LIRMM Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier

# Wavelet Based Data Hiding of DEM in the Context of Real-time 3D Visualization

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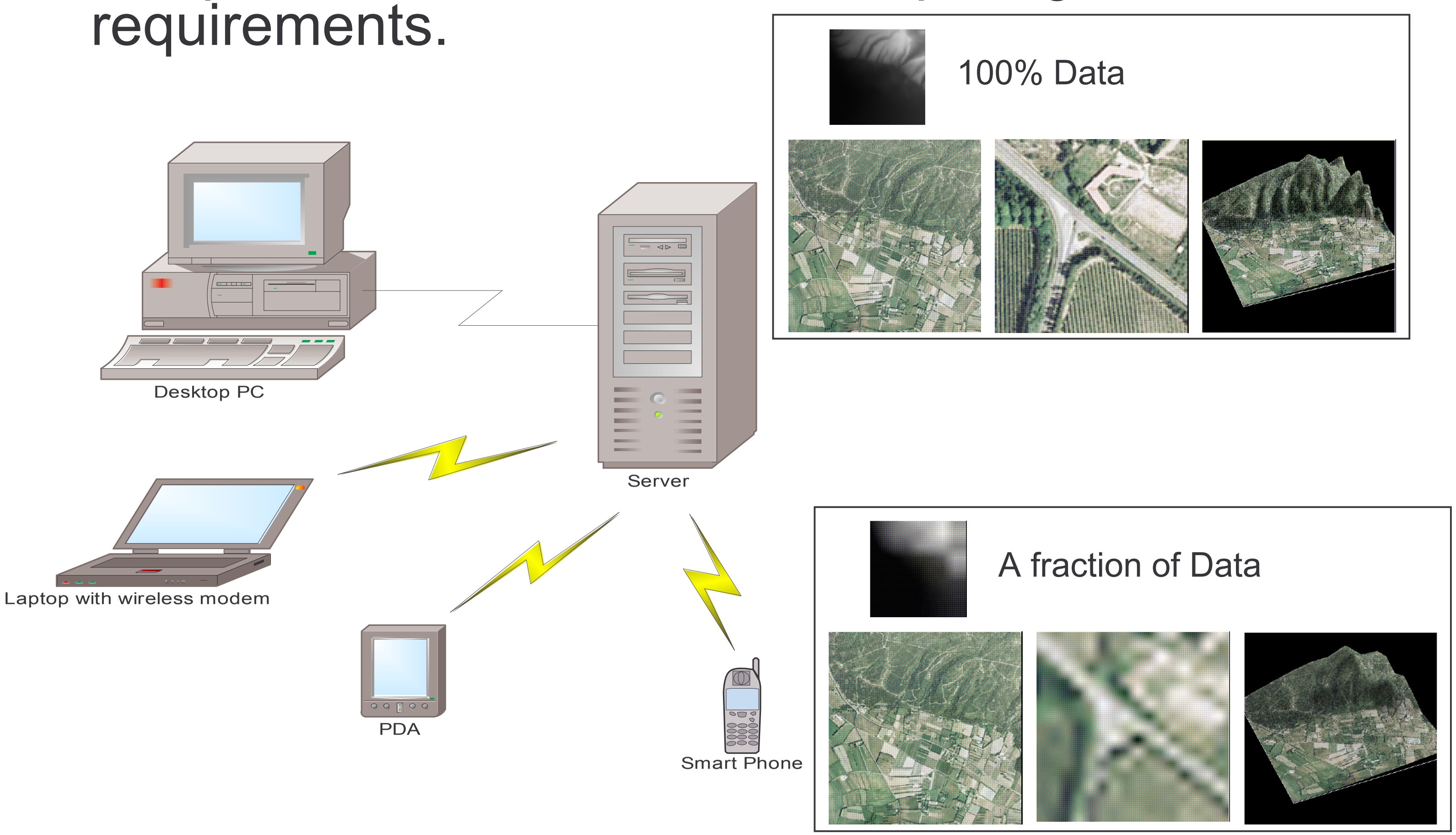
# The Problem

To effect an optimal real-time 3D visualization:

- for a client server environment in a scalable and synchronized way
- compatible with the client's computing resources and requirements.



