

# REMOTE BIOMEDICAL IMAGE PROCESSING USING MATLAB WEB SERVER

*M. Pánek and A. Procházka*

*Institute of Chemical Technology, Department of Computing and Control Engineering*

## Abstract

The paper is devoted to image analysis using discrete transforms and namely Wavelet transform to find two-dimensional signal components, to enable its denoising and to allow the following image segments detection and classification. The main part of the paper is devoted to description of Matlab Web server enabling remote data processing including analysis of signals and images sent to the Server through Internet.

## 1 Introduction

Image processing forms a very important part of general signal processing methods with applications in many information systems including biomedical and engineering signals. The paper is devoted to basic mathematical principles of Wavelet transform that can be used in this case for image decomposition, analysis of its components, modification of resulting coefficients and reconstruction of the original image.

The main part of the paper is devoted to the description of Matlab Web server enabling remote signal processing using methods specified by administrators of such a server and enabling analysis of one-dimensional and two-dimensional signals provided by the user.

## 2 Principles of Image Wavelet Decomposition

Discrete transforms of observed one-dimensional or two-dimensional signals provide an efficient tool for signal analysis. Wavelet transform (WT) stands in this view for a general and powerful mathematical tool providing the alternative to the short-time Fourier transform (STFT) and enabling signal decomposition and reconstruction [3, 1].

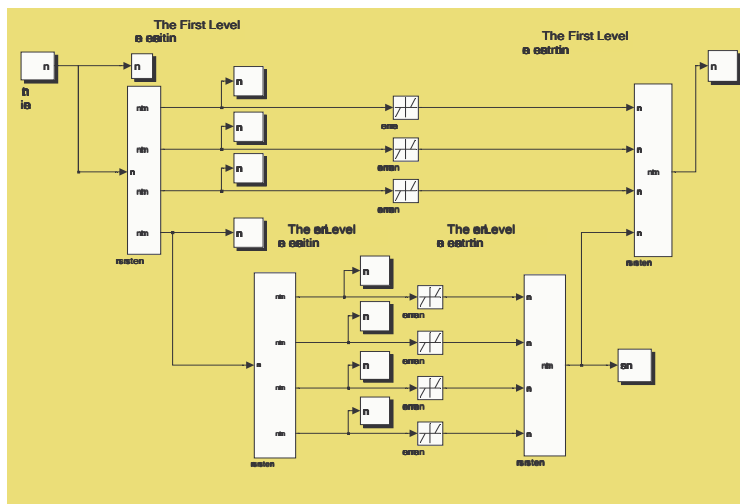


Figure 1: Wavelet tree for image decomposition into two levels and subsampling in the Simulink environment

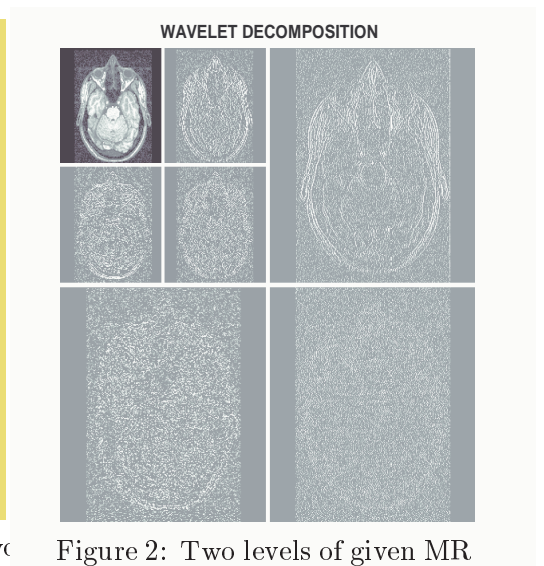


Figure 2: Two levels of given MR image decomposition

The set of Wavelet functions is derived from the initial function  $W(t)$  resulting in the set

$$W_{m,k}(t) = \frac{1}{\sqrt{a}} W\left(\frac{1}{a}(t-b)\right) = \frac{1}{\sqrt{2^m}} W(2^{-m}t - k) \quad (1)$$

for discrete parameters of dilation  $a = 2^m$  and translation  $b = k 2^m$ . The basic efficient way to evaluate wavelet transform coefficients using the signal processing notation assumes

implementation of the Mallat's pyramidal structure of wavelet transform coefficients. In the case of decomposition of images it is possible to use a tree structure [2] presented for two steps of image decomposition in Fig. 1. The image is decomposed in this way into 4 subimages in the first stage. Low-pass image component evaluated both for image columns and rows is then decomposed in the same way again. Results of such a two level image decomposition is presented in Fig. 2 for the biomedical image obtained by the magnetic resonance (MR).

