ZeroTree Coding

EZW: Embedded ZeroTree Wavelet Encoding

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Update: Dec. 2000

What is “Embedded” ?

- משובץ

- Progressive: every bit you “add” - you increase the accuracy of the “number” you transfer - as in: π

- You can stop at any accuracy you like !

- Now…we need to know what ‘Zerotree’ is … assuming Wavelets is already known .

Coding: Motivation

- In the compression process, the DWT transforms the pixels into coefficients.
- The purpose is to be able to represent the image with minimum number of non-zero coefficients.
- After we have the coefficients, the next mission is to code only the most important coefficients ("non-zero's") with minimum bits.

Zerotree Algorithm

- An efficient coding technique, for pyramidal transformations.
- The bit-stream includes information in order of importance: “Msb” first and “Lsb” last, so we have a progressive reconstruction of an image, and we achieve most efficient compression for a pre-defined bitrate.

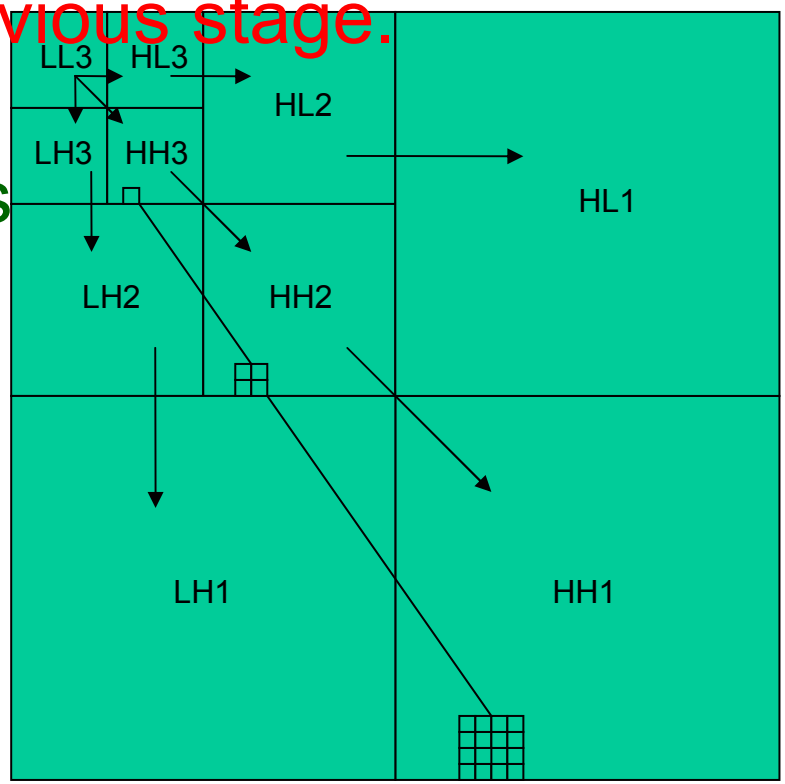
Pyramidal Transform

- Using DWT, we have a pyramidal construction: within every stage ("scale") we filter the image and decimate to a lower resolution.
- The result is that for higher scale, the "area" covered by each coefficients is larger than the area covered by the coefficients in the previous scale.

Parent-Child Structure

For each stage (except the first one), every coefficient is calculated as a weighted average of several neighbor coefficients from the previous stage.