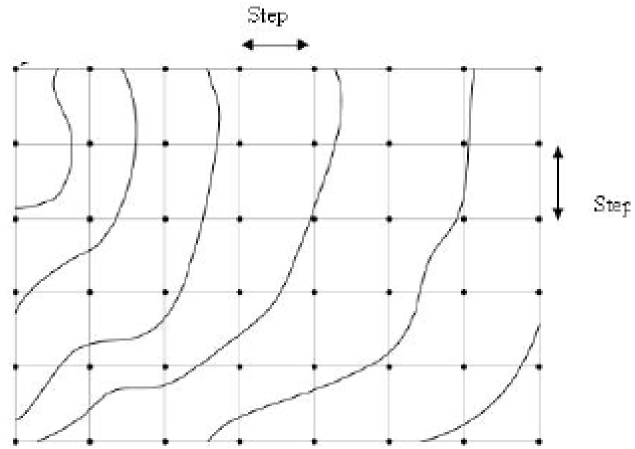
# The Proposed Solution

- Our Approach:
  - Discrete Wavelet Transform (DWT): JPEG2000
  - Data Hiding: LSB based synchronized embedding
- Advantages:
  - Compression: reduce the amount of data
  - Scalability: different levels of detail for various:
    - Platforms
    - Users (quality needs)
    - Application & Network contexts (point of view & bandwidth)
  - Synchronization: reduce the number of files

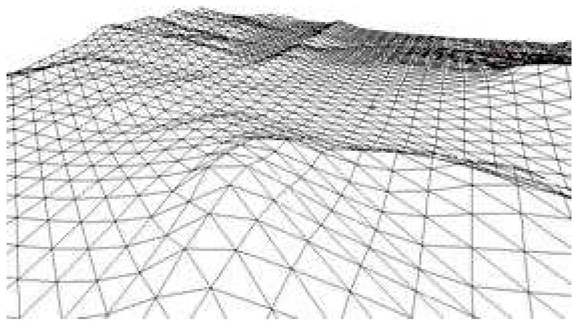
# 3D Visualization

- Three files are necessary
  - Image of Texture
  - Altitude DEM (Fig. a)
  - Geo-referential coordinates (longitude / latitude)
- Two steps for visualization:
  - – Creation of the 3D Mesh: Triangulation (Fig. b)
  - – Aerial Photograph : mapped onto the triangles for 3D visualization (Fig. c)

(a)

