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3D Reconstruction of NMR Images by LabVIEW

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Abstract: This paper introduces the experiment of 3D reconstruction NMR images via virtual instrumentation - LabVIEW. The main idea is based on marching cubes algorithm and image processing implemented by module of Vision assistant. The two dimensional images shot by the magnetic resonance device provide information about the surface properties of human body. There is implemented algorithm which can be used for 3D reconstruction of magnetic resonance images in biomedical application.

Keywords: Image processing, 3D reconstruction, magnetic resonance, NMR images, LabVIEW

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1. Introduction

Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) usually deliver cross-sectional images of the human body. The sampling is done in a set of coplanar slices with adjustable distance and thickness. If sequences of adjacent images are put together, the result will be a 3D volume representation of the human body part under analysis [1].

To reconstruct an isotropic 3D volume, the inter-slice distance should be close to the inter-pixel distance. The distance between consecutive slices is usually larger than the distance between consecutive pixels within a slice, so an interpolation must be done to obtain the pixels between the slices. This is a powerful tool to aid surgery and medical diagnosis. An isotropic volume reconstructed in this way can be manipulated like the original body, without any risk to it. Nevertheless, two distinct steps are necessary to reconstruct a 3D volume: the 2D Reconstruction of each slice and the 3D Volume Reconstruction.

2. Virtual instrumentation – LabVIEW

The LabVIEW is a graphical programming environment, which can be used to built data acquisition and instrument control application. The LabVIEW graphical dataflow language and block diagram approach naturally represent the flow of our data and intuitively map user interface controls to his data, so we can easily view and modify our data or control inputs. The LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. The LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help us troubleshoot our code [2].

