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3D-FILTERS FOR MEDICAL IMAGE PROCESSING IN THE NI LabVIEW

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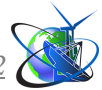
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Abstract. *The relevance of topic of the work is related to new opportunities in medical diagnostics and rehabilitation engineering, which are based on special processing of images of computed tomography and magnetic resonance imaging. In both cases, 3D reconstruction of objects based on a set of tomographic layer-by-layer images is used. In the tasks of rehabilitation engineering, the results of 3D reconstruction are used to create prototypes of prostheses, and in diagnostics - to facilitate the identification of diagnostic signs. In both applications, an important stage of processing is the filtering of the created 3D objects with the aim of either smoothing the surface of printed prosthetic prototypes, or adjusting the detailing of diagnostic features when comparing 3D objects. At the same time, in the presence of a large number of different implementations of filters for processing one-dimensional signals and 2D-images, in the three-dimensional case, there is a gap here. In particular, it concerns to the NI LabVIEW software environment, which is quite widely used now in many medical applications. In the work, the development and testing of 3D filters of various types in the NI LabVIEW environment was carried out for medical applications.*

Key words : *3D filters, NI LabVIEW, 3D reconstruction, smoothing the surface, 3D objects.*

Introduction Computed tomography (CT) and magnetic resonance imaging (MRI) created the foundations for significant improvement of medical diagnostic tools, as well as rehabilitation engineering at the modern stage. In both cases, 3D reconstruction of objects based on a set of tomographic layer-by-layer images is often used. In the tasks of rehabilitation engineering, the results of 3D reconstruction are used to create prototypes of prostheses, and in diagnostics - to facilitate the identification of diagnostic signs.

In prosthetics, 3D reconstruction allows you to get closer to the industrial semi-automatic mode of manufacturing prototypes by printing them on 3D printers. In diagnostics, the reproduction of 3D objects, firstly, improves visibility, and secondly, in the case of paired or symmetrical organs, it is possible to use the method of comparing a healthy and mirrored pathological part in order to draw the diagnostician's attention to their differences. In both cases, an important stage of preprocessing is the filtering of created 3D objects with the aim of either smoothing the surface of printed prosthetic prototypes, or adjusting the detailing of diagnostic features when comparing 3D objects. After all, it is clear that the diagnostic signs of



pathologies are usually significantly larger than the size of voxels of the reproduced 3D objects. Therefore, before comparing 3D images of paired organs, it is suggested to apply different 3D filters or their combinations with adaptive parameters to them. In this way, it is possible to adjust the detail or sensitivity of the diagnostic method of comparison depending on specific circumstances.

The purpose of the work is development and testing of 3D filters of various types in the NI LabVIEW environment for medical applications.

Main text

NI LabVIEW is chosen as the development environment, which is quite widely used now in many medical applications [1]. A set of layer-by-layer CT images of the knee part of the patient's legs was chosen as a sample of 3D reconstruction for testing, which without pre-processing have a rather complex spatial structure, which as a result clearly illustrates the feasibility of the proposed filtering tools.

For 3D reconstruction, the method of constructing and visualizing isosurfaces is most often used, that is, the geometric location of points with the same density of X-ray absorption in the case of CT [2].

To illustrate the 3D reconstruction, a library function of the NI LabVIEW environment was used (Figure 1, here the “filters” modules developed in this work are added to the library function; the composition of this modules will change in the process of further analysis).