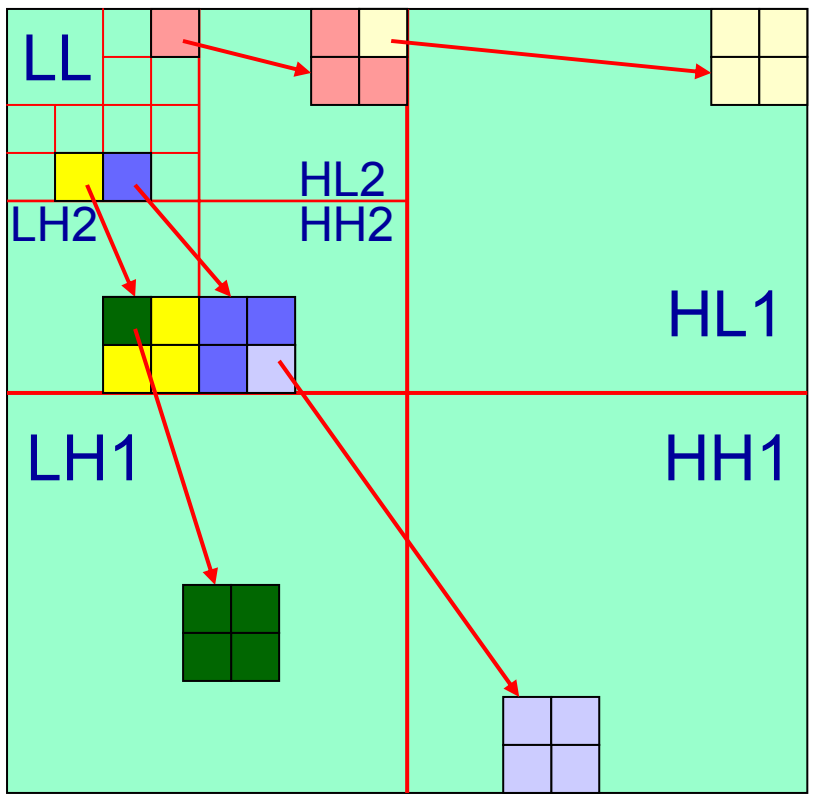
Every coefficient is a "parent" for the previous related coefficients.

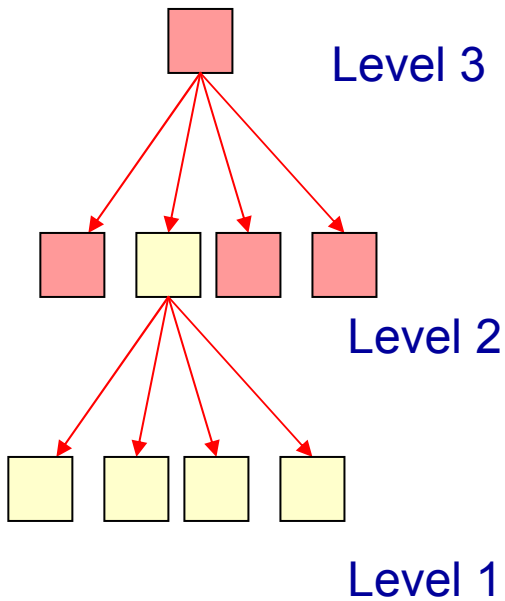


Parent-child dependencies of subbands. Note that the arrows point from the subbands of the parents to the subbands of the children

‘Quad-trees’: Wavelets Coefficients in different sub-bands

The image in DWT domain





A ‘Zero-Tree’

- A quad-tree of which all nodes are equal to or smaller than the root.
- The ‘Tree’ should be coded with a single symbol, and decoded (at the receiver) as a quad-tree, filled with zeros.