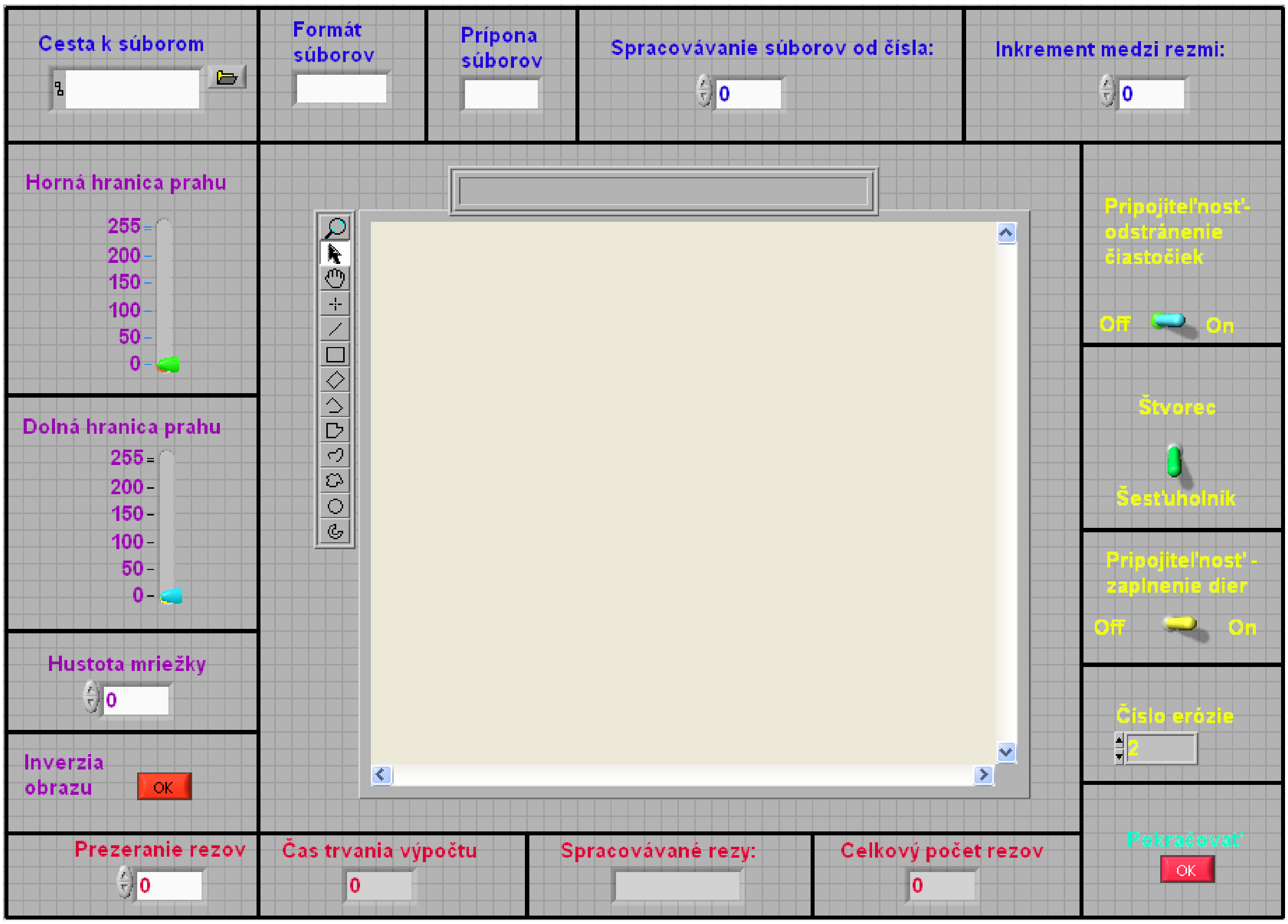

Fig. 1. Front panel of 3D reconstruction settings.

In LabVIEW, we built a user interface, or front panel (Fig. 1, Slovak version), with controls and indicators of 3D reconstruction process. Controls are knobs, push buttons, dials, and other input devices. Indicator are graphs, LEDs, ant other displays. After we built user interface, we add code using VIs and structures to control the front panel objects. The block diagram contains part of this front panel (Fig. 2). There is some of main subVIs such as “rotation Z” subVI, which is use to rotation of pattern voxel. Blocks for comparison of pattern with image voxel based on Boolean values and blocks for their appropriate rotations by three spatial axis. Last three blocks, placed in TRUE/FALSE condition (1.2.3.) are designed to look up, redistribute, format and write final triangle's peaks to output file.

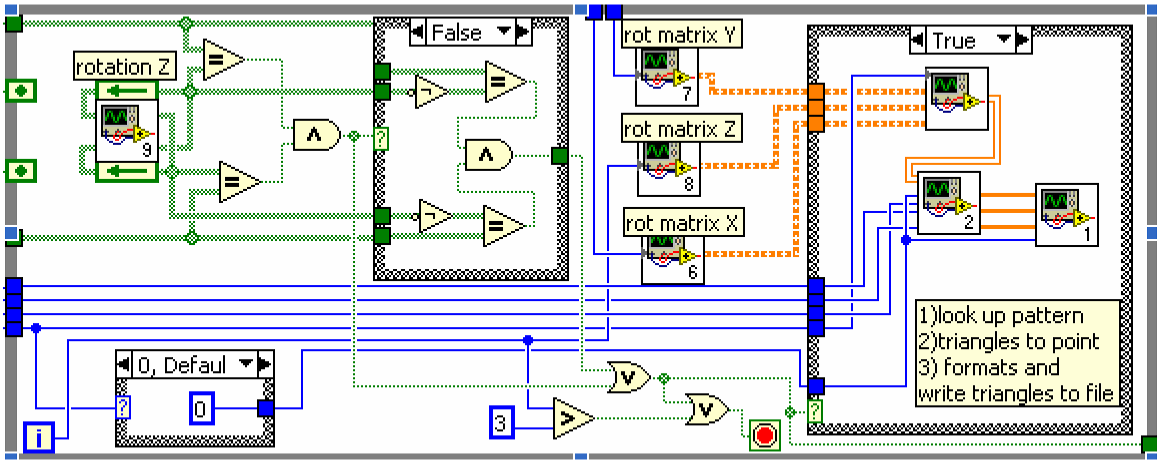

Fig. 2. Part of LabVIEW diagram of 3D reconstruction algorithm.