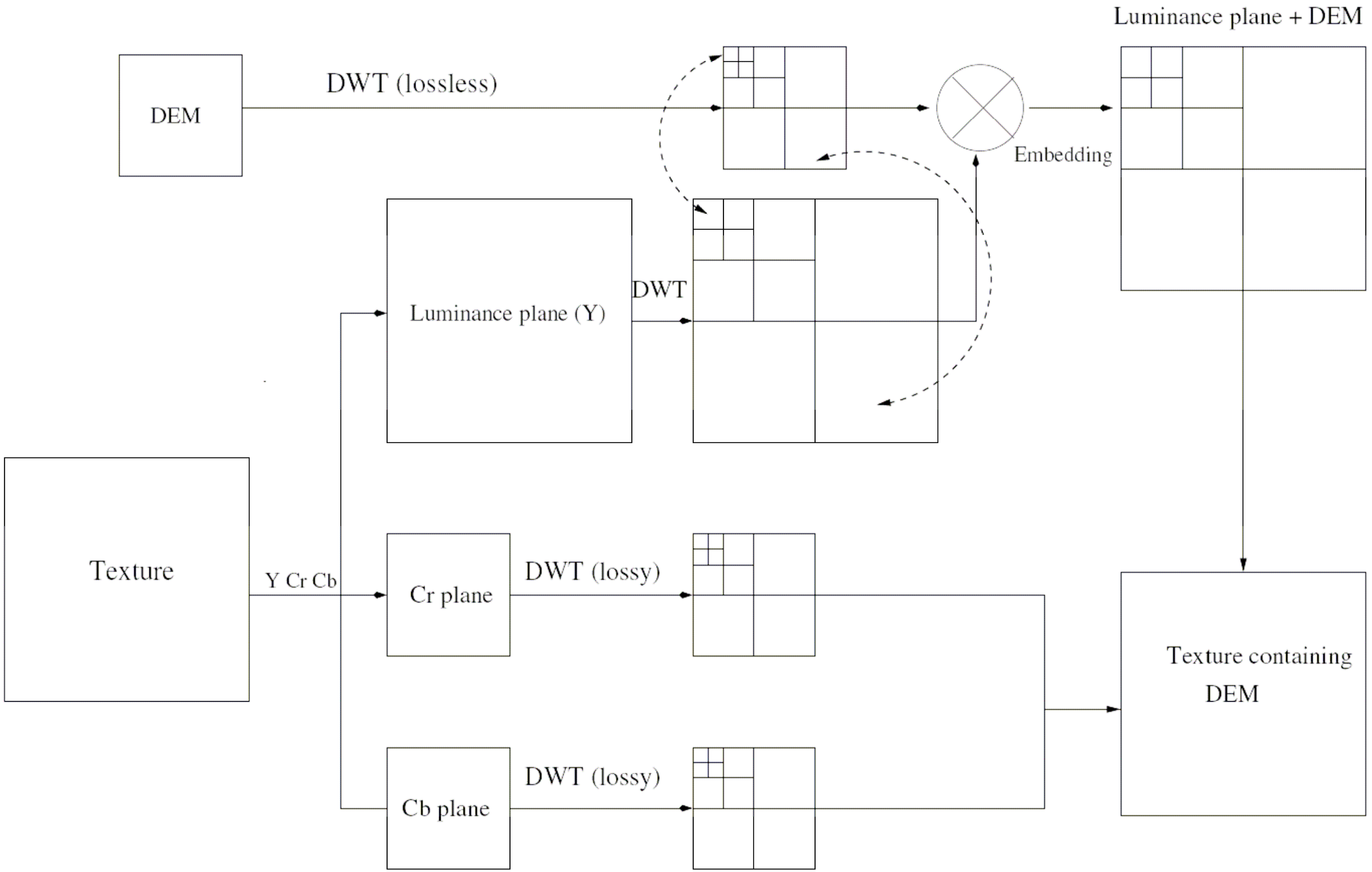



(b)



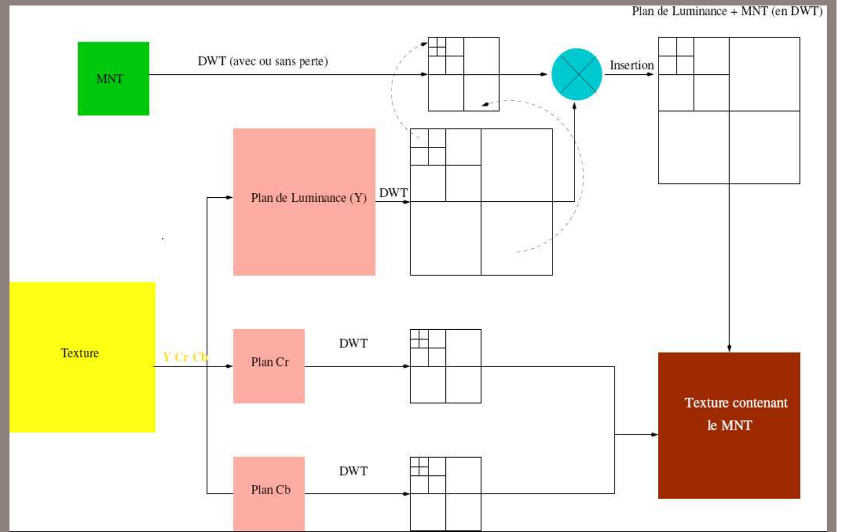
(c)

