer. 1 : laser, 2 : optical fiber, 3 : photographic camera

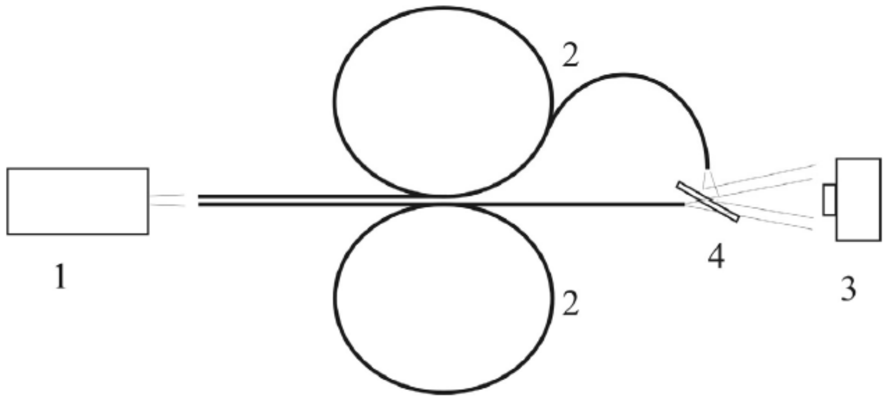
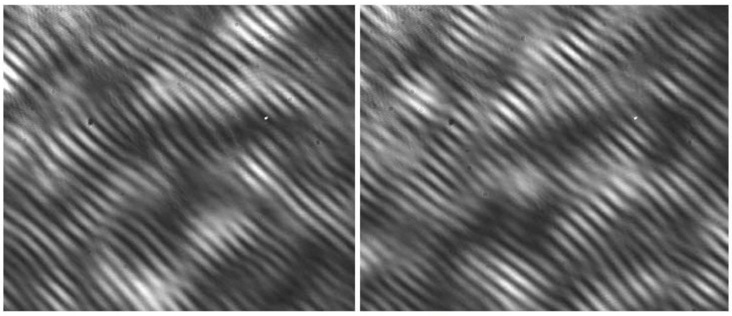


Figure 18. Meter scheme based on the Michelson interferometer. 1 : laser, 2 : optical fiber, 3 : photographic camera, 4 : splitter

The analysis of interferometer response on external influences was carried out by loaded of the first background fiber by paper belt weighing 3 mg or by location at the distance of 10 cm interferometer of a heat source with the temperature of 35 C (at the temperature of ambient space of 25 C). At the interferometer output for digital registration of the holograms formed by interference of background and object beams the monochrome digital photographic camera with the pixel size of 9 x 9 μm was used. The record was carried out on the matrix area of 1000 x 1000 pixels. Time of exposure was 1/10000 sec.

The holograms were recorded using the experimental arrangements described above. In Figure 3 the digital holograms recorded in a condition of interferometer loaded by the paper bent (a) and without loading (b) are presented. The camera objective is removed. The large heterogeneity of intensity is connected with poor-quality chip of the input and output ends of the optical fibers. In Figure 4 the digital hologram recorded by camera equipped by objective is shown. The record was carried out under the scheme presented in Figure2. The objective forms the image of interference pattern at the distance of 5 mm from the beam splitter. At the next stage the differented interferogram was reconstructed under the recorded holograms with the help of algorithm described above. This interferogram contains the quantitative information on phase changes in laser radiation transmitted through loaded optical fiber. Then the area shown in Figure4 by rectangle was selected on this interferogram. In the borders of selected area the surface of phase distortions shown on Figure 5 was reconstructed.



a b

Figure 19. Images of digital holograms recorded in a condition of loaded (a) and unloaded (b) interferometer