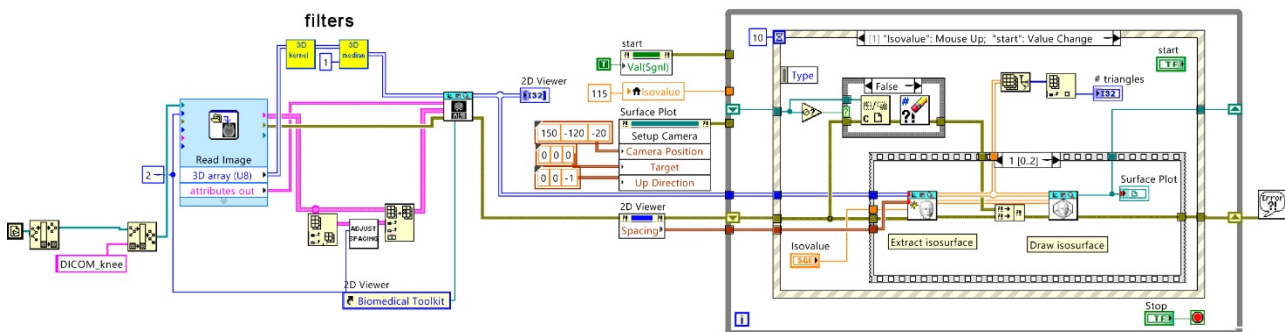


Figure 1 – Block diagram of 3D Image Reconstructor with filters

A source: [3]

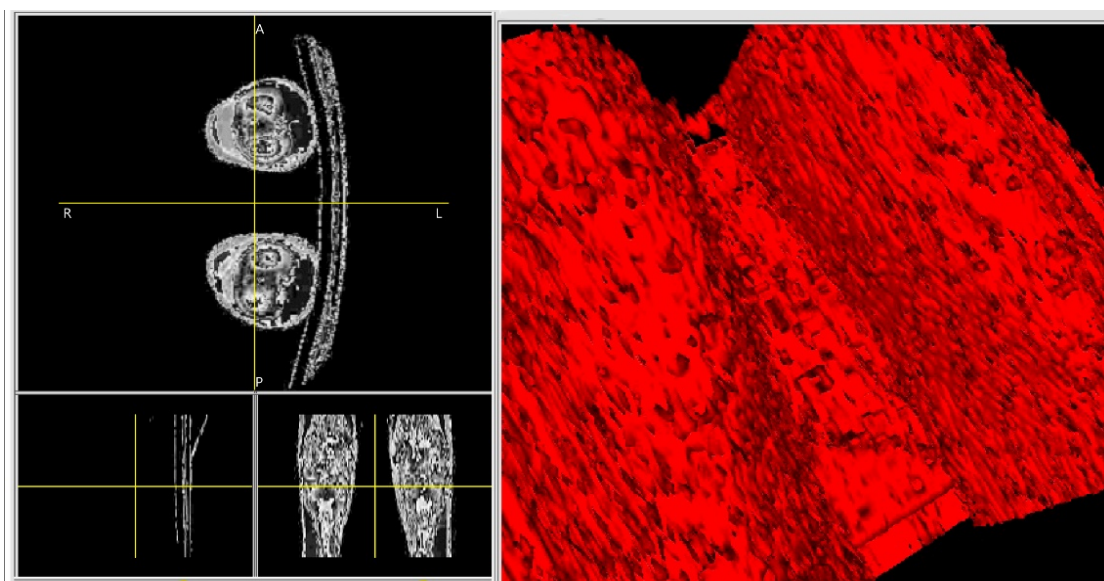


Figure 2 – Controls palette of 3D Image Reconstructor without filters



Without using any filter, the isosurface on the screen of the 3D-reconstructor looks quite complicated (Figure 2). The detailed structure of the surface would interfere with the creation of a prototype of the prosthesis or the detection of diagnostic features.

3D filters were developed to adaptively compensate for excessive detail in order to detect larger diagnostic features or to print prosthetic prototypes on a 3D printer with a smoother surface. Next, the block diagrams of the corresponding filters and the results of their work for smoothing isosurfaces in the 3D-reconstructor are given.

Figure 3 shows a block diagram of a 3D filter that calculates the arithmetic mean in a 3x3x3 sliding window.

