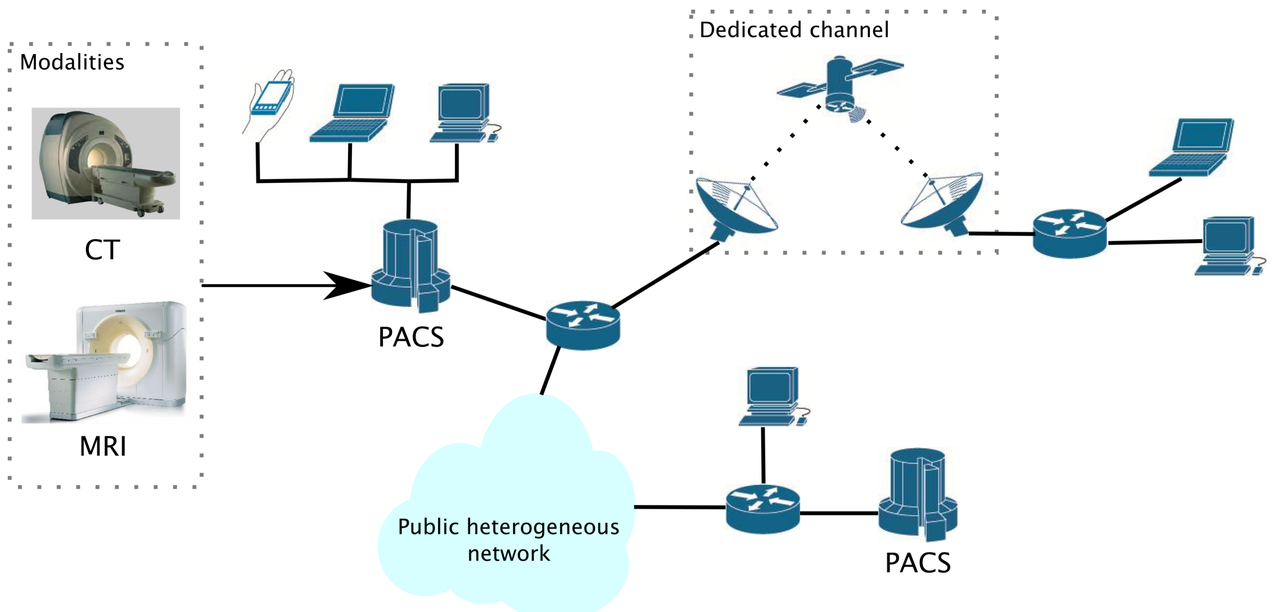
3D-PMDC: A PARALLELIZED MORPHOLOGICAL WAVELET CODEC FOR 3D MEDICAL DATASETS AND TELERADIOLOGY APPLICATIONS

Mario Pezzoni
Information Engineering Dept. (DII), University of Brescia, Italy
Mario.pezzoni@ing.unibs.it

Abstract: Modern medical imaging modalities produce **increasingly large datasets**. This trend can be **in contrast with the computation and transmission time requirements** coming from **critical teleradiology applications**. Multidimensional image compression techniques can be considered as enabling solutions on condition that they are able to guarantee a suitable combination of rate-distortion and computational performance which fulfill all the application domain requirements. In this work, we present a parallel version of our 3D Embedded Morphological Dilation Coding algorithm that allows a significant reduction of computation costs and the concurrent conservation of coding performance and of other relevant bitstream properties. A **comparison with the recently released JPEG2000 part 10 (JP3D) standard** put in evidence the value of the proposed solution, especially for teleradiology applications over heterogeneous networks.

Today heterogenerous teleradiology scenario



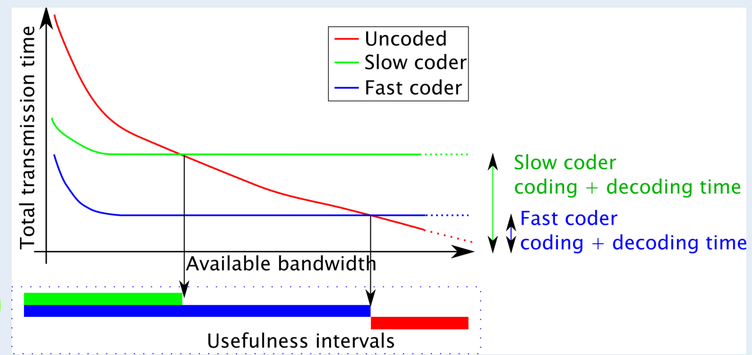
Motivation: Is it always useful to compress?

