The sensitivity evaluation of the television sensor for the radiation-resistant transmitting television camera based on vacuum transfer tube

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Abstract. Television and computing systems on the base specialized television systems for visual measuring of control internal surfaces tracts technological channels, metalworking and working spaces uranium-graphite nuclear reactors reviewed, pattern obtained, allowing define sensitivity this television systems, taking into account range from lens before object in this work.

1. Introduction
Television and computer systems (TVS) are used to detect objects, control linear dimensions, shape, color temperatures and areas of products, detect changes on an object, etc. Regardless of the purpose of the TVS, it includes a television sensor that converts an optical image into an electrical signal.

We will consider a television sensor based on a vacuum transmission tube - radiation-resistant vidicon LI501-1MK in this paper. The fuel assemblies created on the basis of this vidicon are capable of operating in conditions of increased radiation up to $5 \times 10^7$ Rad.

Fuel assemblies using this vidicon can be used to obtain information on the state of the internal surfaces of the paths of technological channels, metal structures and the working space of uranium-graphite nuclear reactors.

The Television Computing Complex (TCC) was created at the Department of Television and Control TUSUR on the basis of a specialized television system (STVS) for visual and measuring control of the internal surfaces of the paths of technological channels, metal structures and the working space of uranium-graphite nuclear reactors [1].

2. Description and characteristics of fuel assemblies on a radiation-resistant vidicon
To register a laptop with a video signal from a transmitting camera, video capture device (TV tuner) “Behold TV Columbus” as a PCMCIA board is used.

The device has the following features:
1. Viewing video from VHS (Composite) and S - VHS video inputs;
2. Digital image processing and doubling the frame rate when viewing;
3. Support for additional plug-ins - plug-ins;
4. Recording video in AVI, WMV, MPEG 1, MPEG 2 format using the codecs installed in the operating system;
5. Image processing during recording and splitting a file into segments of a given size;
6. Capture of individual frames and a series of frames in BMP and JPEG formats with a resolution of up to 768x576;

7. Remove noise and increase clarity.

The video signal received from the transmitting camera (figure 1) has the following features, manifested in aggregate or separately:

1. Low contrast.
2. Global change in average brightness level.
3. Change the clarity of the image.
4. Global change in video due to movement of the transmitting camera (shiver, swing, rotation).
5. Low-frequency and pulse noise.

The video signal processing (figure 2) within the framework of the task is to improve the quality of its display to facilitate the possibility (and increase the probability) of detecting surface defects. The video from the transmitting camera has an interlaced structure.

The composition of the video editor includes the following filters:

- **Image binarization.** All signal levels below the specified level are equal to the zero level, and all levels above the specified level - to the maximum. As a result, only two signal levels. Thus, it is possible to divide (by signal amplitude) information into "useful", which must be preserved, and "parasitic" (noise, interference), which must be eliminated. The level of binarization is indicated as a setting.

- **Limit by levels.** Like binarization, it divides information according to signal amplitude levels, but there are several levels. Those. signal levels within a certain range are equal to a certain level. Thus, the number of signal levels in the image decreases, i.e. reduced image detail. However, such a transformation allows you to explore the elements of the image that have the desired signal levels, without being distracted by other "minor" details of the image. The setting indicates the number of levels of restriction. The range (0 - 255) is divided into the appropriate number of restrictive ranges.

- **Invert image.** When processing, we are dealing with a brightness range (0 - 255). The new pixel value is calculated by the formula: \( I = 255 - x \), where \( x \) is the value of the current pixel before processing, and \( y \) is the value of the current pixel after processing. Inverted image may be more visually visible. For example, signal levels close to black differ worse than signal levels close to white. Thus, image objects with a small amplitude can be represented more clearly after inverting. No additional settings.

- **Filter "brightness correction".** This filter is designed to adjust the average brightness level of the image. The setting (both positive and negative) of the additive to the current average brightness level acts as the setting.

The composition of the video editor includes the following spatial processing filters:

- **Laplacian.** Used to highlight high-frequency elements of the image - differences in brightness in all directions. After processing, we obtain contours from brightness differences. No additional settings. When processing sharp changes in brightness, the appearance of "false" contours on the image is possible.