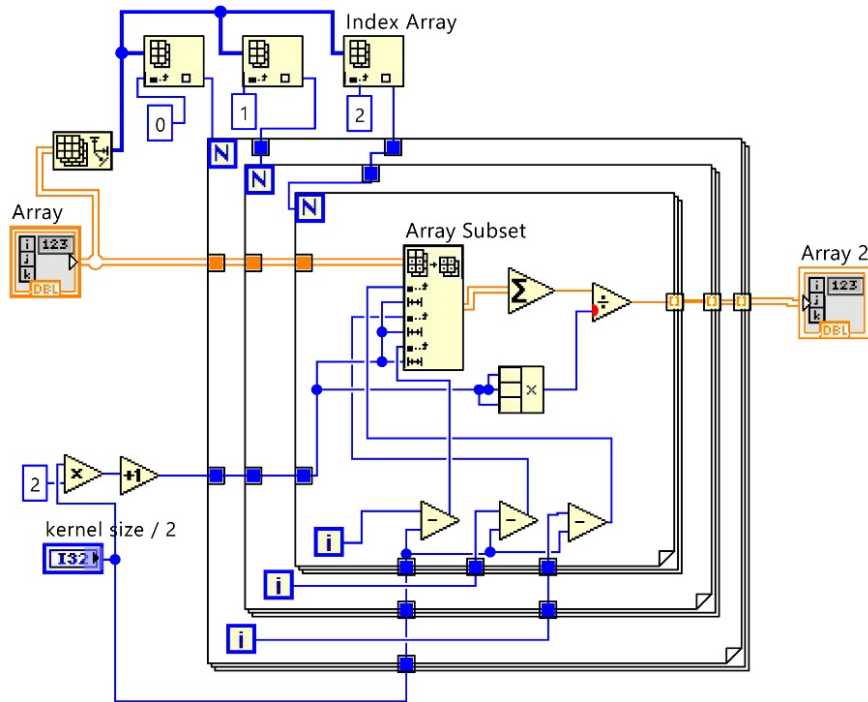


Figure 3 – Block diagram of mean 3D-filter

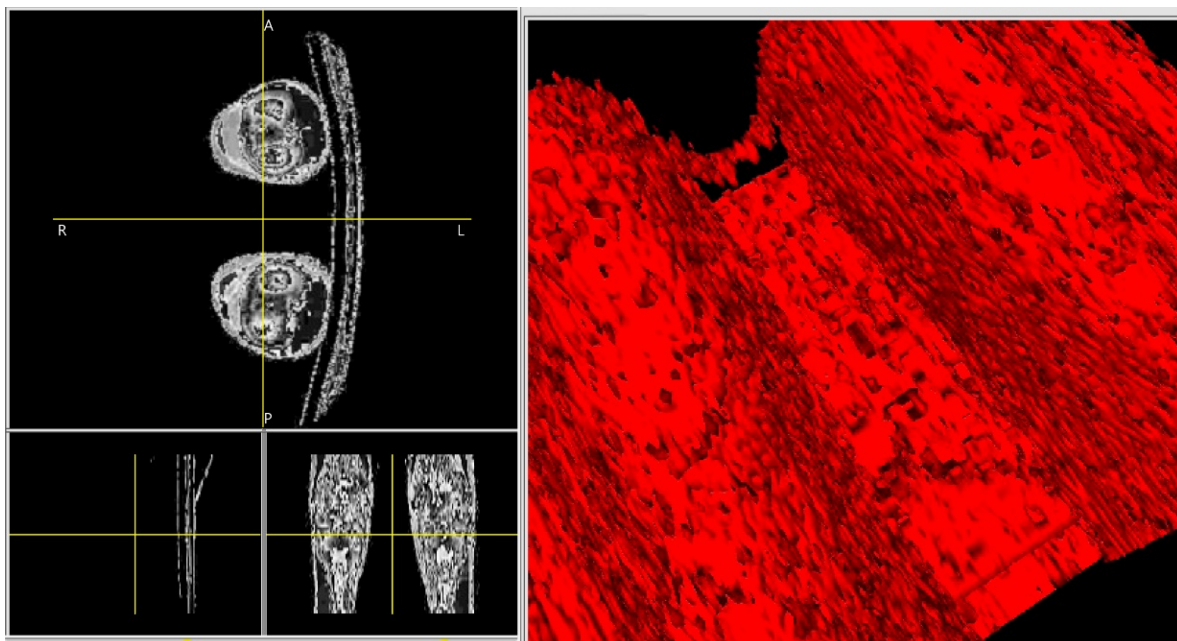


Figure 4 – Controls palette of 3D Image Reconstructor with mean filter



Figure 4 shows the result of the arithmetic average filter on the 3D-reconstructor screen.