Transmission time without coding

$$T_{total} = \frac{S}{B_T}$$

Transmission time with coding

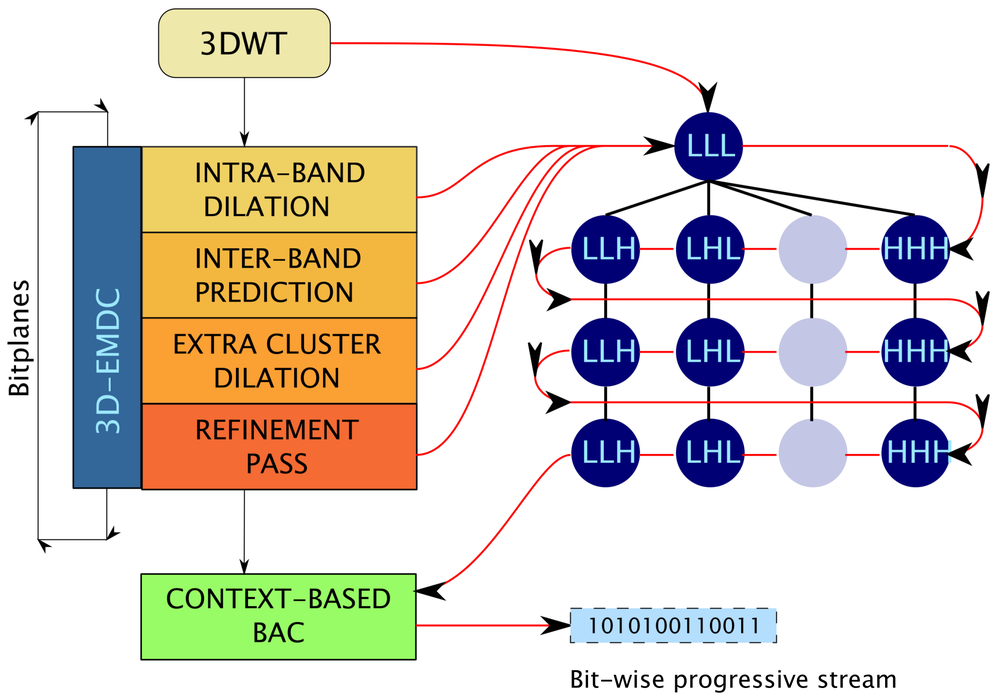
$$T_{total} = \frac{S}{B_T CR} + \frac{S}{B_C} + \frac{S}{B_D}$$