The general idea

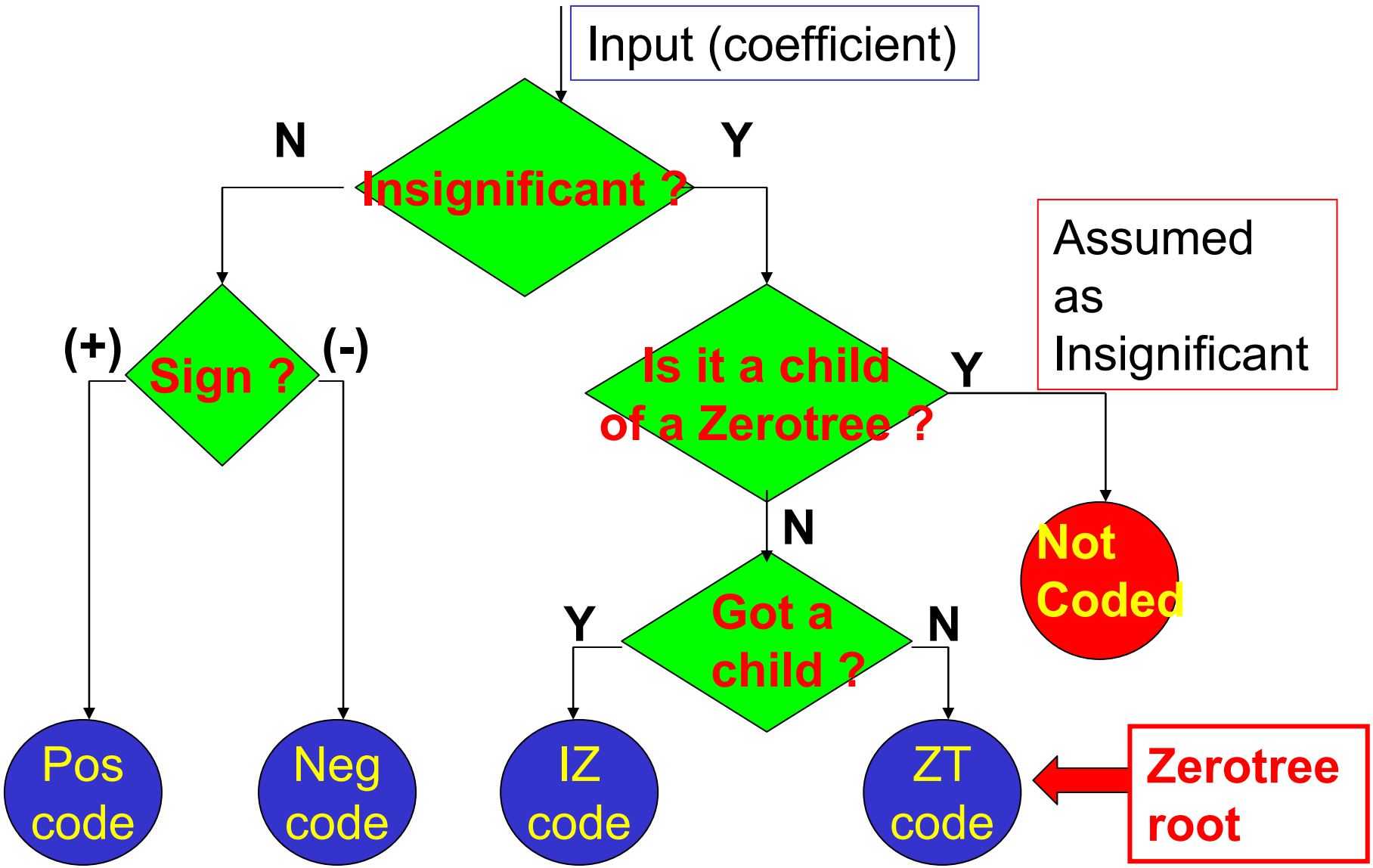
- Assumption: the wavelet coefficients decrease with scale:
  - all the coefficients in a quad-tree will be smaller than a threshold if the root is smaller than it
- This assumption can be violated from time to time, but in practice its probability is very high
- The cost: addition of zerotree symbol to the code

Significance of coefficients

- The last coefficient (in the lowest resolution) is the "parent" of the whole image.

- Remember: if a "parent" is Insignificant in a low-resolution image (with reference to a certain threshold), than we assume that all its children are also insignificant (with reference to this threshold !)

