

INFORMATION TECHNOLOGY & IMPLEMENTATION (SATELLITE)



# INFORMATION TECHNOLOGY & IMPLEMENTATION (SATELLITE)

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FACULTY OF COMPUTER SCIENCE AND CYBERNETICS)  
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This book includes abstracts of the 11th International Conference "Information Technology and Implementation (Satellite) – 2024". Philosophical, theoretical and applied aspects which describe the results, problems and prospects of the creation and use of intelligent computing methods and creating of information systems and technology on their basis are reviewing.

Main tracks of the conference are: Artificial Intelligence Technologies and Data Science, Cyberspace Protection Technologies, E-government, E-commerce and E-learning Technologies, Network, Internet and Smart Technologies, Software Engineering, Data Structures and Computing.

До цієї збірки увійшли тези доповідей 11-ї Міжнародної конференції «Інформаційні технології та впровадження (сателітної) – 2024». Розглядаються філософські, теоретичні та прикладні аспекти, які описують результати, проблеми та перспективи створення і використання інтелектуальних обчислювальних методів та створення на їх основі інформаційних систем і технологій.

Основні напрямки конференції: Технології штучного інтелекту та Наука про дані, Технології захисту кіберпростору, Електронне урядування, електронна комерція та Технології електронного навчання, Мережеві та Інтернет-технології, Розумні технології, Розробка програмного забезпечення, Структури даних та Обчислення.

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**Dmytro Pupchenko**

Master of Computer Sciences

**Volodymyr Gorokhovatskyi**

Doctor of Technical Sciences, Professor

*Kharkiv National University of Radio Electronics, Kharkiv, Ukraine*

## ACCELERATED FILTRATION OF ULTRASOUND IMAGES

**Abstract:** The aim of this work is to create a high-speed algorithm for filtering ultrasound images that has the added property of edge preservation. The performance of popular methods is reviewed. A method of enhancing the existing method based on the decomposition of calculations into a one-dimensional space is proposed. The proposed solution significantly reduces computational costs without losing the efficacy of noise filtering. The overall effectiveness of ultrasound image filtering in terms of performance and quality has been experimentally confirmed.

**Keywords:** ultrasound images, filtering, speckle noise, decomposition, processing speed.

Ultrasound (US) imaging is based on generated images that are distorted by noise known as speckle noise. It occurs because soft tissue cells under the influence of an ultrasound wave receive energy from the wave and scatter this energy in all directions. Depending on the location of other scatterers in the vicinity, propagating ultrasound waves can experience both constructive and destructive interference depending on the phase of the waves during their interaction. One of the results of this phenomenon is the formation of speckle noise in the generated image [1], as shown in Fig. 1.

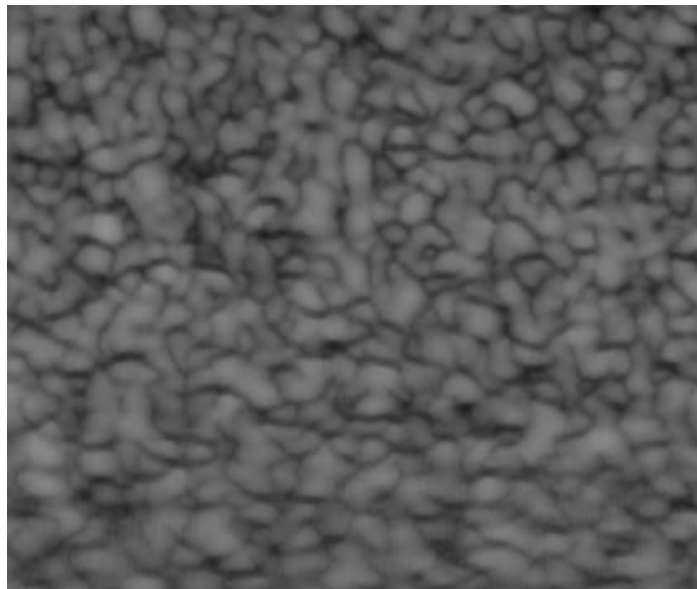


Figure 1 – Example of speckle noise on a uniform area of 1 cm<sup>2</sup>

In this situation, image filtration is a necessary and very important step in ultrasound visualization, because speckle interferes with the diagnostic interpretation of the examination data by distorting the size, borders, and texture of the tissue under analysis, or even completely removes small features such as small vessels, cysts, tissue inflammation, etc.

Traditional filtering techniques, such as Gaussian blurring and other methods based on local kernels, are often unable to preserve image details, especially when a high degree of filtering is required [2-4]. However, the distortion of details leads to the loss of valuable diagnostic data and a high risk of false diagnosis. This can also be harmful in multi-component filtering systems [5,6], or if the filtered image is to be used as data for further segmentation and classification [6-8].

This creates the need to develop novel filtering systems that can filter out noise while preserving typical diagnostic features in the image. Therefore, many works on ultrasound image filtering propose various edge-preserving filtering methods to reduce noise and preserve image features [2-5]. However, despite significant progress, the developed solutions are still an order of magnitude slower than state-of-the-art filters based on local kernels.

Among the many edge-preserving filters, the most popular are those based on the bilateral filter. The optimized RTBF method [4] calculates the filtered result using a weighted average of neighboring pixels, taking into account the intensity difference between them in the kernel. However, it is computationally expensive, especially when a large kernel is used for the most efficient speckle filtering. At the same time, the proposed techniques for further accelerating RTBF can no longer provide the required quality of smoothing, edge and detail preservation.