Figure 5 shows a block diagram of a 3D-filter performing convolution with a Gaussian filter core in a 3x3x3 sliding window.

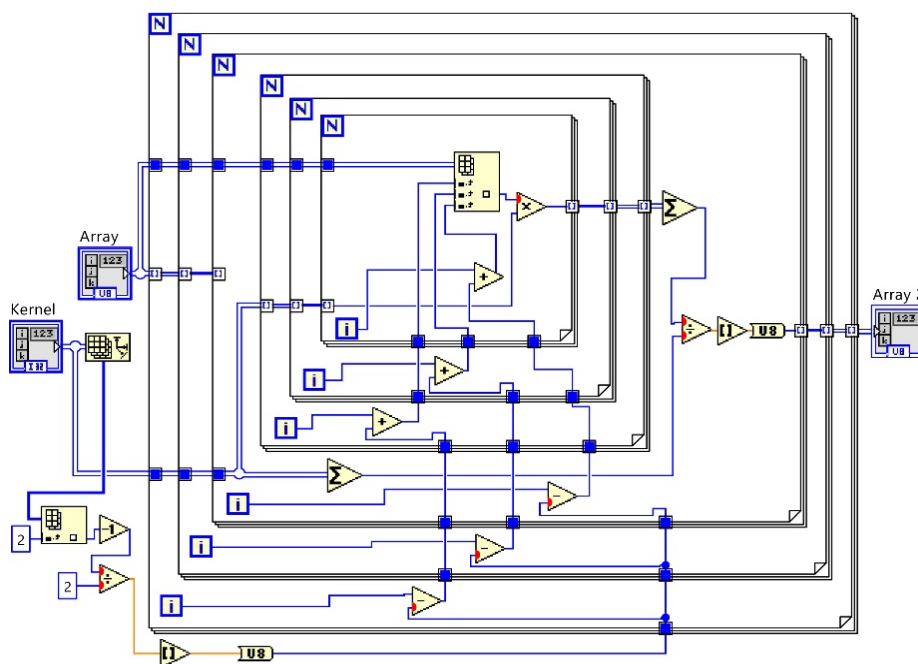


Figure 5 – Block diagram of Gaussian 3D-filter

Figure 6 shows the result of the Gaussian filter on the screen of 3D-reconstructor.

