Methods to Reduce Network Load when Transmitting Computer Images in Real Time

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Abstract: *The new approach related to the reduction of network traffic when transmitting computer images in real time has been studied. Two methods for computer image encoding and transmission in networks have been proposed. First method is directed to full-color computer image compression and transmission based on color palette reduction and "color coarsening", dictionary encoding and the second one aimed at computer binary compressed image transmission with the use of adaptive statistical threshold, based on the iterative classification and segmentation using line primitives and object boundaries to obtain binary image representation. The comparative results of four experiments of full-color image representation; grayscale image; image changes and color indexation; image changes with binarization (last three with data compression) have shown the effectiveness of the proposed methods for data transmission with several hundreds of times compression ratio depending on the image type and content in comparison with original image.*

***Keywords*:** Screen image compression, transmission, image segmentation, line primitives, object boundaries, binarization**.**

1. INTRODUCTION.

The excessive load of the network structure is one of the major problems associated with computer screen image transmission in real time used in several image processing applications such as video surveillance, video archiving, etc.

Since the elements of full-color images for RGB format are encoded with the use of least three bytes, the amount of information of computer screen data to be send cause a significant increase in traffic or load on the network.

There are a number of proven approaches [1-5] to address the problem, based on separate coding of individual parts of the image and data compression.

For example, the work of Tony Lin et all [6] presents a compound image compression algorithm for real-time applications of computer screen image transmission called shape primitive extraction and coding (SPEC) that segments a compound image into text/graphics pixels and pictorial pixels, and then compresses the pixels of first class with a lossless coding algorithm and the pictorial pixels with standard lossy JPEG method.

In this study, we used a similar to [6] approach of image classification and it separate encoding, but have applied more simple algorithms of lossless and lossy compression and implemented a real data communication system for dynamically changing computer screen image transmission. Furthermore, in this paper we have used the simple compression algorithms (dictionary and run length coding) to perform deliberate slight degradation only in places where the change has occurred and only in case when new colors have appeared for the previous image palette.

Thus, applying the dictionary compression and "color rounding" procedure of changed image parts at transmitter side we obtain the full-color screen image with a little loss of color only in places where there were slight changes at the receiver side.

To evaluate the decrease of the network load with the use of applied algorithms with color range reduction in specific areas achieving relatively high compression ratios maintaining the acceptable for specific tasks quality we have examined several scenarios of computer screen images transmission:

- Full-Color Image representation data transfer (FCI).
- Grayscale Image data transfer (GI).
- Image Changes and Color Indexation with Compression data transfer (IC&CIC).
- The only Image Changes Binarization with Compression data transfer (ICBC).

In conclusion, the paper presents the comparative results of experiments for transmission of different images for the above scenario, demonstrating the effectiveness of the proposed approaches to encode and transmit the computer screen images to reduce the traffic cost.

2. APPROACHES FOR IMAGE CODING AND TRANSMISSION.

2.1. Original image transfer.

To transfer the full-color image the full screen image picture is represented as the chain of bytes and transmitted in a network without compression. On the receiving side the transmitted image is created by processing the received stream of bytes. This transmission method called as FCI in 1-st chapter is further presented for comparison with other methods using proposed approaches for the reduction of transmitted image information.

Transmission occurs without any loss of quality, but there is a palpable strain on the network. The image that is transmitted is shown in Fig. 1.

Fig. 1 - Original computer image

2.2. Grayscale image data transfer.

The method, named as GI, consists of transmitting only the luminance image. It does not use any additional compression algorithms, to demonstrate how to reduce the load on the network. The luminance channel is obtained in GI data transfer after conversion of full-color image from RGB representation to HLS format that is used in all proposed processing algorithms. The cost for pixel representation does not exceed one byte that allows to achieve a significant reduction in the load on the network. On the receiver side we obtain the gray image that is shown in Figure 2.