# The Proposed Method



# The Proposed Method

- **Transformation of texture image from RGB to YCrCb**
- **Wavelet Transformation**
  - Lossy DWT of the Texture (YCrCb)
  - Lossless DWT of altitude (DEM)
- **Synchronized Data Insertion**
  - Data : DWT(DEM); Cover : DWT(Y)
    - ✓ Same number of decompositions
    - ✓ Correspondence between subbands
  - Factor of insertion (E)
    - 1 coeff DWT(DEM) of 2 bytes per 32x32 block of DWT(Y) for our example
    - LSB based Insertion: running a PRNG for pixel allocation
    - ($E = m^2 / N^2$ (coefficients/ pixel) ; Block size = 1/E )
- **Final Embedded Image**



# Results

Altitude Image

(64x64 coefficients)

1 coefficient = 16 bits

Texture Image

(2048x2048 pixels)

1 Pixel = 24 bits

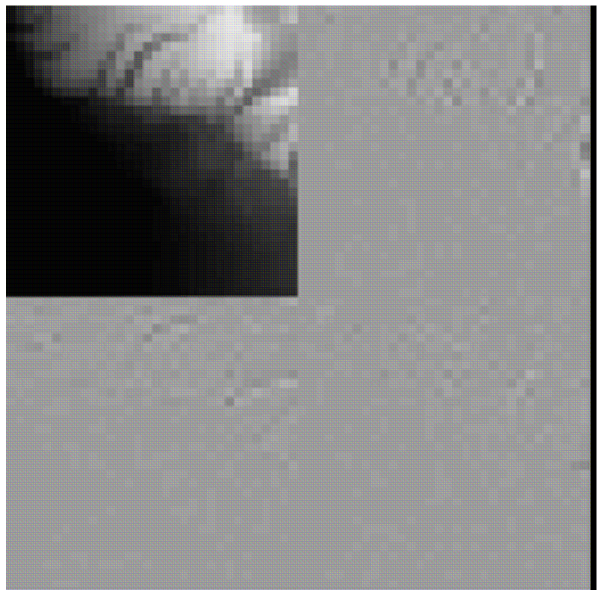
Texture Image

(A part magnified)

# Level 1 Transformation

Texture

(2048x2048 pixels)



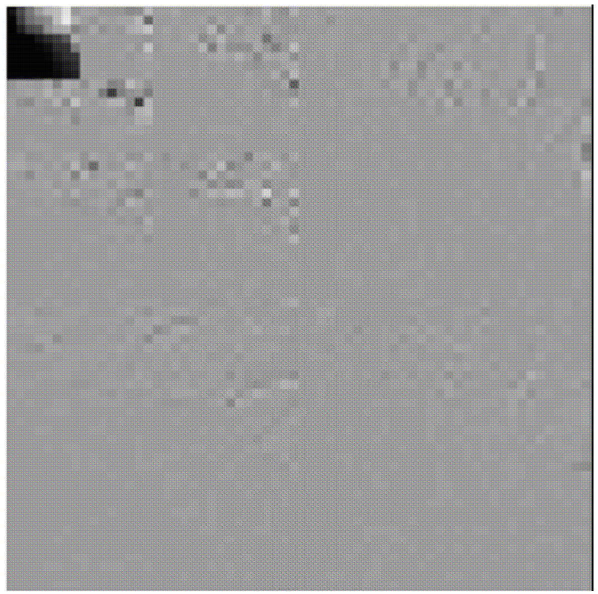
Altitude

(64x64 coefficients)

# Level 3 Transformation

Texture

(2048x2048 pixels)



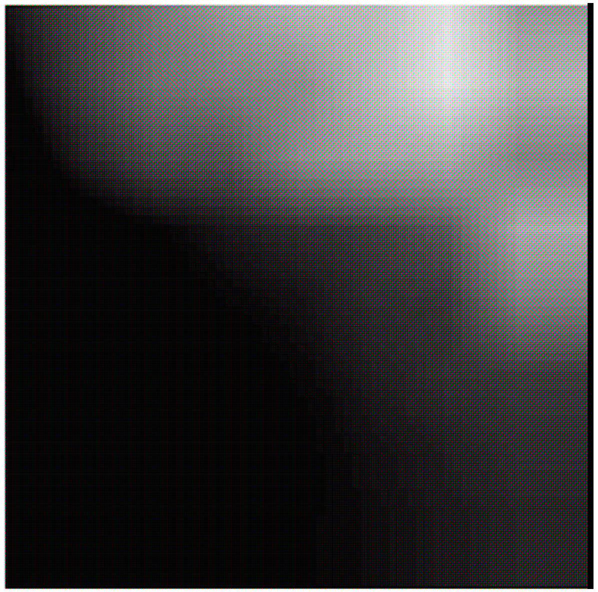
Altitude

(64x64 coefficients)

