#147

BICA*AI 2023

BICA VPS 2023

Combined contrast enhancement algorithm for high dynamic range images.

M.A. Kazakov[1].

[1]Institute of Applied Mathematics and Automation KBSC RAS (IAMA KBSC RAS), Nalchik, Russia. kasakow.muchamed@gmail.com.

IAMA KBSC RAS

INSTITUTE OF APPLIED MATHEMATICS AND AUTOMATION OF KABARDIN-BALKAR SCIENTIFIC CENTER OF RAS

SUMMARY

The work proposes a combined contrast enhancement method that can significantly increase the contrast of raw images with a large dynamic range. The combined method uses a partition-based clustering algorithm, Sobel filters, and Contrast Limited Adaptive Histogram Equalization algorithm (CLAHE).

INTRODUCTION

Image contrast enhancement is the process of improving the visual quality of an image by adjusting its brightness, color, and sharpness. It can help to reveal hidden details, highlight important features, and reduce noise or blur in the image.

When working with raw images obtained directly from the matrix of equipment (for example, X-ray), the tasks of correcting the histogram and improving contrast arise. In particular, highlight regions, which correspond to very high pixel intensity, make the informative area very dim. In the informative region of an image, the pixel intensities may lie close together compared to the dynamic range, making the image illegible.

Preprocessing is important not only for improving human perception of an image, but also necessary when working with automated data analysis.

CLAHE

The CLAHE algorithm is the basis of the proposed method. It is an image processing technique used to enhance the contrast and improve the details in images, particularly in regions with varying lighting conditions or low contrast. Here's a brief overview of the CLAHE algorithm:

Dividing the Image: The input image is divided into smaller, non-overlapping tiles or blocks.

Histogram Equalization: Histogram equalization is applied individually to each tile.

Contrast Limiting: To prevent excessive contrast enhancement and the amplification of noise, CLAHE introduces a contrast limit or threshold for each tile.

SOFT CLIP HIGHLIGHT AREAS

Here is a step-by-step description of the highlight areas reduction algorithm:

1. The histogram is split into N bins ($N = 24$ is a fairly optimal choice).

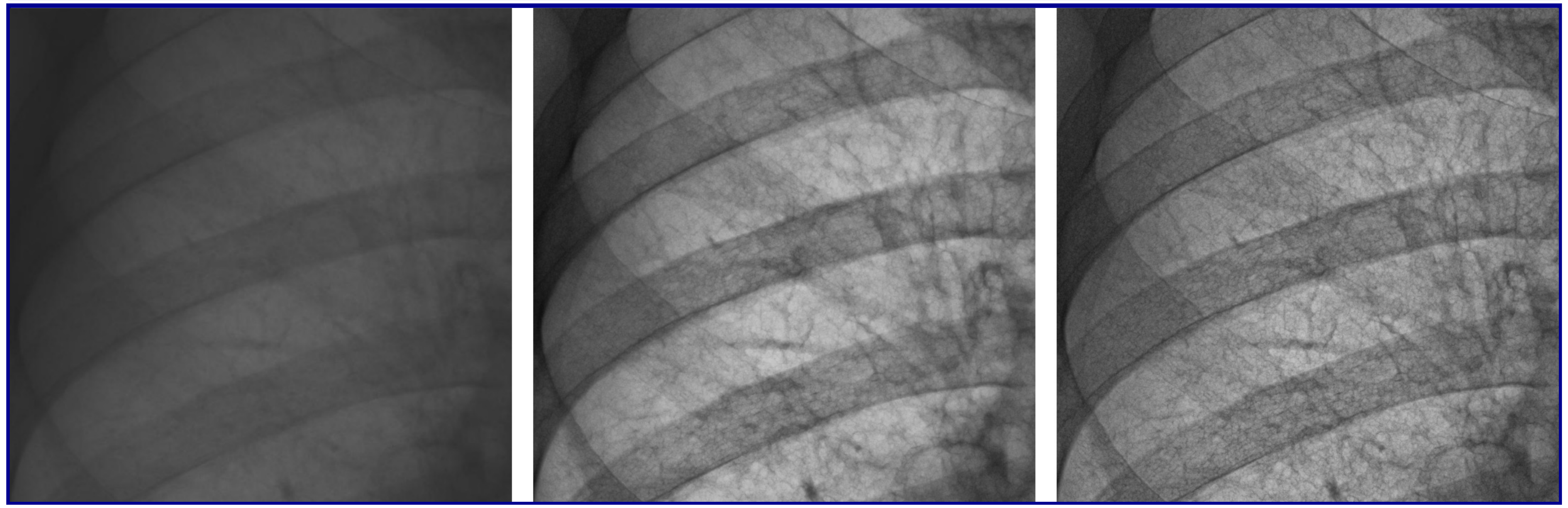
2. The first bin is selected by iterating over bins, starting from bin with index 0. The first bin is the one whose value exceeds the specified density threshold. This bin initializes the cluster.

3. Starting from the first bin, a frame moves along the histogram, covering 3 bins. At each position, the average of the bins values is calculated. Frame shifts to the right, expanding the cluster until the average value of bins is less than the specified density threshold.

4. The right boundary of the formed cluster is taken as the cut point t. Soft clipping of the right part of the histogram is performed. This is done by gamma transformation of all pixels whose intensity exceeds the cutoff point (i.e. for $r > t$):

$$s = (r - t)^{\gamma} + t$$

Fig. a) origin; b) depth=4; c) depth=8



COMBINED ALGORITHM

The first step is soft clipping the highlight areas. In the second step, the histogram is equalized by combining several CLAHE transforms with different tile grid sizes and contrast factors. The number of CLAHE transformations is specified by the depth parameter. Empirically, it has been found that the best results are achieved by choosing the base CLAHE transform with tile grid size equal to 6 (depth = 1), which doubles the tile grid size at each depth step. The optimal result is obtained with depth equal to 4. An increase in depth is accompanied by an increase in image detail, but at the same time it is accompanied by an increase in the running time of the algorithm, and an increase in noise. An example of image processing can be seen in Figure 2: here are the original image obtained from the X-ray equipment, the processing results at depth = 4 and depth = 8 (see results in Fig).

CONCLUSIONS

The proposed combined method allows you to effectively improve the contrast of the raw image obtained on the equipment matrix and achieve high detail, due to highlight areas reduction and a combination of CLAHE transformations. The method is suitable for processing 8bit images, however, more significant results can be achieved on larger bit images (e.g. 14bit or 16bit), the dynamic range of which is much wider. By adjusting the depth, you can achieve different levels of detail. However, it should be borne in mind that high detail requires more computing resources, and is accompanied by some increase in noise.