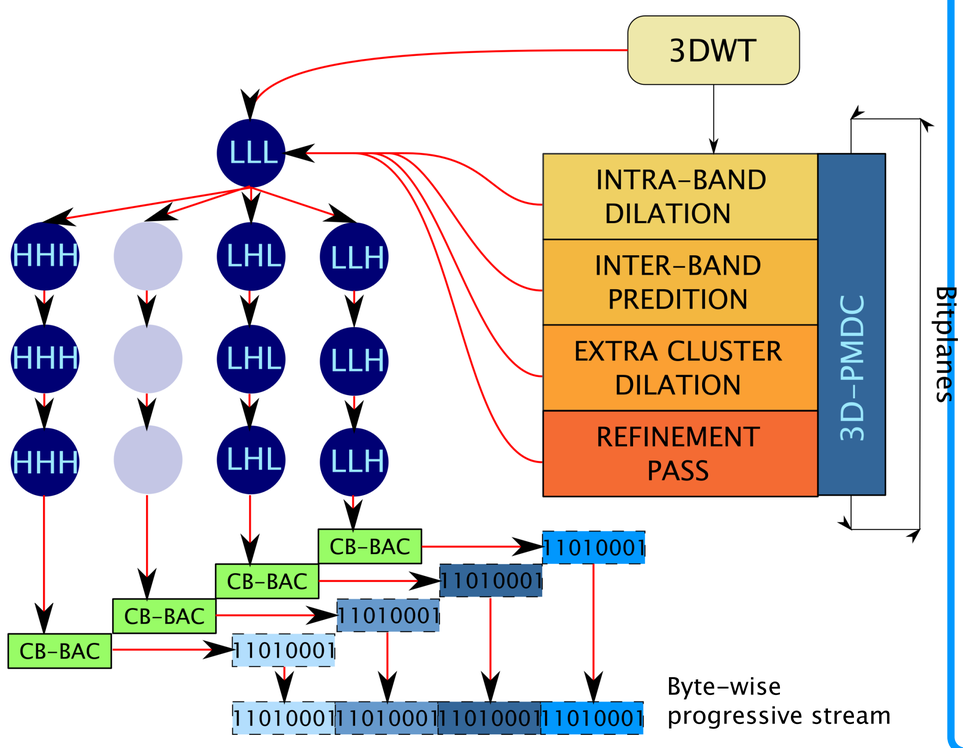


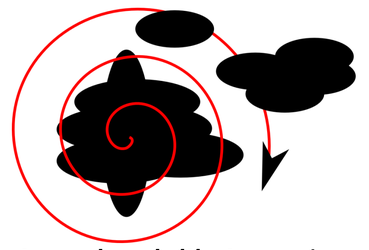
S: data size, $B_{C,D}$: coding/decoding speed [bit/sec] , CR: compression ratio, B_T: bandwidth

Objective:
Reduce coding and decoding time without losing compression effectivness.

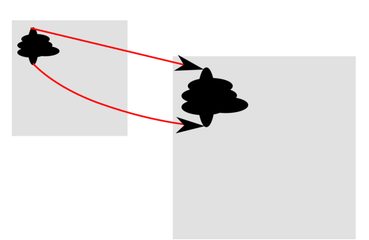
Solution:
The state-of-the-art EMDC morphological coder, has been modified to reduce coding and decoding time. A data parallelization technique has been developed to achive the same compression effectiveness in less time.





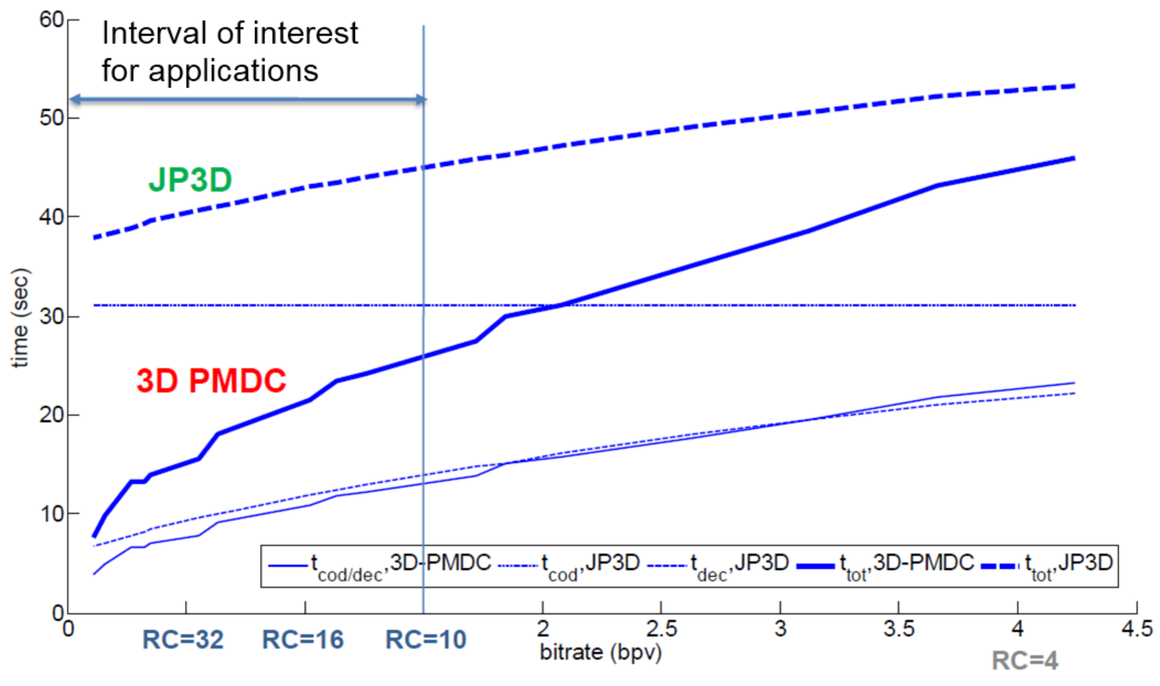


Intra-band dilation and ***Extra cluster dilation*** exploit wavelet coefficient clusterization