LabVIEW Express technology transforms common measurement and automation tasks into much higher-level, intuitive VIs. With Express technology, thousands of nonprogrammers have taken advantage of the LabVIEW platform to build automated systems quickly and easily. LabVIEW delivers the performance, flexibility, and compatibility of a traditional programming language such as C, C++ or BASIC. In fact, the full-featured LabVIEW programming language has the same constructs that traditional languages have - variables, data types, looping, and sequencing structures as well as error handling. And, with LabVIEW, we can reuse legacy code packaged as DLLs or shared libraries and integrate with other software using ActiveX, TCP, and other standard technologies.

3. Proposed Solution for 3D Reconstruction of NMR by LabVIEW Diagrams

The main idea of this paper is created a functionally algorithm, implemented at LabVIEW for 3D reconstruction of images which are defined previous like 2D images / slices / from MRI machine (Fig.3). Created application requires a set of 2D grayscale images with defined header file format. This is given by filling of blue colour fields at the front panel (Fig.1.). We have to fill all the fields to program works properly.

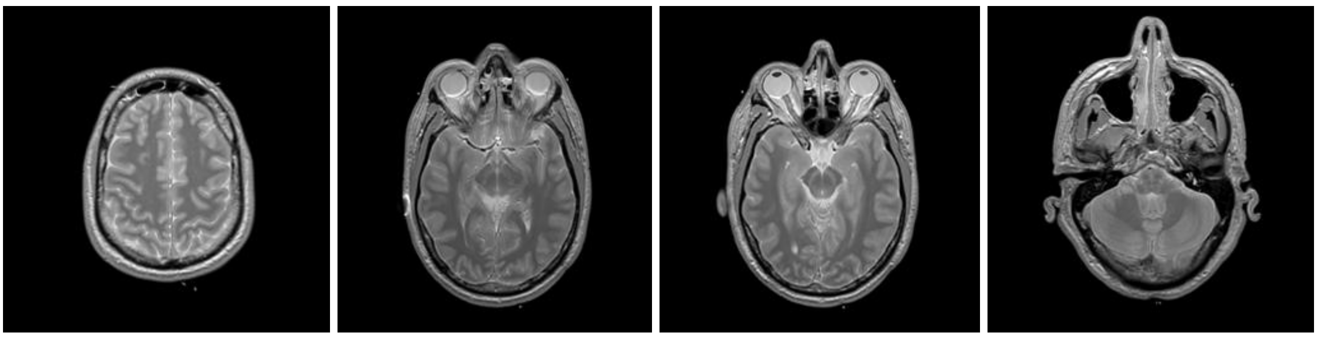

Fig. 3. Sequence of 2D slices from MRI.

When all the required parameters of the fields and sliders are adjusted, we can click at the „Continue“field. After this, program takes all pre-defined 2D images and consequently will perform following operations: image threshold, filling holes, connectivity for various directions and erosion operation. Result of this operation – image pre-processing is a sequence of 2D pre-processed images

(Fig. 4), which are suitable for next application of created algorithm. These slices contain only two states of information – true or false. This data format is suitable for Marching cubes algorithm.