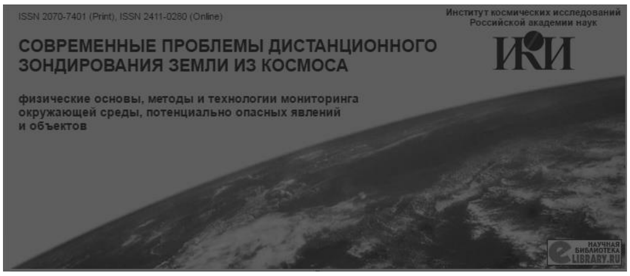

Fig - 2. Grayscale Image

2.3. Image changes transfer with color indexation and compression.

This method of IC&CIC data transfer involves the transmission of color information of only the changed pixels in screen image. For example, when the user is reading text by the use of scrolling around the pixels corresponding to the area of interest is only sent over the network that give a tangible advantage over the full color image transmission.

To encode the image based on the color indexing a vocabulary (palette) for compression has been created. It has 32 768 different items, including the main part and the auxiliary part. On the basis of statistical experiments the main colors of computer images we bounded by the number M=28672. The auxiliary part consist of A=4096 sells used for the representation with “color coarsening”. The redrawing of screen image is originally produced.

Then image processing is organized according to the steps presented in Fig.3. To obtain the necessary statistic the counting of color image pixels is applied. The colors of the image are indexed in the range $[0, M)$ and transmitted along with the defined color palette to a receiver. The created color palette have the reservation for so-called rounded colors that will be used for “color coarsening” of color representation in the auxiliary part of dictionary. Further, pixel by pixel comparison of current image with previous image scan is performed.

When a mismatch of color indices for successive pixels of current and previous image scan is found, the color index in the palette of the previous image is verified. If this color exists the new color index from M part of dictionary is transmitted to receiver, and if the color is not present in palette, the rounded (unimportant) color from A part of dictionary is transmitted performing “color coarsening”. To improve the compression ratio the encoding of repetitive color elements (indexes) is used.

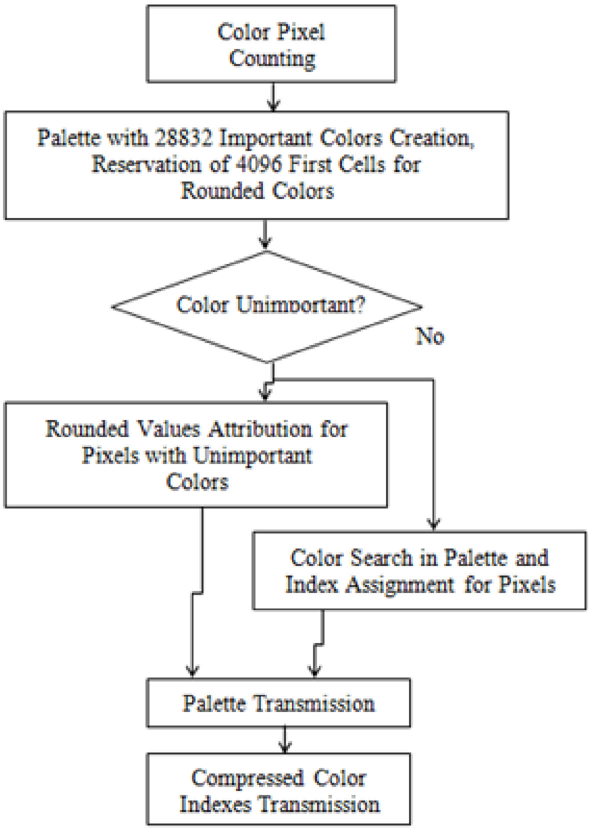

Fig. 3. Image transmission with color indexation

The compressed image data transfer begins from palette followed by indexes transmission.

In the case of a large number of new colors appearance the when the changed data transfer results in “color coarsening” for more than 30% of the entire image, the image scan is completely reproduced and new palette and color indexes are transmitted.

As it can be seen from Fig.4 for IC&CIC data transmission, we obtain image with very little quality loss.