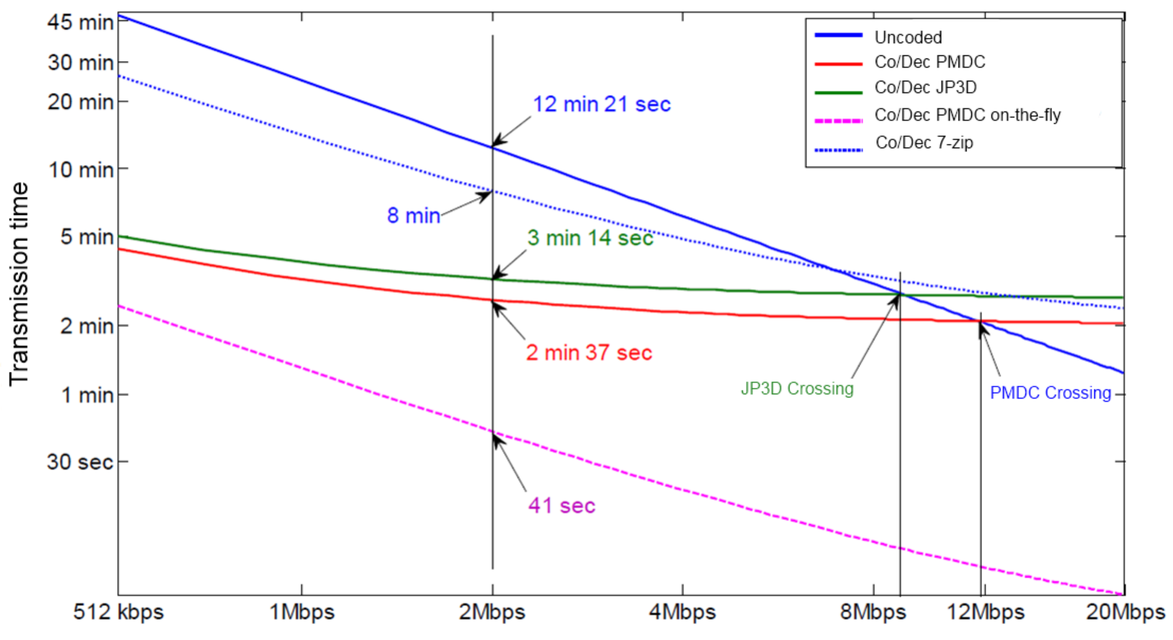
Inter-band prediction predicts coefficients form father sub-bands

3D-PMDC vs JPEG2000 part10 (JP3D): computational performance



JP3D implementation from :
Vrije University of Brussels IRIS Lab., "Iris software," http://www.irissoftware.be/

Total transmission time on common bandwidth values



On-the-fly mode:3D-PMDC can send the partially coded stream without waiting for the coding process to end (required in JP3D).

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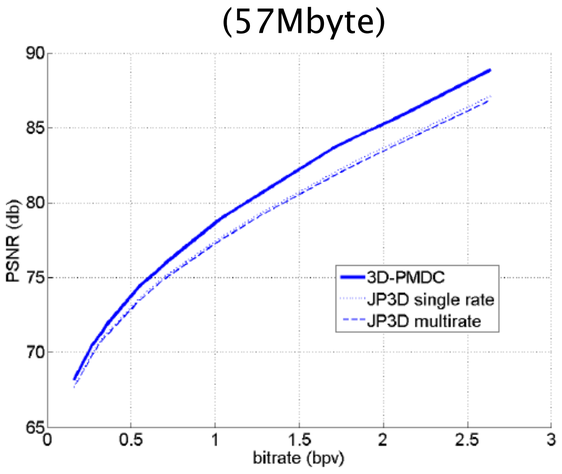
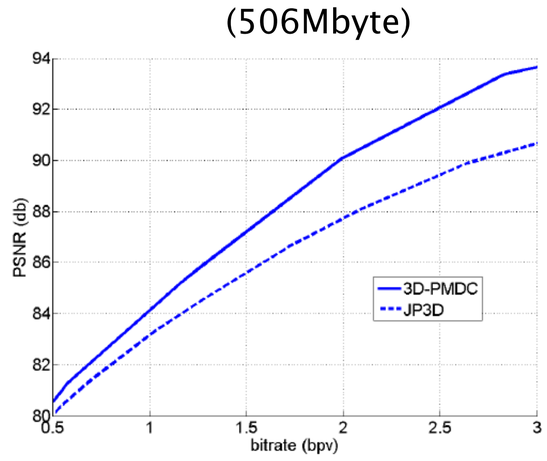
Visual and R-D Results