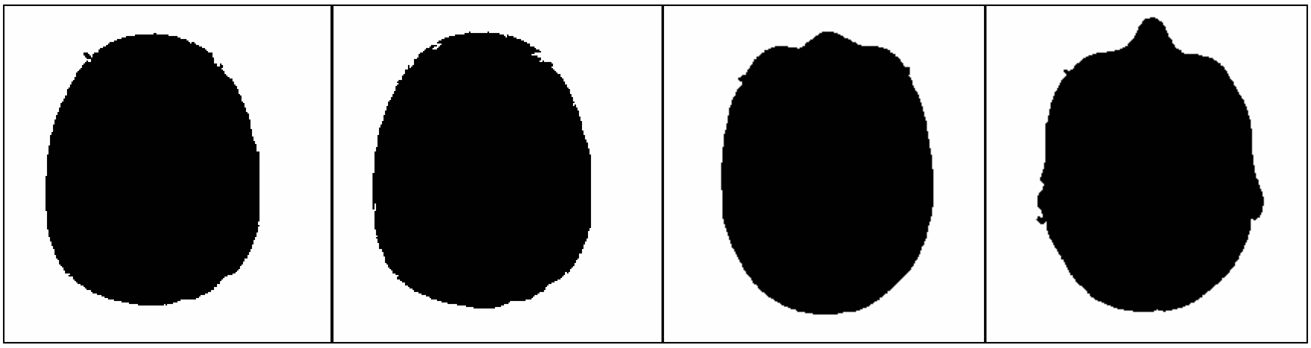

Fig. 4. Sequence of 2D slices after image preprocessing operations.

The main principle of marching cubes algorithm is generation of triangle network based on corporation of input image voxels with voxels defined by look up table of marching cubes algorithm mentioned in [3]. Final triangle network is represented by a cover of 3D reconstructed object.

NMR Images of head are obtained from Visible Human Version 2.0 [4]. This database contains very large database of NMR images in very high resolution therefore it is convenient for test algorithm. Resolution of scanned data is 230x230 pixels.

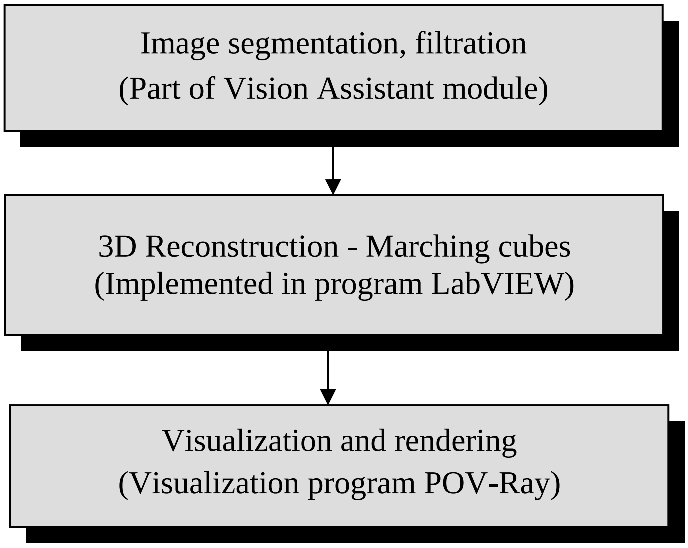

Fig. 5. Algorithm of 3D reconstruction.

Reconstruction algorithm is implemented in LabVIEW with Vision Assistant module (Fig. 5.). In Vision assistant is written script for segmentation and processing of 2D images (filtrating, threshold). 3D reconstruction is written in program LabVIEW. Visualization and rendering of final triangles is powered by program POV-Ray.

4. Experimental Results

In the Fig. 6 is shown final image of 3D reconstructions of head from NMR in high quality (135 subdivisions) and one slice of head from magnetic resonance. On head we can see detailed contour of head with maximum details of magnetic resonance.