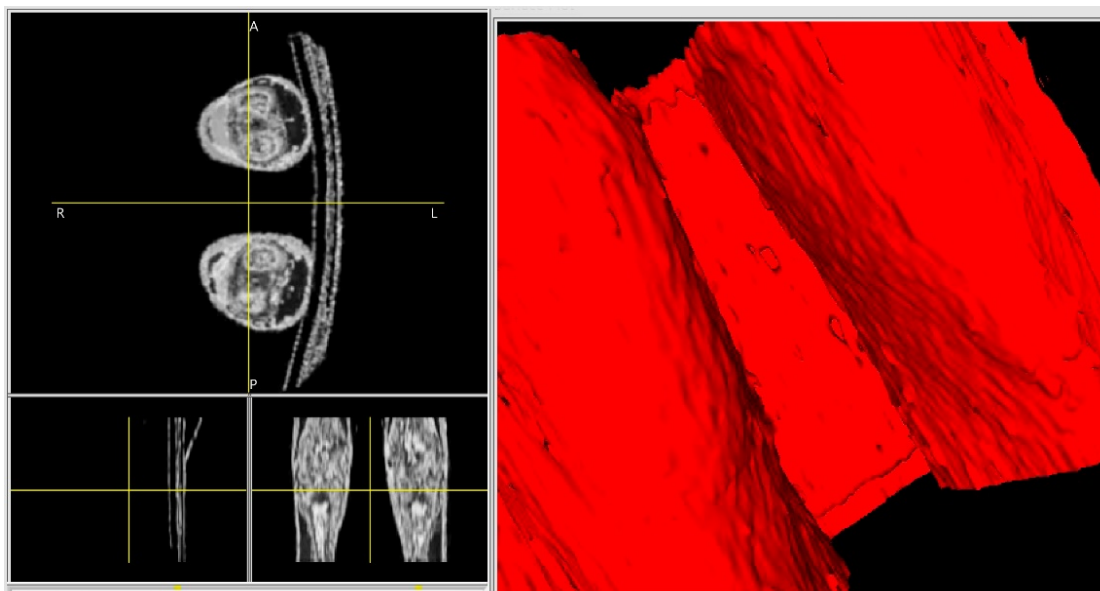


Figure 6 – Controls palette of 3D Image Reconstructor with Gaussian 3D-filter

Figure 7 shows a block diagram of a 3x3x3 median 3D-filter.

Figure 8 shows the result of the median 3D filter on the 3D-reconstructor screen

And finally, (Figure 9) shows on 3D-reconstructor screen the result of double 3D-filter, which consists in sequentially performing Gaussian and median filtering.

