One-Dimensional Discrete Wavelet Analysis

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1. In Matlab the Procedure of Discrete Wavelet Analysis

Procedure:
1. Load a signal
2. Decomposition
3. Construct coefficients
4. Reconstruct signal

2. Discrete Wavelet Analysis using the Command Line

2.1 Single-level decomposition
1. Load a signal From the MATLAB prompt and set the variables.
   ```
   load leleccum;
s = leleccum(1:3920);
l_s = length(s);
   ```
2. Perform a single-level decomposition of the signal using the db1 wavelet.
   ```
   [cA1,cD1] = dwt(s,'db1');
   ```
3. To construct the level 1 approximation and detail (A1 and D1) from the coefficients cA1 and cD1.
   ```
   A1 = idwt(cA1,[],'db1',l_s);
   D1 = idwt([],cD1,'db1',l_s);
   ```
4. To display the results of the level-one decomposition.
   ```
   subplot(1,2,1); plot(A1); title('Approximation A1')
   subplot(1,2,2); plot(D1); title('Detail D1')
   ```
5. Regenerate a signal by using the Inverse Wavelet Transform.
\[
A0 = \text{idwt}(cA1,cD1,'db1',1_s);
\]
\[
err = \text{max}(abs(s-A0))
\]

2.2 Multilevel decomposition

1. Load a signal from the MATLAB prompt and set the variables.
\[
\text{load leleccum;}
\]
\[
s = \text{leleccum}(1:3920);
\]
\[
l_s = \text{length}(s);
\]

2. Perform a level 3 decomposition of the signal.
\[
[C,L] = \text{wavedec}(s,3,'db1');
\]

3. Extract approximation and detail coefficients.
\[
cA3 = \text{appcoef}(C,L,'db1',3);
\]
\[
cD3 = \text{detcoef}(C,L,3);
\]
\[
cD2 = \text{detcoef}(C,L,2);
\]
\[
cD1 = \text{detcoef}(C,L,1);
\]

4. Reconstruct the Level 3 approximation and the Level 1, 2, and 3 details.
\[
A3 = \text{wrcoef}('a',C,L,'db1',3);
\]
\[
D1 = \text{wrcoef}('d',C,L,'db1',1);
\]
\[
D2 = \text{wrcoef}('d',C,L,'db1',2);
\]
\[
D3 = \text{wrcoef}('d',C,L,'db1',3);
\]

5. Display the results of a multilevel decomposition.
\[
\text{subplot}(2,2,1); \text{plot}(A3);
\]
\[
\text{title}('\text{Approximation A3}')
\]
\[
\text{subplot}(2,2,2); \text{plot}(D1);
\]
\[
\text{title}('\text{Detail D1}')
\]
\[
\text{subplot}(2,2,3); \text{plot}(D2);
\]
6. Reconstruct the original signal from the Level 3 decomposition
\[ A_0 = \text{waverec}(C, L, 'db1'); \]
\[ err = \max(\text{abs}(s-A_0)) \]

3. Discrete Wavelet Analysis using the Graphical Interface

1. From the MATLAB prompt, type \texttt{wavemenu} to start the 1-D Wavelet Analysis Tool.
2. Click the **Wavelet 1-D** menu item.
   The discrete wavelet analysis tool for one-dimensional signal data appears.

3. Load a signal.

4. Perform a single-level wavelet decomposition.
   Select wavelet type then click the **Analyze** button.
   After a pause for computation, the tool displays the decomposition.

5. Saving Information to Disk
• Saving Synthesized Signals:
  From the Wavelet 1-D tool, select the File⇒Save⇒Synthesized Signal menu option.

• Saving Discrete Wavelet Transform Coefficients:
  To save the DWT coefficients from the present analysis, use the menu option File⇒Save⇒Coefficients.

After saving the wavelet coefficients to the file xxx.mat, load the variables into your workspace. For example:

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<th>Name</th>
<th>Size</th>
<th>Bytes</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>coefs</td>
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<td>16056</td>
<td>double array</td>
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<tr>
<td>longs</td>
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<td>double array</td>
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<td>0</td>
<td>double array</td>
</tr>
<tr>
<td>wname</td>
<td>1x3</td>
<td>6</td>
<td>char array</td>
</tr>
</tbody>
</table>

These variables represent the wavelet coefficients (cA3, cD3, cD2, cD1).

If we want to obtain the approximation and details, type

```matlab
A3 = wrcoef('a',C,L,'db1',3);
D1 = wrcoef('d',C,L,'db1',1);
D2 = wrcoef('d',C,L,'db1',2);
D3 = wrcoef('d',C,L,'db1',3);
```