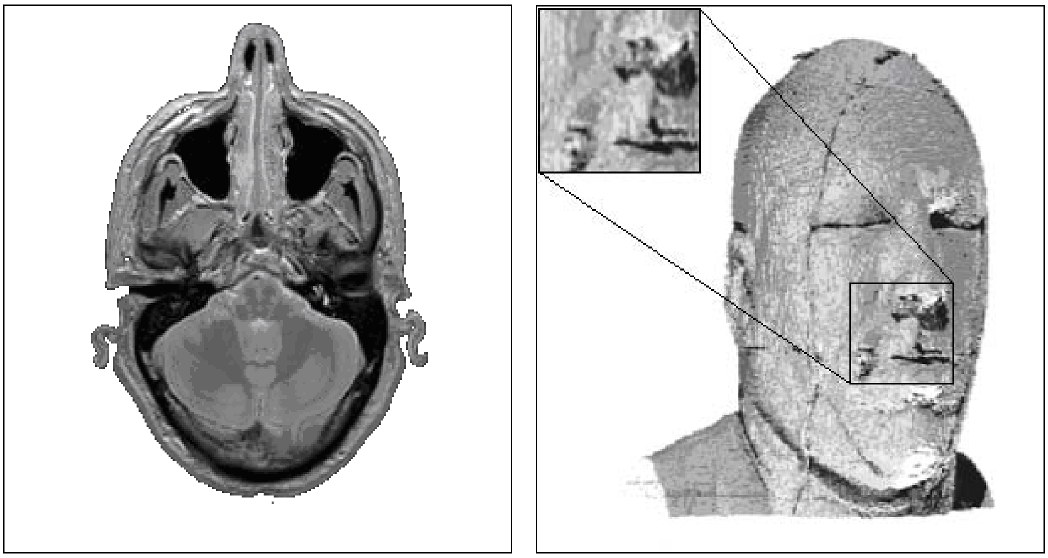

Fig. 6. Slice of magnetic resonance and final head reconstruction (on the left), 270 subdivisions.

We can see that a lot of details are lost, but time of reconstruction is 10 times faster like final reconstruction.

In the Fig. 7 is shown 3D reconstruction of head from NMR in lost quality in 54 (on the left) and 135 (on the right) subdivisions. We can see that image is very similar to final image (Fig.6), a lot of details are lost. Advantage is speed of reconstruction which is three time faster. Reconstruction of head is drawn 241 374 triangles.

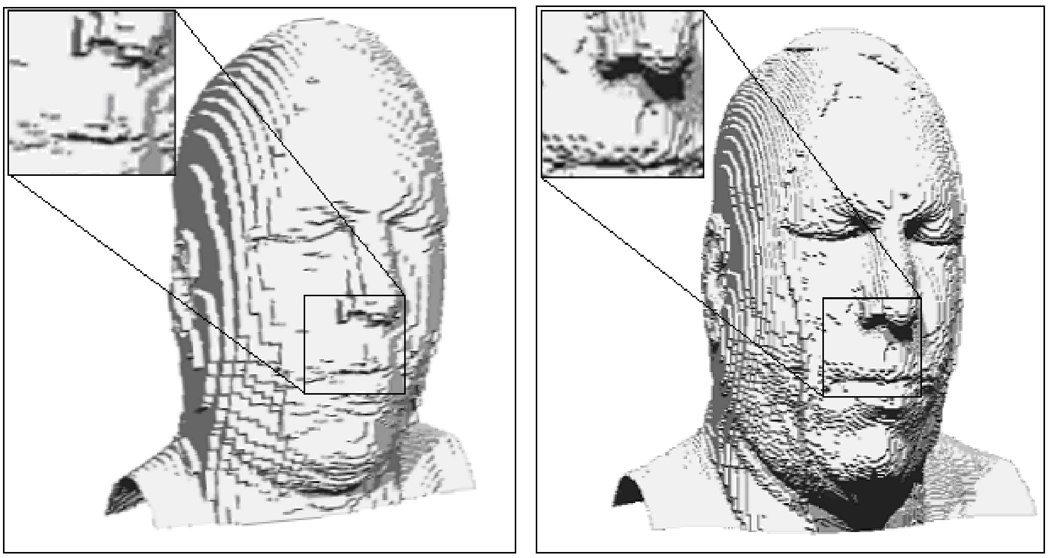

Fig. 7. Lost quality of head reconstruction of NMR 54 and 135 subdivisions.

5. Conclusions

In this paper is presented methods for 3D reconstruction of biomedical images from NMR. The presented method is implemented in program LabVIEW. Presented NMR images of head were obtained from Visible Human. The main addition of this work is implementation of mentioned method in program LabVIEW and module Vision Assistant. Experimental result in LabVIEW is comparable to conventional program as Matlab. An advantage of presented method in this article is its simple implementation and very good final result of scanned data if there is enough of subdivision. The disadvantage of mentioned method is necessary very much triangles in result object.

Acknowledgements

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Guide for Contributors

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- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
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- Nanosensors;
- Microsystems;
- Applications.

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