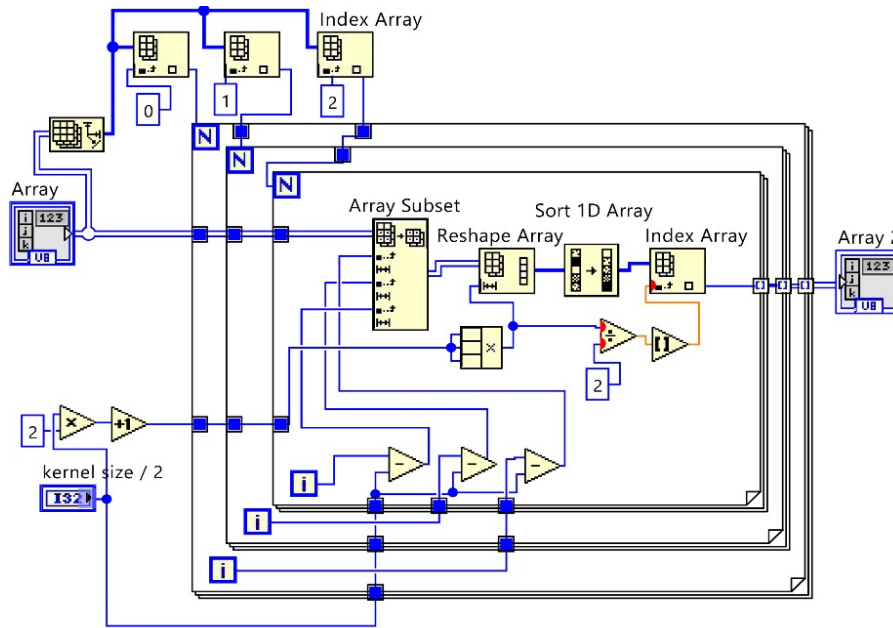


Figure 7 – Block diagram of median 3D-filter

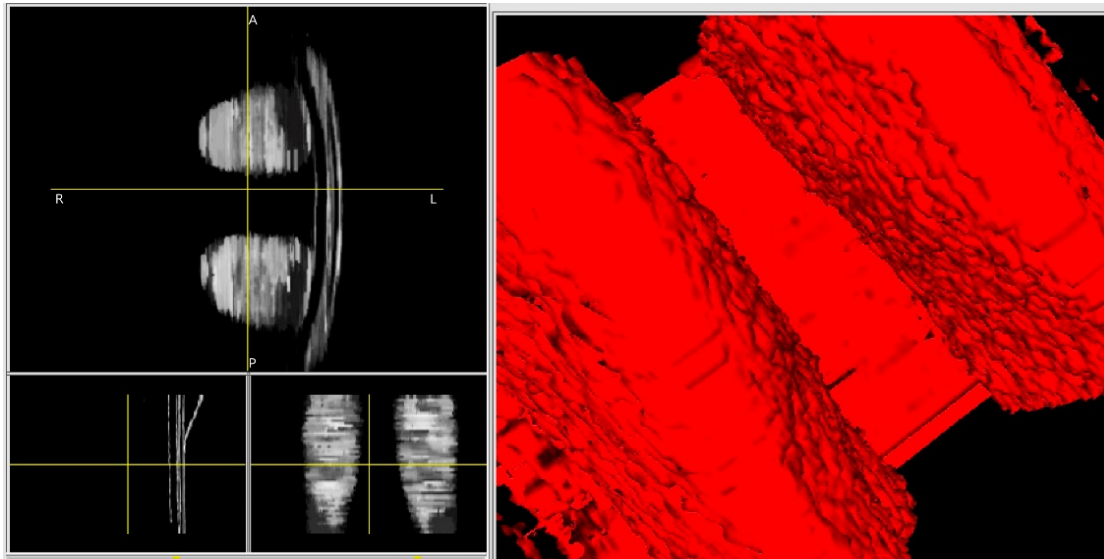


Figure 8 – Controls palette of 3D Image Reconstructor with median 3D-filter

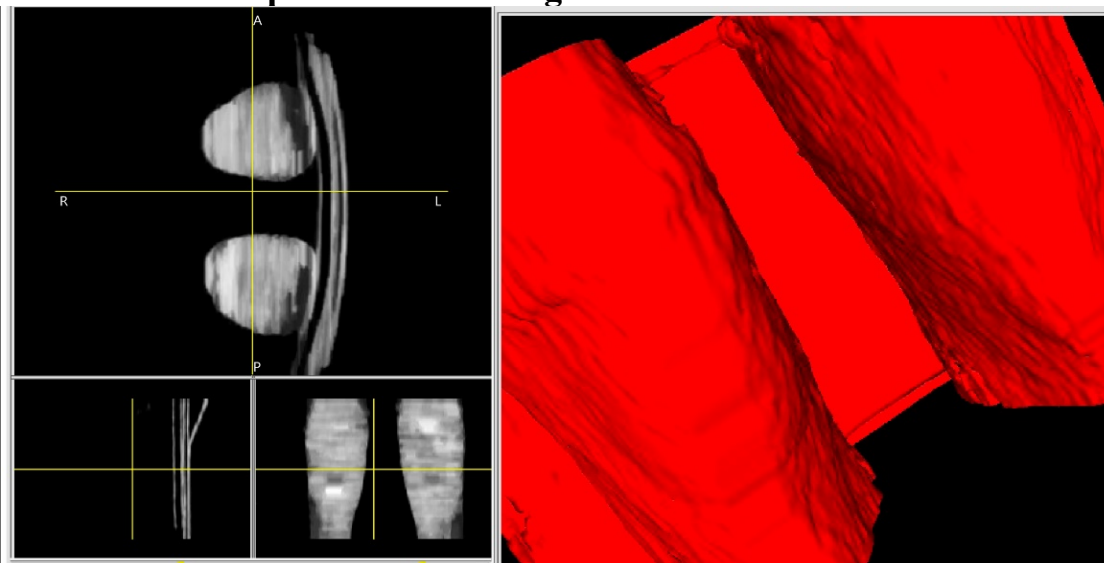
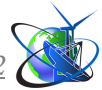


Figure 9 – Controls palette of 3D Image Reconstructor with double Gaussian and median 3D-filter



Summary and conclusions.

For the adaptive adjustment of the display detailing of three-dimensional objects for purposes of diagnostics and rehabilitation engineering, the use of 3D-filters for preprocessing of three-dimensional arrays of voxels built on the basis of CT and MRI results is proposed, and the corresponding filters are implemented in the NI LabVIEW software environment.

The results of such filters usage are analyzed on example of CT images of the knee part of the patient's legs. The comparative analysis shows that the best smoothing of the surface created by 3D-reconstructor occurs when using a double filter consisting of a Gaussian filter and a median, slightly worse smoothing occurs when only the Gaussian filter is used. All other options are significantly worse. At the same time, it should be borne in mind that the use of the median filter requires much more computer resources, or the filtering time will be significant. Thus, the 3D Gaussian filter is optimal for the purposes of this work in the sense of a combination of satisfactory results and processing time on ordinary (non-specialized) computers.

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