

PROCESSING OF X-RAY IMAGES OF THE HUMAN BODY FOR SECURITY TASKS

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Abstract

We present the application of different filtering algorithms to simplify the search for suspicious objects on the X-ray images. We have proposed a modification of Roberts gradient filter with window size 4x4, allowing to identify 12 directions in the $O(36*N)$ operations over the image. Summation image after adaptive equalization with the obtained gradient image, corrects deficiencies of the equalization.

Purpose

X-ray inspection systems are used in airports to screen passenger's luggage. By developers of Budker Institute of Nuclear Physics was set up a low dose digital X-ray scanning device SibScan[1,2] which allows scanning passenger without harming them to detect suspicious objects on the human body. With this approach, the main target of the image analysis software is to ease human perception and semiautomatic search for suspicious objects.

Roberts operator 4x4

$$S_{11} = \sum_{i=1}^2 \sum_{j=1}^2 d(i,j) \quad S_{12} = \sum_{i=1}^2 \sum_{j=3}^4 d(i,j)$$

$$S_{21} = \sum_{i=3}^4 \sum_{j=1}^2 d(i,j) \quad S_{22} = \sum_{i=3}^4 \sum_{j=3}^4 d(i,j)$$

$$J_1 = S_{22} + S_{12} - S_{11} - S_{21}$$

$$J_2 = J_1 - 2d(4,3) + 2p(1,2)$$

$$J_3 = J_4 + 2d(3,4) - 2d(2,1)$$

$$J_4 = S_{12} + S_{11} - S_{22} - S_{21}$$

$$J_5 = J_4 + 2d(2,4) - 2d(3,1)$$

$$J_6 = J_1 + 2d(4,2) - 2d(1,3)$$

$$l = \arg\max_{k=1..6} (|J_k|)$$

$$X = |J_l|$$

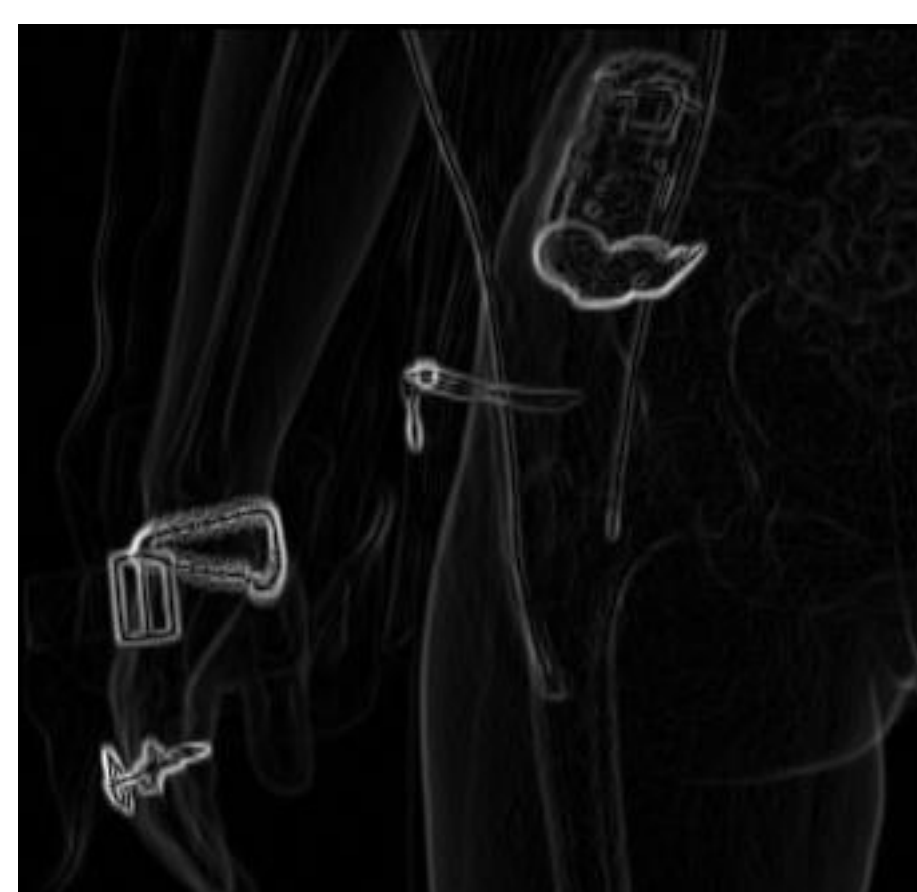
$$D = l * \text{sign}(J_l)$$

| | m-2 | m-1 | m | m+1 |
|-----|-----|-----|-----|-----|
| n-2 | d11 | d12 | d13 | d14 |
| n-1 | d21 | d22 | d23 | d24 |
| n | d31 | d32 | d33 | d34 |
| n+1 | d41 | d42 | d43 | d44 |

X and D are the value and the direction of the gradient. This modification of Roberts[3] filter allows to identify 12 directions in the $O(36*N)$ operations. This filter uses optimally the available statistics i.e. Sobel [4] filter and Prewitt [5] ignore the middle element while calculating the gradient.



Roberts 2x2



Roberts 4x4

Improving the visual quality of the image

To increase the contrast was proposed to use adaptive histogram equalization CLAHE [6]. It allows seeing small objects inside the human body. The combination of different filters, such as the logarithm, the median filtering [7] in conjunction with addition or subtraction, can obtain images with better contrast in a part of dynamic range.