### 3 Wavelet Noise Reduction

Signal or image de-noising can be realized both in the time domain using finite impulse response filters in many cases and in the frequency domain after the application of a properly selected transform. In the case of Wavelet transform the method presented in Figs. 3, 4 and 5 include

- Signal decomposition using a selected Wavelet function up to the given level and evaluation of wavelet transform coefficients  $\{c(k)\}_{k=0}^{N-1}$
- The choice of threshold limits  $\delta$  for each decomposition level and modification of its coefficients using for instance soft thresholding for evaluation of values

$$\bar{c}_s(k) = \begin{cases} \text{sign } c(k) (|c(k)| - \delta) & \text{if } |c(k)| > \delta \\ 0 & \text{if } |c(k)| \leq \delta \end{cases} \quad (2)$$

- Signal reconstruction from modified Wavelet transform coefficients

Results of this process depend on the proper choice of Wavelet functions and the selection of threshold limits.

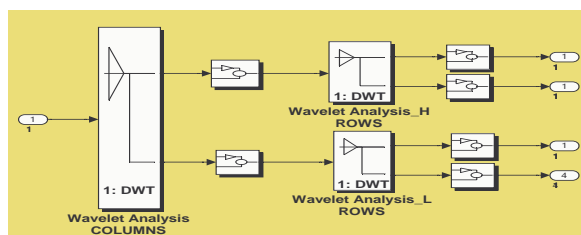


Figure 3: One step of image decomposition

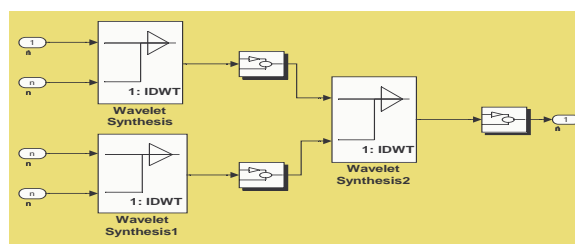


Figure 4: One step of image reconstruction

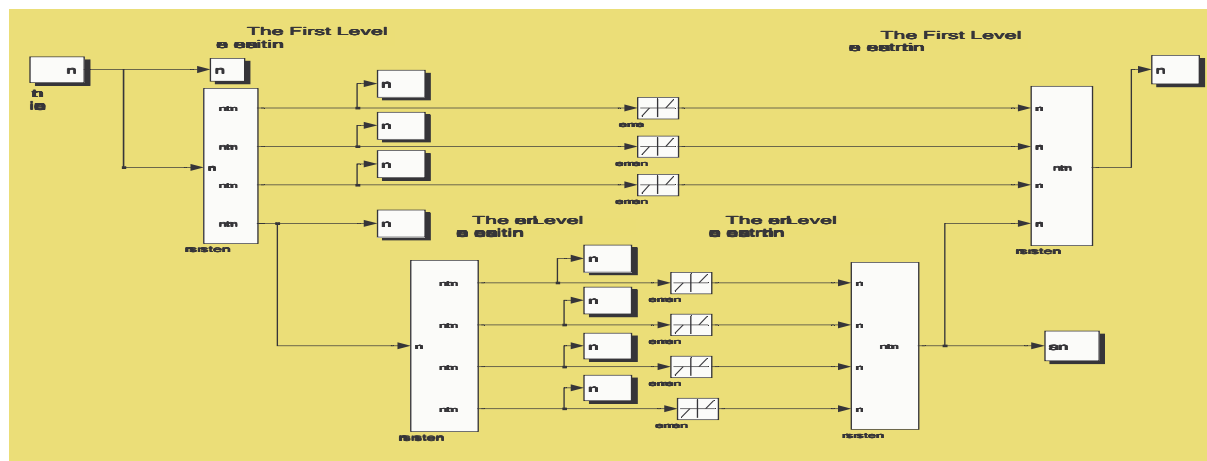


Figure 5: Principle of image Wavelet de-noising including two-dimensional signal decomposition, Wavelet coefficients modification and final image reconstruction

### 4 Matlab Web Server

Matlab Web server is a very powerful tool enabling the access to algorithms written in the Matlab environment and to the set of signals to anybody having access to Internet. It is possible to apply it both for educational purposes and for research as it allows to use a WWW page designed by the server administrator for presentation of programs and remote signal processing. This approach enables to use very easily the latest version of the Matlab environment.