# Observations

| **Resolution Level** | 0 (all the data for $DWT^{-1}$) | 1 | 2 | 3 |
|---|---|---|---|---|
| **% Transmitted Data** | 100% | 25% | 6.25% | 1.6% |
| **$PSNR_{Texture}$ (dB)** | 37.62 | 26.54 | 22.79 | 20.90 |
| **$PSNR_{Altitude}$ (dB)** | $\infty$ | 40.37 | 33.51 | 29.25 |
| **$\sqrt{MSE}_{Altitude}$ (m)** | 0 | $\sqrt{5.97}$ = 2.44m | $\sqrt{29.00}$ = 5.39m | $\sqrt{77.37}$ = 8.8m |

# Reconstruction from the Image of Approximation at Level 3



Altitude Image

(64x64 coefficients)

1 coefficient = 16 bits

Texture Image

(2048x2048 pixels)

1 Pixel = 24 bits

Texture Image

(A part magnified)

Only 1.6% of the initial data utilized

# Results

The Original Example

Altitude Image

(64x64 coefficients)

1 coefficient = 16 bits

Texture Image

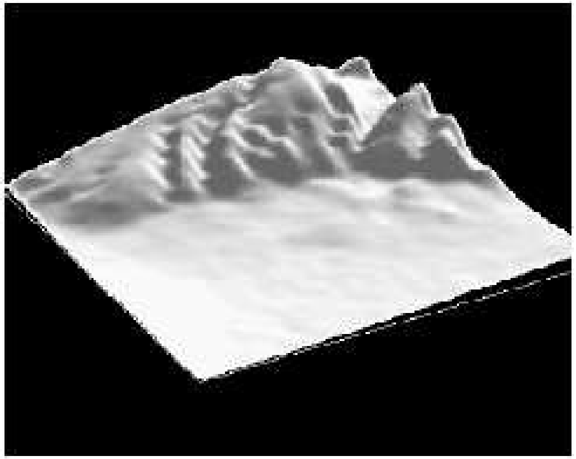
(2048x2048 pixels)

1 Pixel = 24 bits

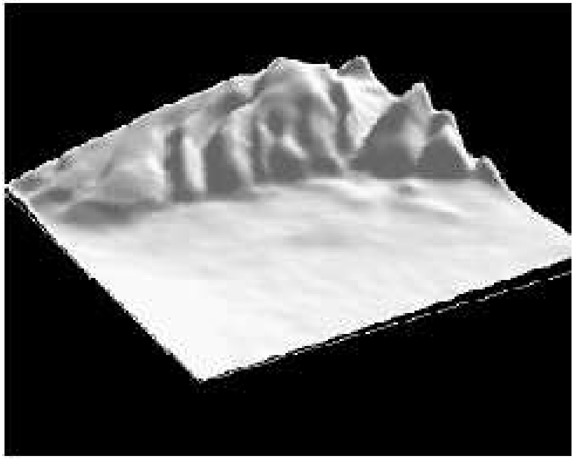
Texture Image

(A part magnified)

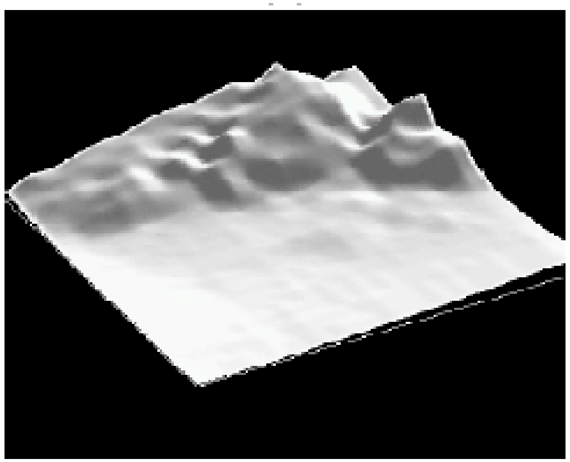
# 3D visualization of the Altitude from the Image of Approximaton