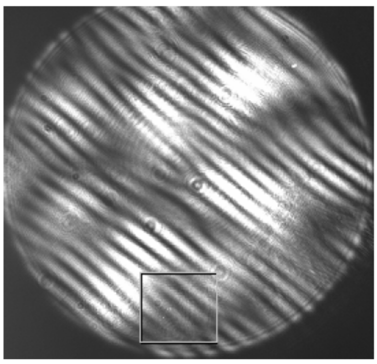


Figure 20. The digital hologram recorded by objective equipped camera

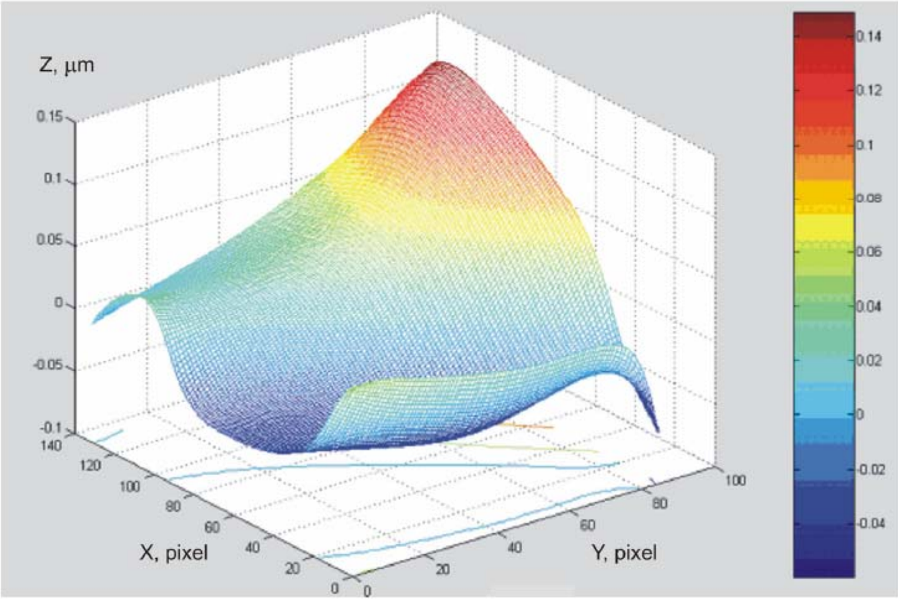


Figure 21. Interactive presentation of phase changes in the selected fragment of tested optical fiber section

From this figure one can see that the phase incursion in laser radiation transmitted through the selected area in the fiber section in recalculation on optical path length is 0.22 µm at external dot loading on a cable of 3 mg. The accuracy of measurements along z axis was 5 nm

6. Conclusion

One of the most modern course of the compensation methods development are segmentation methods, that finds implementation in the object – oriented TV images processing. Was specified that presented method by mean of the interframe difference has quite easy implementation, but also it requires the collective implementation with others methods such as parameter models method. This work results could be used for the video saving in the different information keeping devices, in the video cameras and digital photo cameras.

After the improving this video-codec could be used for the digital TV signals transfering by the cellular connection chanals with a speed no more then 2 Mbit/c and by the Internet chanals.

Every color has its own luminance value in proposed color space and there are no essential color tone changes and color distortion after the brightness editing in proposed color space.

Thus the capacities of a digital double-exposed holographic intreferometry method and developed computational procedure for quantitative analysis of phase changes arising in radiation propagated in optical fiber at over small mechanical influences are shown. In our experiments the accuracy of measurements along z axis in recalculation of a phase on an optical path was 5 nm. The above described method can be applied to diagnostics of optical splitters, connectors, focusing optics, welded assemblies of optical fibers. On the basis of the developed schemes the sensitive gauges of external influences can be created.

For the process of iteration would be convergent it is necessary, that values modules of diagonal matrixes Coefficients $H_{ds}(\omega,l)$ were more than modules of other coefficients. In the certain situations, not resorting to method of search of pseudo-decisions, this problem can be solved as follows. In system of the equations are allocated the equations with coefficients which modules there are more than sum of modules of other coefficients of the equation. Each allocated equation write out in such line of new system that the greatest on the module the coefficient has appeared diagonal. Practically it is carried out by an arrangement of detectors (receivers) on object in points where the allocated signal prevails of other signals.

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