MRI Enhancement on the Base of Morphological Processing

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Abstract – **In the paper is presented an approach for magnetic resonance imaging (MRI) Enhancement. It consists of the following basic stages for image processing: changing the brightness of the image by equalization of the global histogram, selecting of the region of interest (ROI) and morphological processing of the selected ROI. Some results of the experiments are presented, which are made by computer simulation in MATLAB Environment.**

Keywords – **MRI Enhancement, equalization of histogram, region of interest, morphological processing, computer simulation.**

I. INTRODUCTION

Image enhancement is one of the categories of image processing, attempts to make diagnostic more obvious. The purpose of this paper is to demonstrate some techniques that enhance the appearance of MR Images, including the nonlinear morphological filtering of single images to reduce noise and to solve complex problems with shape and contours of objects [1].

In this work are presented algorithms for increasing the image contrast by histogram equalization, selecting regions of interest and morphological filtering by means of three different morphological operators [2]. It's described an idea of using MATLAB environment, real digital MR images and evaluation of experimental data and results. On the base of mathematical morphology and its fundamental operations – dilation and erosion are constructed functions and algorithms increasing MR Image quality [3]. By properly choosing of opening filtration, top & bottom hat filtration, motion blur filtration and different forms of structuring element, we eliminate local structures or modify local geometry of the image [4],[5],[6].

The aim of algorithms, based on morphological operators, is a noise suppression and detail preservation abilities of the selected regions of interest (ROI) of MR image. In the paper are analyzed some quantitative estimation parameters: Signal to noise ratio in the noised image (SNR_Y), Signal to noise ratio in the filtered image (SNR_F), Effectiveness of filtration (E_{FF}), Peak signal to noise ratio (PSNR).

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II. BASIC STAGES IN MRI - PROCESSING

Image enhancement techniques are applied to digital grayscale MR images of the head and stomach that exhibited diverse pathology. MRI processing consists of three different morphological methods, comparison between different types of filtration and generalization of the experiments and results. In this paper are presented three stages of the algorithm, used to improve image quality.

The first step in MRI processing is increasing the contrast. For that step is necessary to increase the brightness of the image by equalization of its histogram. This is performed with the next sequence:

- Input of the MR image;
- Decomposition of the original image in YUV components;
- Estimation of Y component histogram;
- Equalization of Y component global histogram;
- Displaying the results on the screen and writing the processing image in a proper file format.

The use of histogram equalization is applied to images in order to increase the grey level contrast between pixels.

The second step is to define a ROI (region of interest) from MR image. It can be selected in interactive procedure from the operator. The result of ROI image is written in a file format that can be used in the morphological processing.

Step three includes morphological opening of the image, combination of top hat and bottom hat morphological filtration and a motion blur method. In this paper is made a comparison between the different types of filtration on the base of the experimental results.

The first processing method is morphological opening that can be used to remove small objects from the image while preserving the shapes and size of larger objects in the image [7]. To morphologically open the MR image, are performed following steps:

- Reading the ROI image and displaying it;
- Creating a disk-shaped structuring element with a radius of 5 pixels;
- Removing small objects having a radius less than 5 pixels by opening it with the disk-shaped structuring element created in previous step.

The second morphological method combines top hat and bottom hat filtering, which are used together to enhance contrast in the image. This method extracts the original image from the morphologically closed version of the image. It is used to find intensity troughs in an image. This algorithm includes following steps:

- Reading the ROI image and displaying it;
- Creating a disk-shaped structuring element, needed for morphological processing;
- Adding the original image to the top-hat filtered image, and then subtracting the bottom-hat filtered image.

The third method - motion blur filtering includes the following steps:

- Reading the ROI image and displaying it;
- Creating a 2D filter, that becomes a vector for horizontal and vertical motions;
- Displaying the result of filtration.

On the base of applied algorithms to selected ROI images, which were already density increased by equalization of global histogram, are presented parameters that measure the effect of introduced techniques. These characteristics are PSNR - peak signal - to - noise ratio and EFF - effectiveness. In this work are used ten different MR images, which are processed consequently by histogram equalization, opening filtration, top & bottom hat filtration and motion blur filtration. The results of using of these methods are presented in tables and diagrams.

Morphological operators are compared together and one of them is estimated as a most effective method.The following quantitative estimations can be used [8]:

- Signal to noise ratio in the noised image SNR_Y [dB], given in Eq. 1:

$$SNR_y = 10\lg \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[y(i,j)]^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}[y(i,j)-x(i,j)]^2} \quad (1)$$

where $x(i,j)$ is a pixel from the original image; $x_F(i,j)$ is a pixel from the filtrated image; $y(i,j)$ is a pixel from the noised image.