PMDC vs JP3D: R-D performance

Dataset MR 320x180x320x2 (57Mbyte)



Dataset CT 512x512x966x2 (506Mbyte)

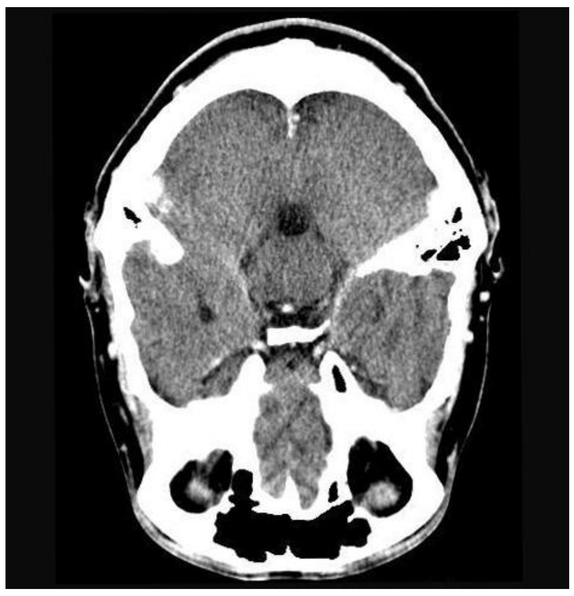


A note about PSNR:

Input data are stored as 16-bit integer
So the PSNR is computed as follow.

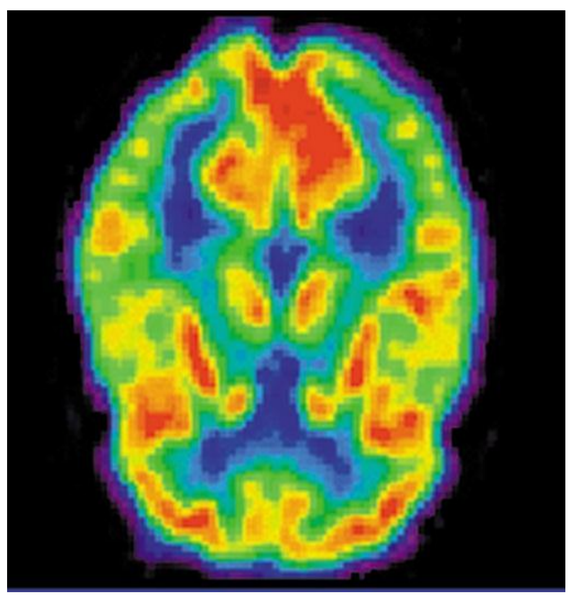
$$PSNR = 20 \log \frac{2^{16} - 1}{MSE}$$

Future development



Different modalities for each patient.

Same subject in different prospectives



- Inter-modal compression
- ROI generation

Data registration to match the same informaton

CONCLUSION

In this work, we presented and tested a parallelized version of the EMDC codec in its 3D extension, 3D-PMDC. A significant reduction of the computation time has been obtained with no costs in terms of coding performance. The symmetric operational structure of the coder and decoder allows on-the-fly coding (decoding) during data streaming, with potential reduction of the coding latency to the order of magnitude of the (also parallelized) wavelet transform computation. This establish the possibility to efficiently code large datasets on widespread multi-core PC and server architectures. From a rate-quality point of view, we obtained good coding performance along with the conservation of relevant characteristics of the EMDC bitstream, like the substantial progressivity (bytewise quality scalability), the spatial scalability (dyadic) and the possibility to define reference quality levels associated to the structure of the coding algorithm (fractional bitplanes). Timing and coding performances of the proposed 3D-PMDC constitute a technological basis to cope with the more and more demanding requirements of modern teleradiolog applications involving large datasets, also considering the diffused need to exploit existing telecommunication infrastructures. A benchmark comparison with the JP3D standard gives additional value to the obtained performance and to the peculiarities of the proposed solution. Clinical experimentations about the proper usage of the proposed coding technologies should be made, also in light of the emerging guidelines issued from the main radiologists associations.