Fig. 4. Image with color indexation

2.4. Image binarization, compression and transmission.

This method can be used for applications where it is important to determine the content of the image, and not to receive a precise copy of it. To determine the image content we consider the application of so-called binarization procedure that which converts a color or gray image into an image having only black and white pixels. Obviously the transition to black-and-white copy of the screen image will significantly reduce the load on the data network. There are many different algorithms for image binarization. However, they are often used for gray image conversion, which leads to the loss of information and the difficulty to recognize the required objects.. To solve this problem, we can use the selection of the most informative parts of color image components or perform the image binarization in parallel for all components [7], that leads to increase of complexity. Therefore, to improve the conversion accuracy and reduce the time to perform this procedure the adaptive binarization algorithm based on the luminance of HLS image has been proposed in this paper. We perform the process of binarization locally with the use of second component of HLS with dynamic threshold that significantly improve the quality of recognition and the number of detected elements.

In the case of a binary image, when the color of the object is not important, it is possible to obtain a sufficiently large compression ratio and thus significantly reduce the load on the network.

The conversion from three byte image format to a binary one leads to the achieving the compression ratio of two dozen times. However, with the application of run length coding we can achieve even greater compression ratios. To implement this method an algorithm that takes into account the dynamic change of screen content, presented in a binary format has been proposed (Fig. 5).

Initially, the image is scanned column by column and row by row in order to find the geometric primitives, typical for a computer image - horizontal and vertical lines. Further search for the boundaries of objects, that are also have linear structure, is performed.

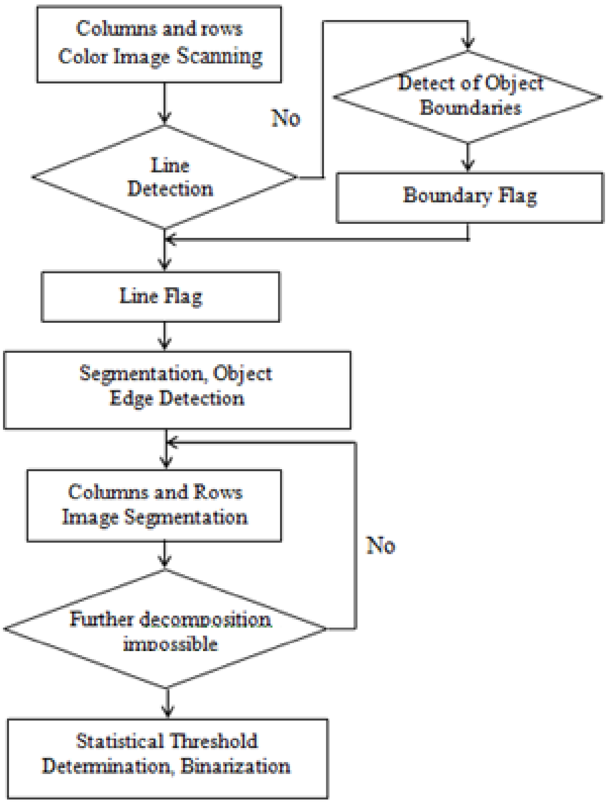

Fig.5. Image transmission with binarization and compression

When these primitives are found, special flags are appeared and algorithm proceeds to the process of segmentation and definition of objects' boundaries. Then segmentation is made taking into account the structure of columns and rows of pixels. We look for nested objects and checked whether it is possible to further decompose the image. Hence each embedded object is sought to perform a dynamic threshold binarization.

The transferred structure for the changed part of binary image acquires a more compact form that significantly reduces the load on the network (Fig. 6).

Fig. 6. Binary image with compression

3. EXPERIMENTAL RESULTS

To perform the experiments the developed software was installed at one work station making the transmission in real-time of user's screen screenshots over the network to another workstation when any changes has been appeared according to methods described above. At the expiration of the user activity image transmission was stopped and the throughput was calculated. The amount of image information transmitted over the network for two methods has been fixed for the entire session.