The whole system presented in Fig. 6 allows the user to open his Web page explorer and to have his own data files prepared for their analysis and processing. In the first step he can choose whether to process reference data files available on the server or his own signals or images stored in his files in MAT or TXT format. In the second step he can choose the method for data processing and in the final step he can select available parameters.

After the choice of a data file and a method for its processing selected algorithm is applied and results are immediately presented in the newly opened window. Results can then be transferred to the user computer for their further analysis and processing.



Figure 6: Matlab Web server use for digital signal processing

## 5 Application

Remote biomedical image processing forms one of very interesting applications of Matlab Web server. To enable such an application it is necessary to study both medical problems including magnetic resonance (MR) images analysis and mathematical principles of such a processing at first. In this case signal de-noising forms a basic problem allowing Wavelet decomposition and reconstruction. Resulting program presented in its simplified form in Fig. 7 provides results in Fig. 8. Input variables are stored in a structured variable  $h$  and a special part of the program allows signal name detection to allow invariance to the user choice.

Similar approach can be applied in further application as well allowing any engineering, speech, biomedical and other signals and images processing.

```

function rs = recon7(h)
%% Structure of the Input Variable %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% h.filename - given MAT signal file
% h.level    - Wavelet decomposition level
% h.lambda   - threshold limit for signal reconstruction
% h.path     - directory of signal file
% h.wavelet  - Wavelet function
%% Activation of the Processed Image and Detection of its Name %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
load([h.path h.filename]);
p=who('-file',[h.path h.filename]); eval(['s=' p{1} ',';]); s=im2double(A);
figure(1); imshow(s); title('ORIGINAL IMAGE');
%% Image Decomposition to a Given Level %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[c,l]=wavedec2(s,str2double(h.level),h.wavelet);
%% Signal Denoising and Reconstruction %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
i=find(abs(c)<=str2double(h.lambda)); cd(i)=0;
i=find(abs(c)>str2double(h.lambda));
cd(i)=sign(c(i)).*(abs(c(i))-str2double(h.lambda));
z = waverec2(cd,l,h.wavelet);
figure(2); imshow(z); title('RECONSTRUCTED IMAGE');

```

Figure 7: Algorithm for image Wavelet decomposition, denoising and reconstruction

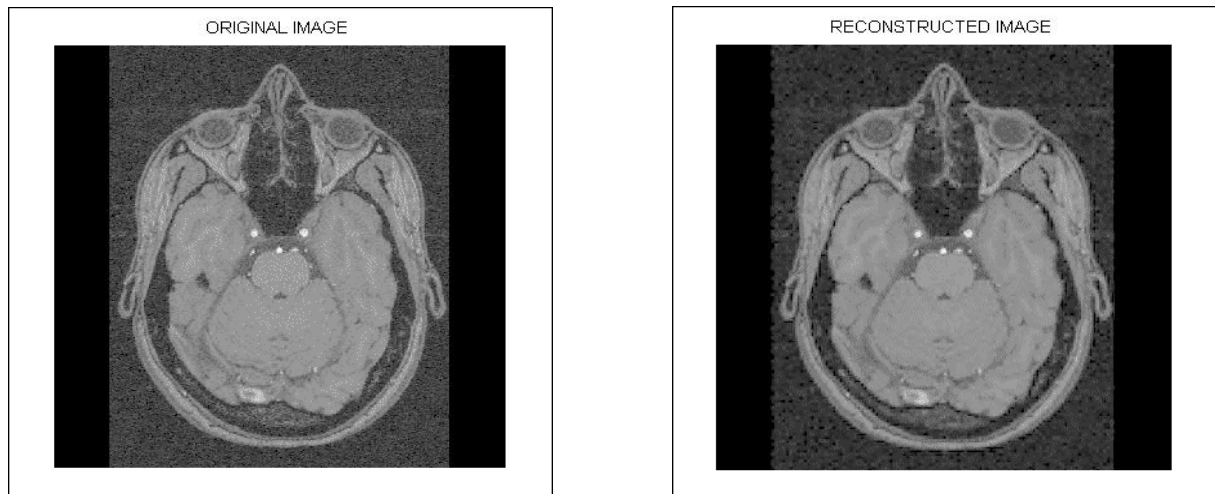


Figure 8: Magnetic resonance image before and after its processing using Wavelet method denoising by Daubechies Wavelet function of the forth order

## Acknowledgement

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## References

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