3D Image Processing
Lab Assignment 3
3D Wavelet Compression

Due: 09 December 2014, 9:30am

In this assignment you will see one of the main applications of Wavelet transforms. You can use *Matlab Wavelet Toolbox* or *Octave Signal Package* in this assignment. A good documentation for them can be found here:

`http://www.mathworks.de/de/help/wavelet/functionlist.html`

Any other Matlab/Octave toolbox, or C/C++/Java/etc libraries have to be confirmed by us before being used for this assignment. Since Octave does not normally have 3D analysis tools, you are not allowed to use 3D analysis functions in Matlab as well, such as `wavedec3` and `waverec3` in Matlab/Octave.

If you are using Octave, Octave Signal Package can be downloaded from:

`http://octave.sourceforge.net/signal/`

and it is installed inside Octave by the following command:

```
cd download_folder
pkg install signal-1.3.0.tar.gz
```

Or if you use **MacPort**:

```
port install octave octave-signal
```

To use it, you have to load the package using the following command in Octave:

```
pkg load signal
```

It is recommended to use **UviWave** library instead that works for both Matlab and Octave:

`http://cas.ensmp.fr/~chaplais/UviWave/About_UviWave.html`

(a) (10 Points) Implement a 3D wavelet and inverse 3D wavelet transforms using 1D wavelet transforms. You can use any implementation of 1D wavelet transform, such as `dwt` in Matlab Wavelet Toolbox or Octave Signal Package, `wt/iwt` in UniWave, or `fwt/ifwt` in Octave Ltfat Package. It should have the following interface:

```
y3d=wt3d(x3d,h1d,g1d,k)
x3d=iwt3d(y3d,h1d,g1d,k)
```

where `x3d` is the input 3D signal, `h1d` is the 1D low-pass approximation filter, `g1d` is the 1D high-pass detail filter, and `k` is the number of scales(levels).

The encoded signal, `y3d`, should have the standard layout, having approximation at the top-front-left block and diagonal details at the bottom-back-right side.
(you are allowed to look at the implementation of `wt2d` and `iwt2d` functions in UniWave library as hint.)

(b) (5 Points) Load the 3D data set `lab3.vol`.

(c) (10 Points) Make sure you load the data properly. To do so:

(1) Slice the data set through the middle, parallel to the YZ plane. Show the image of the slice.

(2) **If you are using Matlab**, Display the 3D visualization of 3D data using `sliceomatic` and put a screenshot of a good view in your report: `http://www.mathworks.com/matlabcentral/fileexchange/764-sliceomatic`

(d) (5 Points) Apply 4-level Haar wavelet to the data using `wt3d` function you implemented.
(Optional) Play with other wavelet families. you can find a list of some popular wavelets with the instruction `waveletfamilies('f'/'n'/'a')` in Matlab.

(e) (10 Points) Reconstruct and visualize the 3D data from only 1 level of the wavelet tree using your `iwt3d`. Your visualization should include slices passing through the center, parallel to XY, XZ, and YZ planes.

(f) (15 Points) Thresholding:

(1) Pick a threshold, say T=1.0

(2) Change all values with absolute value of less than T to 0.0

(3) Reconstruct the 3D data from the new wavelet tree

(4) Visualize the new data

(5) Calculate PSNR

(g) (15 Points) Draw a graph of PSNR-quality vs. Threshold using the function you implemented in (e)

(h) (20 Points) Find a way to efficiently store the thresholded data in (e) to compress the volume `lab3.vol` to `lab3.vol.compressed`

(i) (10 Points) Open the compressed data file and retrieve the 3D data

Submission

You need to submit a pdf report, and one Matlab/Octave function for each task, all in the same folder. Please write your name and student ID on top of each Matlab file as well as the pdf report. Feel free to define other auxilary functions. I should be able to test your code with the following sequence of commands:

```
y3d=wt3d(x3d,h1d,g1d,k)

x3d=iwt3d(y3d,h1d,g1d,k)

img3d = taskB(filename);

taskC(img3d);

img_wt3d = taskD(img, type);

img3d_REC = taskE(img_wt3d);

[img3d_REC_THR, PSNR] = taskF(img_wt3d, T);

taskG(img_wt3d);

taskH(img3d);

img3d = taskI(filename);
```

If you are using other programming/scripting languages: please provide similar functions. Your code should also include a Makefile to compile and a README.txt explaining the procedure I can follow to test your code and call the functions listed above.