- **Filter "Sharpness".** The task of improving the clarity of the image is to highlight its high-frequency details. To do this, the image is processed by an averaging filter, then the difference between the original image and the result of its "averaging" is determined. The final result is obtained after summing the source and differential images. Obviously, the difference in the low-frequency regions of the original image will be much less than in the high-frequency regions. Thus, low-frequency areas are almost unchanged, and areas with high-frequency parts will become more contrast. Additional settings: aperture size (weight matrix) of the averaging filter. The aperture of the filter has the form of a "filled" square. Thus, the height (width) of the matrix is indicated as the size of the aperture.

- **Filter "Contrast".** The brightness histogram shows how fully the range of brightness is used in the image. Those. how many elements (pixels) of the image have the corresponding brightness value. The histogram of a contrast image is usually evenly distributed over the entire range. The image with such a histogram, as a rule, is perceived (visually) as better. In a low-contrast image, the histogram is
concentrated on a certain part of the range. This site can be characterized by two quantities: the lower and upper thresholds. The choice of values affects the final distribution of the histogram over the entire range (0 - 255).

During correction, the histogram "stretches" over the entire range, and the dark and light elements of the image become, respectively, darker and lighter. Used at the request of the user. Additional settings: the lower and upper thresholds of the histogram.

- Rank intraframe filter. Instead of convolution, a sample of pixels corresponding to nonzero elements of the filter mask is used. The resulting sample is sorted by increasing amplitude. From the resulting variation range, an element is selected, which is the result of processing. Thus, the choice of the middle element of a series implements the well-known median algorithm, which is used to eliminate impulse noise and, unlike the averaging filter, at the same time allows preserving the form of sharp changes in brightness. Additional settings: the size of the mask (the mask is in the form of a square), the number of the selected element of the variation series. Note that the closer the number is to the boundaries of the variation range, the closer the characteristics of the rank filter are to the characteristics of the high-frequency filter.

3. The sensitivity of television sensors on vidicons

The basic requirements, to television sensors, relates primarily ix provide high sensitivity. Usually, the literature presents dependencies for assessing the sensitivity of sensors based on CCD and CMOS arrays. In this connection, it is of interest to obtain similar dependences for radiation-resistant fuel assemblies on a vidicon.

Sensitivity is usually defined as the luminance value at the facility in lux, providing the specified quality parameters of the output video signal. The color temperature of the light source must be indicated.

Integral sensitivity is the ratio of the output video signal to the illumination on a photosensitive surface or on an object under specified conditions – accumulation time, color temperature of the light source, etc. Let us turn to the concept of illumination on a photosensitive surface. It is based on the well-known dependence of the image of the object. $E_{\text{im}}$ from the illumination of the object $E_{\text{ob}}$ [2, 3]

$$E_{\text{im}} = E_{\text{ob}} \frac{\rho_{\text{ob}} \sigma_{\text{ob}} \theta^2}{4(1 + \beta)^2} = E_{\text{cn}} \frac{\rho_{\text{ob}} \sigma_{\text{ob}}}{\beta^2} d^2 ,$$
where \( \beta \) is the linear image scale (system magnification ratio), \( d = \frac{\beta}{2(1+\beta)} = \frac{D}{2a} \), \( a \) is the distance between the lens and the object, \( D \) is the diameter of the entrance pupil of the lens, \( \theta \) is the relative aperture of the lens, \( \rho \) is the reflection coefficient; \( \tau \) is the lens transparency ratio.

In [4], a refined dependence is given

\[
E'_{im} = E_{ob} \rho \tau \frac{d^2}{\beta^2 (1 + d^2)}.
\]

In [4], a method was proposed for calculating the light illumination of an image depending on the illumination of the object of observation, which uses a refined dependence of the solid angle on the flat:

\[
\Omega = 2\pi (1 - \cos \frac{\alpha}{2}).
\]

This method considers the solid angle as a part of the space bounded by a certain conical surface, and not repelled by the method of measuring the solid angle. It is advisable to use the dependence obtained in [4] to estimate the integral sensitivity of a television sensor on a vidicon transmitting tube.

\[
E'_{im} = E_{ob} \rho \tau \frac{1}{\beta^2} \left[ 1 - \frac{1}{\sqrt{1 + d^2}} \right].
\]

This dependence takes account of the distance from the lens to the subject is commensurate with the distance to his image, and not much more than him.

4. Conclusion
This paper examined TCEs, based STVS for visually monitoring and measuring the internal surfaces of the channel paths processing, metal working space and uranium graphite nuclear reactors pattern obtained that allows to determine the sensitivity of TCC, take account of distance from the lens to the object.

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