Our research is aimed at developing an efficient methodology for performing edge-preserving smoothing of ultrasound images. For this purpose, we propose to optimize the existing filtering model, which is formulated as minimization of the objective function (WLS) [2]. WLS allows for detailed control of the smoothing process and ensures high quality smoothing and preservation of informative boundaries. However, this is realized at the expense of much greater computational complexity, which makes this technique inaccessible for real-time applications, such as ultrasound imaging procedures.

WLS calculates different weights throughout the image to control the smoothing. This allows the smoothed result to remain close to the input image in areas of high variability, which preserves important details and helps to increase the similarity between similar pixels if there is no strong edge.

The filtering process is formulated as a one-time or iterative solution to a large-scale linear system of equations, using an affinity function and sparse Laplace matrix to describe the relationships between pixels and differences in adjacent regions. These relationships are critical for preserving edges and detail. The solution of this system makes it possible to obtain a filtered image with the required balance of similarity to the origin and filtering strength.

The proposed improvement method is realized by a one-dimensional decomposition of the two-dimensional WLS function. Such a one-dimensional representation allows a solution of a sequence of one-dimensional linear subsystems and makes it possible to use a fast algorithm for solving tridiagonal matrices [3] instead of the Laplace matrix solution algorithm.

To effectively smooth the 2D signal using the proposed 1D solver, a one-dimensional solver is applied sequentially and iteratively along each signal dimension

(rows and columns of the image). Similar principles of multidimensional data processing are also discussed in [6]. Such an implementation is much faster than solving large-scale linear systems obtained without using the proposed decomposition.

We have compared the proposed method with the state-of-the-art method of optimized bilateral filtering RTBF [4]. The results of processing by different methods are shown in Fig. 2. The comparison of methods was performed on ultrasound images of the carotid artery using the Soneus P7 ultrasound scanner and Ultima PX software from Ultrasign Technologies, LLC [5]. The implementation was made in C language, the size of the matrix representation of the image is  $512 \times 256$ .

The criterion for comparison is PSNR (peak signal-to-noise ratio), which is calculated as follows:

$$\text{PSNR} = 10 \log_{10} \left( \frac{S^2}{\text{MSE}} \right), \text{MSE} = \frac{1}{N^2} \sum_{i,j=0}^{N-1} (X_{ij} - Y_{ij})^2,$$

where  $S$  is the maximum intensity of the filtered image, and  $X$  and  $Y$  are the input and filtered images, respectively, with size  $N \times N$ . The PSNR value is high for good quality images and low for low quality images [6].

For the experiment, we used real measured data rather than synthesized speckle noise added to test images. Real data contains significant multilayer complexity, which is difficult to reproduce in synthetic models that simulate the effect of speckle noise. Today, even the most advanced speckle noise generation algorithms cannot accurately simulate the physical processes that occur during ultrasound scanning [9].

Real data also contains important information about pathologies, which is highly relevant for the development and evaluation of image processing methods for disease diagnosis. Synthetic data is usually generated using healthy tissue examples or highly simplified pathology models. This limits its suitability for solving real-world clinical problems, and its usefulness in segmentation and classification algorithms that must deal with various types of noise, scanning artifacts, variations in anatomical structures, and other factors that can significantly affect image quality and visual perception.

The RTBF method on the test images demonstrated a PSNR value of 35.22 dB, and the proposed method has a PSNR value of 34.96 dB. The filtering time is 5.2 ms for the proposed method, which is significantly (five times) faster than 25.3 ms for the RTBF method. For the unoptimized WLS method, the filtering time was 543 ms, which represents a gain in processing time of more than 100 times.

The results of the study showed the effectiveness of the implementation of the developed method to ensure high-speed filtering of speckle noise in an ultrasound image. The developed algorithm for speckle noise filtering based on the fast determination of the minimum of the objective function achieves high-quality filtering, as confirmed by Fig. 2, and is of high performance for real-time use both independently and as part of modern filtration systems.

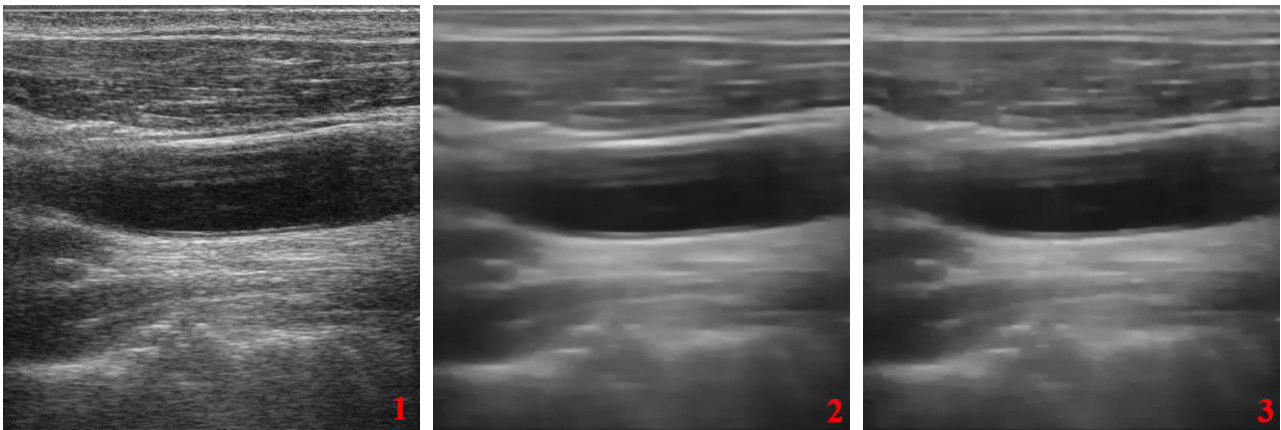


Figure 2 – Comparison of methods for noise removal on a 12 cm<sup>2</sup> area:  
(1) input image, (2) proposed method, (3) RTBF.

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