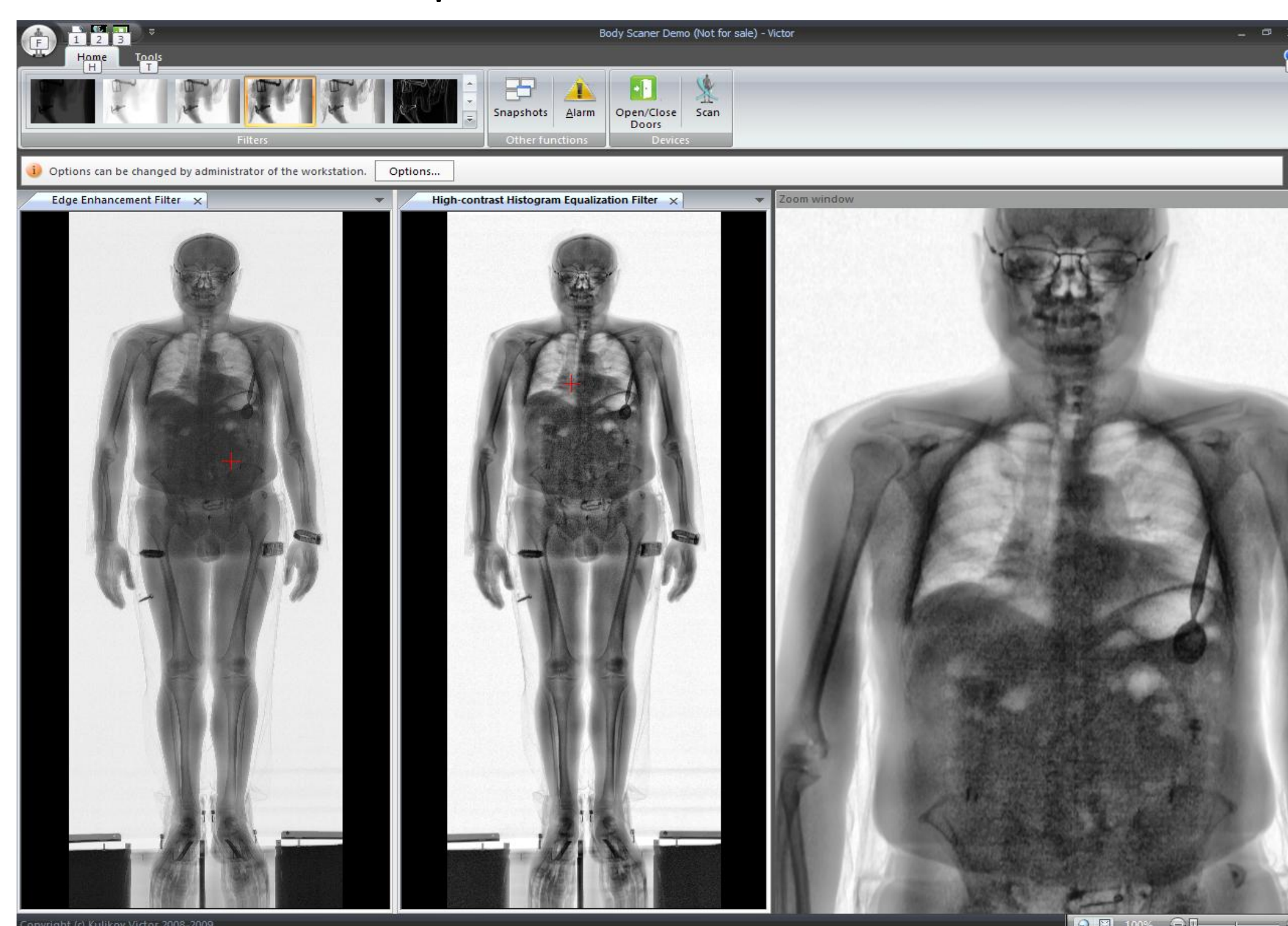
log

log + grad

adapt. equal. + grad.

Software implementation

We have developed software that allows receiving, process, displaying and storing X-ray images. Filtering algorithms were implemented in C++. They are connected to the main program through the component that distributes the image processing between processor cores according to OpenMP technology. This software has been integrated into security system of the Tolmachevo airport of Novosibirsk.



References

1. Babichev E.A., Baru S.E., Neustroev V.A., Leonov V.V., Porosev V.V., Savinov G.A., Ukrantsev Yu.G., "System of radiographic control or an imaging system for personal radiographic inspection", Nuclear Instr. And Methods in Physics Research, A525, p.332-335, 2004
2. Babichev E.A., Baru S.E., Groshev V.R., Khabakhpashev A.G., Leonov V.V., Neustroev V.A., Porosev V.V., Savinov G.A., Shekhtman L.I., "The new effective detector for digital scanning radiography", Nuclear Instr. And Methods in Physics Research, A513, p.57-60, 2003
3. Roberts L.G. – Optical and Electrooptical Information Processing Ed. By J. Trappett, D. Berkowitz. – MIT Press, 1965, p. 159-197.
4. Tennenbaum J.M., Sobel I., e.a. – Proc. Of Intern. Joint Conf. on Artificial Intelligence, 1969, p. 521-526.
5. Prewitt J.M.S. – Picture Processing and Psychopictorics Ed. By A. Rosenfeld, B. Lipkin. – N.Y.: Academic Press, 1970, p. 75-149.
6. ALI M. REZA "Realization of the Contrast Limited Adaptive Histogram Equalization (CLAHE) for Real-Time Image Enhancement" Journal of VLSI Signal Processing 38, p. 35–44, 2004
7. González, R. Woods, R. Digital Image Processing Publishing "Technosphere" Mockava 2006 p. 1070