- Signal to noise ratio in the filtered image SNR_F [dB], given in Eq. 2:

$$SNR_F = 10\lg \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[x_F(i,j)]^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}[y(i,j)-x(i,j)]^2} \quad (2)$$

- Effectiveness of filtration E_{FF} [dB], given in Eq. 3:

$$E_{FF} = SNR_y - SNR_F \quad (3)$$

- Peak signal to noise ratio (PSNR) in [dB], given in Eq. 4:

$$PSNR = 10\lg\left(\frac{MAX_I^2}{MSE}\right) = 20\lg\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (4)$$

where MAX_I is the maximum pixel value of the image, MSE - mean square error.

III. Experimental Results

The formulated stages of processing are presented by computer simulation in MATLAB, version 7.2 environment by using the IMAGE PROCESSING TOOLBOX.

In analysis are used 10 grayscale MR images with different sizes. The original images are in different file formats: jpeg, bmp, but all of them are converted into bmp.

On the base of computer simulation are realized the stages of proposed algorithms: increasing the contrast of the image by equalization of its global histogram, selection of ROI images, morphological filtration. Their combination with top hat & bottom hat filtering gives the best result in image enhancement. The results of these methods are presented in Table 1. The graphical presentation of the results for the investigated image and empiric data are given in Figs.1, 2, 3 and 4. On Fig. 5 are illustrated original MR image and brightness increased image with selected ROI. Fig. 6 presents original and selected ROI image that is filtered by means of three morphological methods. It is shown the visible difference between the original image and top & and bottom hat filtered image, which is a result of the most effective morphological method.

Table I
Experimental Results from Simulation /Average Values of Parameters /

Morph. Operation	PSNR	SNR_F	SNR_y	E_{FF}
M.Blur	34.1389	32.3209	32.1919	1.2461
Opening	34.3554	32.2872	32.1919	1.1639
TopBottom Hat	33.5176	33.2793	32.9749	1.3044

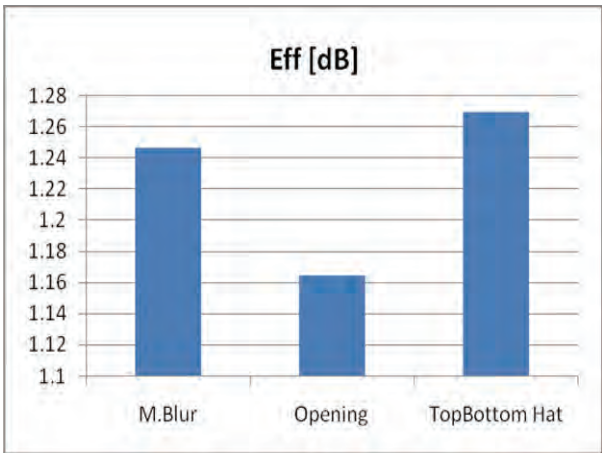

Fig. 1 Diagram of E_{FF} for three different types of filtration.

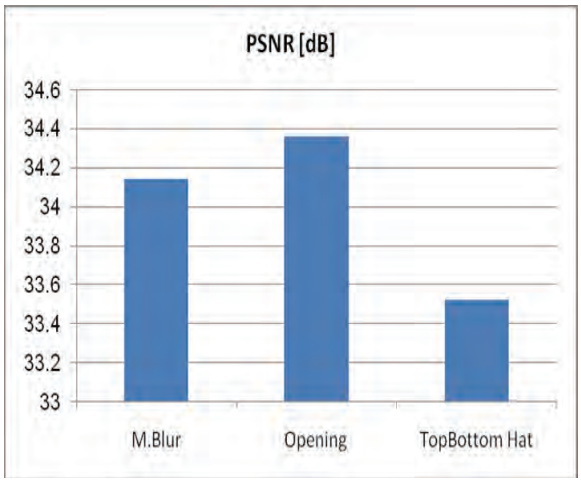

Fig. 2 Diagram of PSNR for three different types of filtration.

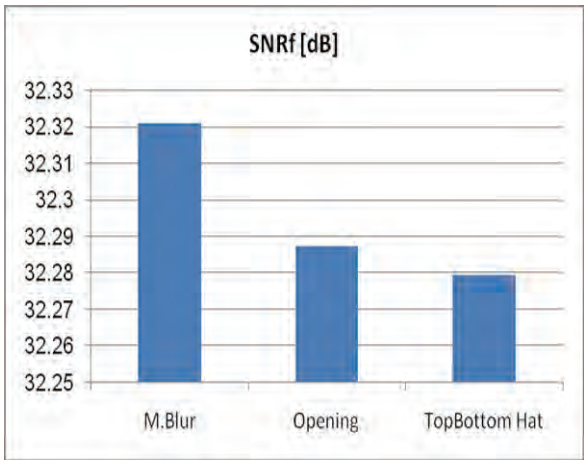

Fig. 3 Diagram of SNRf for three different types of filtration.