It is obvious that for the various user actions, there must be a diverse in the network load and data transmission according to changes in image screenshot.

For example, when user prints a text, the load on the network by using FCI method, it will be equivalent to the transfer of full screenshot information. From the first hand, the load on the network for IC&CIC and ICBC methods by fixing only the image changes is quite small. On the other hand, when user is watching video, where a large number of changed pixels is fixed, the network load will be decreased due to the factor of color elements repetitions, when FCI method and IC&CIC and ICBC methods are compared.

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To find the values of the network load difference for the methods proposed, depending on the user's actions, two comparative tests have been conducted. In the first test the screenshot palette changes were significant (video preview). In the second test the screenshots palette changes were negligible (text printing). The results of test are presented in Fig. 6 and Fig. 7 correspondently.

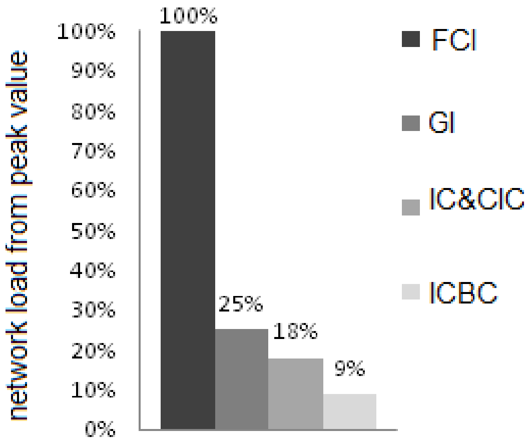

Fig.7. Comparison of transmission methods when screenshot palette changes are insignificant

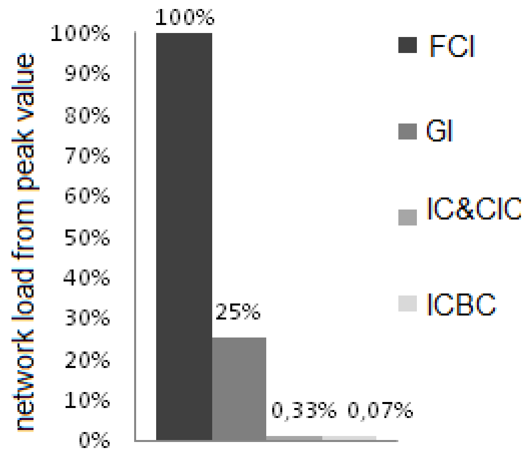

Fig.8. Comparison of transmission methods when screenshot palette changes are significant

The graphs above show the ratio of transmitted amout of data of the current method (marked with gray rectangule) respectively to the method of FCI transfer expressed in percentage.

The graph corresponding to the user's work, in which there were large changes in color palette screenshots present the values 18%, 9% and 0.33%, 0.07% for IC&CIC and ICBC methods correspondently as shown in Fig. 7 and Fig.8. Thus, 1-st method of IC&CIC transmission enables the reduction of network load for more than 300 times; 2-d method of ICBC transmission gives a decrease of network load for about 1500 times as compared to FIC transmission when the color palette changes of image (screenshots) are negligible.

4. CONCLUSION

Thus, depending on specific task demands according to the quality of the image, several solutions have been proposed, that can decrease significantly the network load in real time with high compression ratio depending on the image changes. The results can be used in a number of applications relating to the registration of images, video surveillance and monitoring of user activity. Fo example, to compare the amount of stored image information, using the methods, described in this paper, with a known program for work places registration *kickidler* [8] the necessary calculation was performed. The results show that for the normal user operations, using ICBC transmission method, only about 3 megabytes of total information is transferred to register a single workstation on average per working day, and for IC&CIC transmission method about 10 megabytes is transferred of color image on average during the working day. For comparison, the known program kickidler for registration of work place holds about 500 megabytes of video recording with a single station on average per working day.

Thus, the use of proposed algorithms can significantly reduce the hard-copy of data and time spent in a number of user registration activity tasks.

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