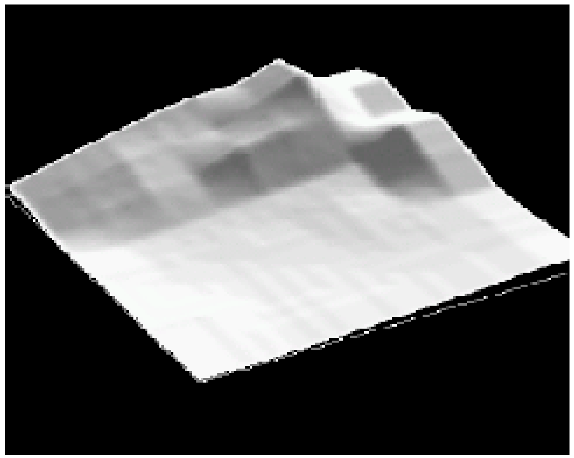
Level 0 - all the information



Level 1

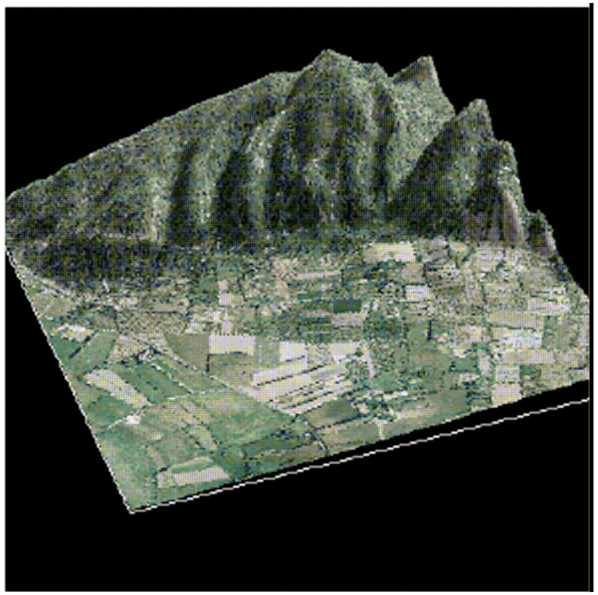


Level 2

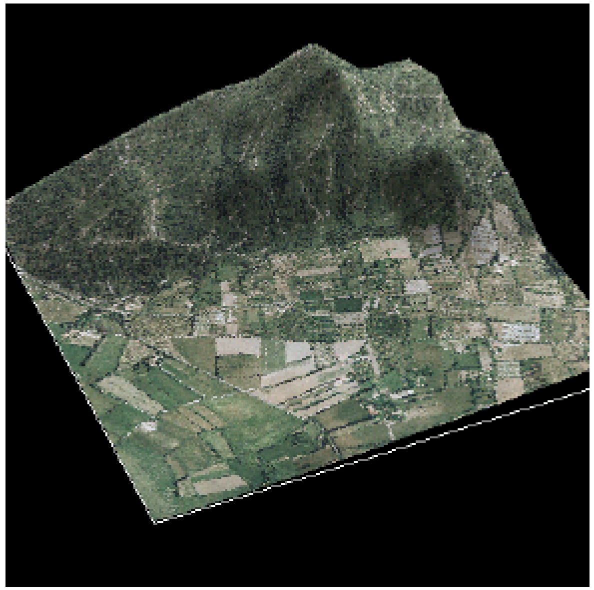


Level 3

# 3D navigation of the Reconstructed Images



All the data



Level 3 lowest suband data

Only 1.6% of the initial data utilized

# Conclusion

Encouraging results in the following contexts:

- Compression
- Scalability
- Synchronization

Perspectives:

- Integration of the method with standard JPEG2000 codec, e.g. OpenJPEG.
- Geometric Wavelets for DEM for compression
- Exploration of Chrominance planes

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# Questions ?

For more information:

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