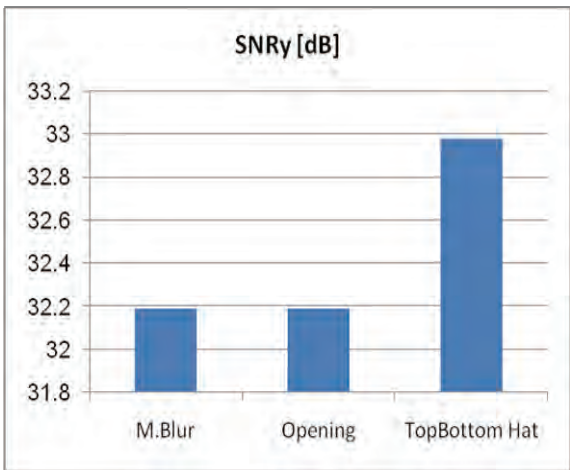

Fig. 4 Diagram of SNRy for three different types of filtration.

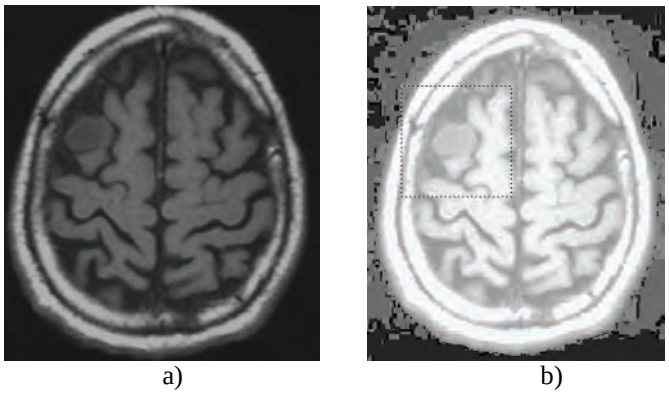

Fig. 5 The original and the brightness increased images with selected ROI:
a) original image; b) brightness increased images with selected ROI
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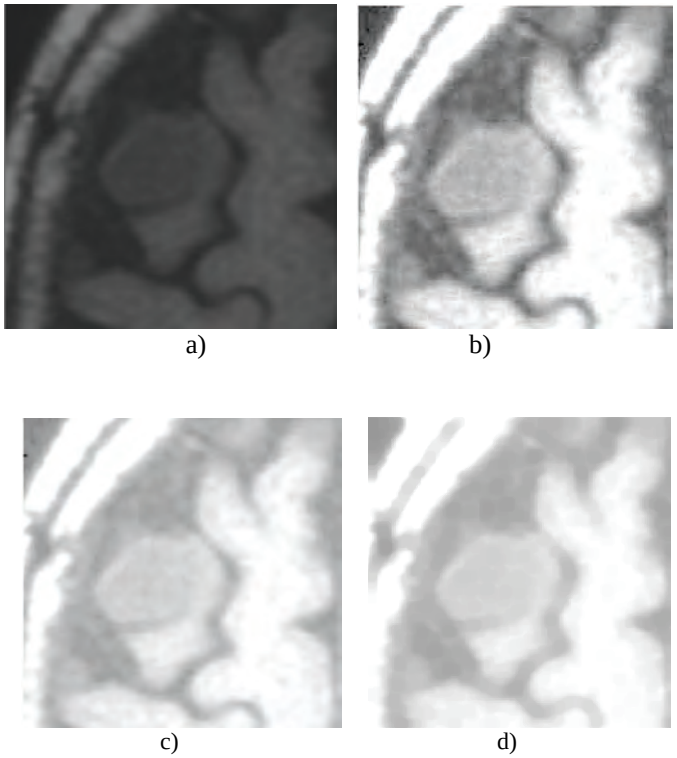

Fig.6. The original and processed selected ROI images by three different types of filtering:
a) original image; b) top&bottom hat filtered image; c) opening filtered image; d) motion blurred image

IV. Conclusion

In this paper is illustrated a post – processing of MR images that combines different techniques of image enhancement. The complex processing has an effect of contrast enhancement and contours determination for selected ROI of different parts of diagnostic MRI. On the base of mathematical morphology, are created algorithms for selecting a ROI and denoising of different parts of MR images. The evaluation of presented parameters helps to

define priorities of opening, closing, top & bottom hat filtering, motion blur method and to choose a most effective method that attempts to make diagnostic more obvious.

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