Significance Map Coding

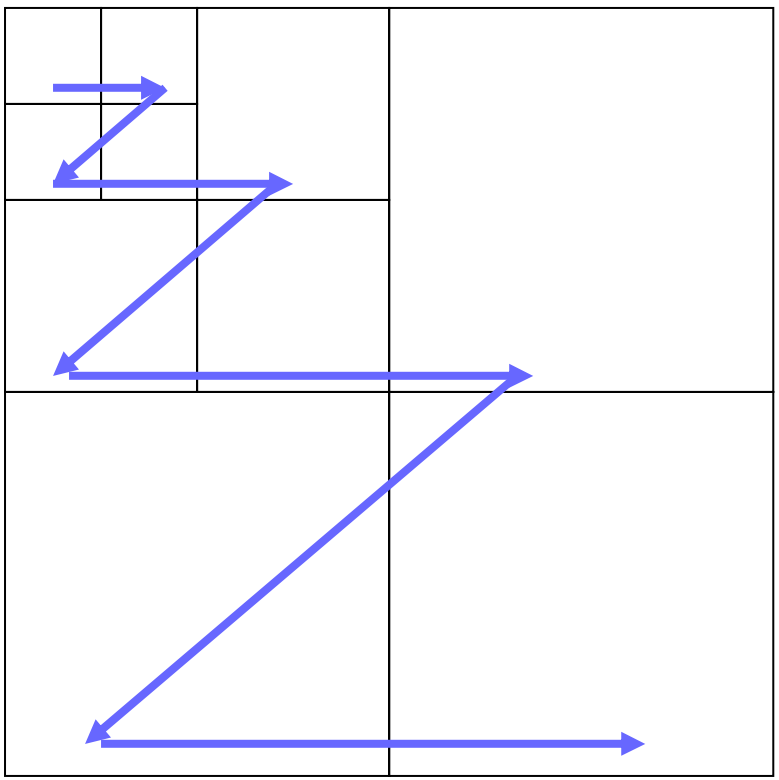


Significance Map Coding (cont'd)

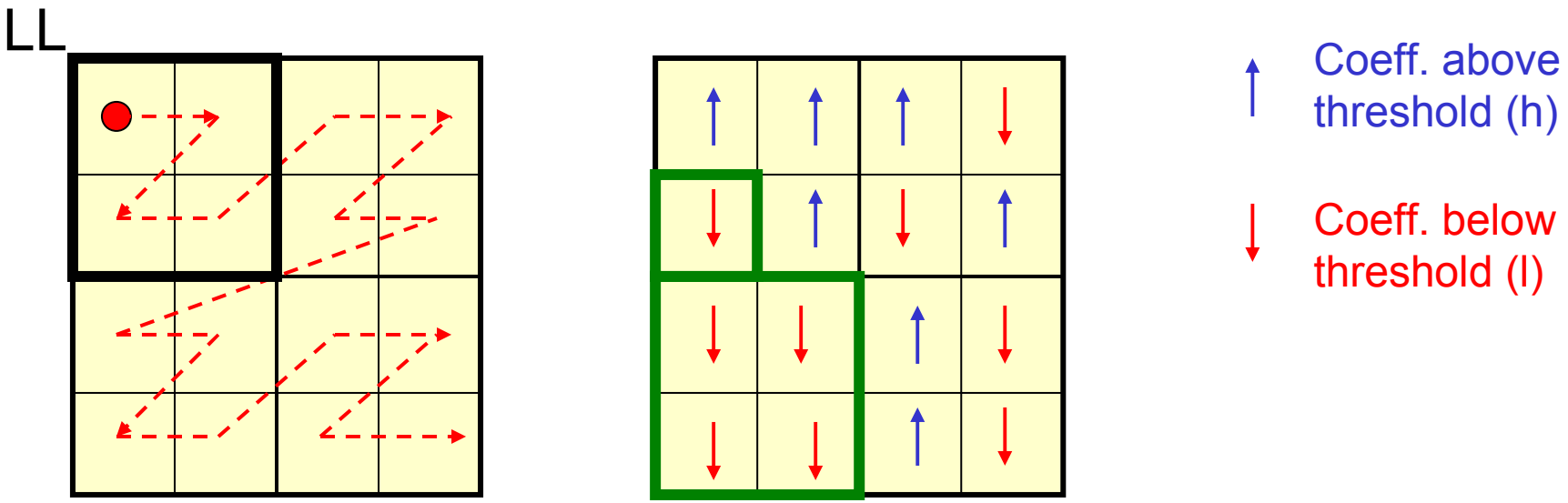
- The coefficients which are roots of a zerotree get a special sign (zt), signing that all their children are also neglected.
- Isolated Zero (IZ) is a Zero coefficient, under the threshold but got at least one child that is NOT Insignificant.
- The sign code (pos/neg) is important for the progressive feature.

Coefficients Scan

- Is done in a Zig-Zag way, so that a child could not be scanned before its parent



Scanning Example



Regular scan: hhlh hllh llll hlhl

Zerotree scan: hhth hllh hlhl

t: zerotree symbol, replaces the 4 L's in the lower left corner + its root

Advantage of Zerotree coding

Better than traditional EOB sign or Run-length

WHY ?

See in slide 9:

Assumption: the wavelet coefficients decrease with scale:
all the coefficients in a quad-tree will be smaller than a threshold if the root is smaller than it

Important references:

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