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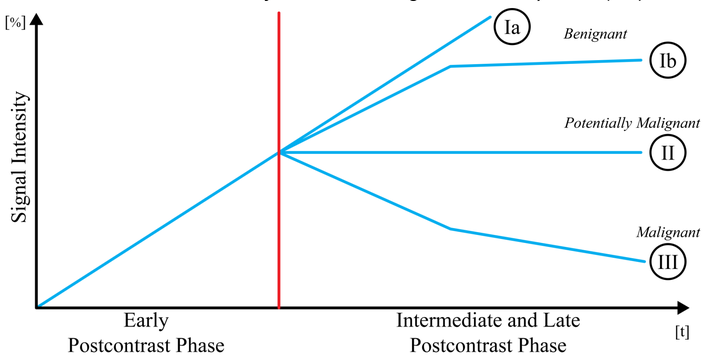
XXIX Cycle - II year presentation

Breast Cancer Analysis in DCE-MRI

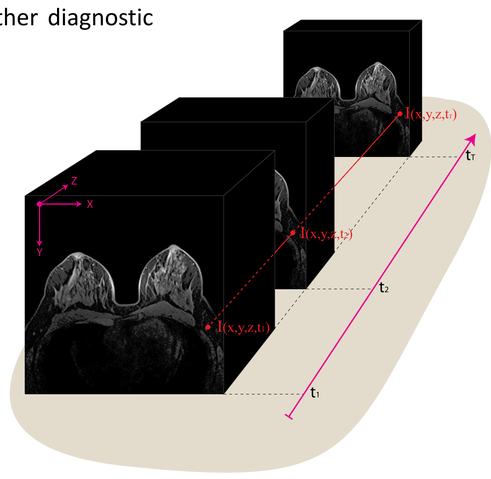
Dynamic Contrast Enhanced-Magnetic Resonance Imaging (DCE-MRI) has recently showed promising results in breast cancer detection and diagnosis. Advantages over other diagnostic modalities are: minimal invasiveness, capability to exploit functional information, high 3D spatial resolution.

"Visual" assessment of DCE-MRI among Time Intensity Curve (TIC)



Benefits of DCE-MRI

- By means of a positive paramagnetic contrast agent, DCE-MRI supplies functional tissue information
- Provides an high spatial resolution (~1mm)
- 4D volume (3 spatial dimensions + 1 temporal dimension)
- Makes use of electromagnetic fields (non-ionizing)
- High sensitivity (>95%)
- Differently from mammography, DCE-MRI permits early detection.



However, due to the **huge amount of data**, DCE-MRI can hardly be inspected without the use of a computer aided support. This stimulated researchers in the last decade to develop **Computer Aided Detection/Diagnosis** (CAD) systems. Among the major issues in developing CAD systems for breast DCE-MRI there are the **detection of suspicious region of interests** (ROIs) and the **classification of detected ROIs into benignant/malignant class**.

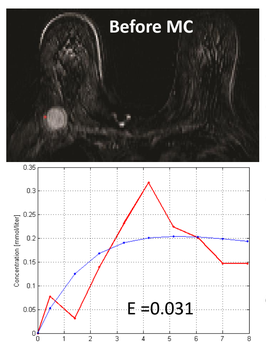
Breast Mask

The breast-mask is a binary mask representing **only breast parenchyma** and excluding background and other tissues (as we propose in [1]).

Signal Intensity (gray scale) — *Otsu's Tresholding (B/N)* — *Closing, hole filling ed erosion*

- Attenuate noise caused by extraneous pixel
- Reduce the computational load of the subsequent stages

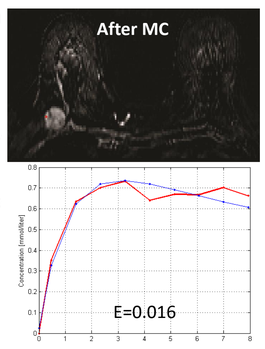
Motion Correction



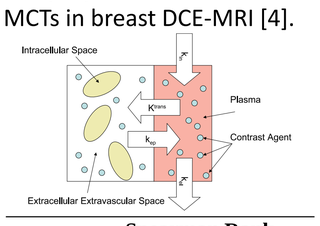
Benefit of a **Motion Correction Technique (MCT)** in DCE-MRI [1]

- No Shadow Ghost.
- Lesion is well-defined.
- The pectoral muscle is easily identified.
- **TIC curves better fit the physiological behavior**.

$$C_t(t) = K^{\text{trans}} \int_0^t \mathrm{e}^{-\frac{K^{trans}}{v_e}(t-s)} \cdot C_p(s)\,\mathrm{d}s + v_p C_p(t)$$



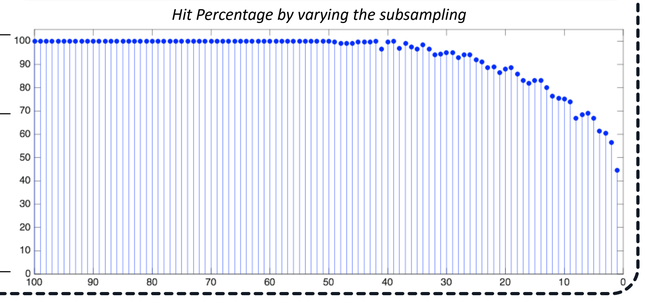
We propose a model-based **Quality Index (QI)** [3] for a data-driven selection of the MCTs in breast DCE-MRI [4].



QI	Spearman Rank Correlation
R-MSE	6.90%
PSRN	13.56%
N-CC	18.26%
HB	31.31%
GCTT	51.15%
TK-W	55.95%
TK-P	59.17%
ETK-W	58.33%
ETK-P	**73.91%**

Pat.	Motion Correction Techniques (MCTs)							
	NO-MC	ML	MEDx3	MEDx5	Ru_AL	Ru_AC	Ru_BL	Ru_BC
p1	4°	5°	**1°**	2°	3°	7°	5°	8°
p2	4°	2°	5°	6°	**1°**	3°	8°	7°
p3	5°	7°	2°	**1°**	3°	4°	6°	8°
p4	7°	4°	3°	2°	4°	**1°**	8°	6°
p5	7°	6°	2°	**1°**	4°	3°	5°	8°
p6	**1°**	4°	2°	3°	4°	4°	4°	8°

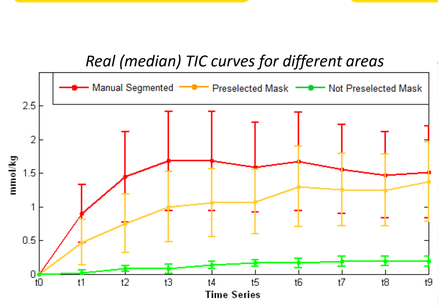
Hit Percentage by varying the subsampling



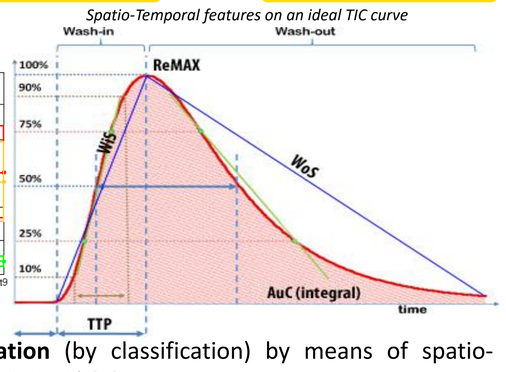
ROI Detection *(by classification)*

Preselection → **Feature Extraction** → **Segmentation**

Real (median) TIC curves for different areas

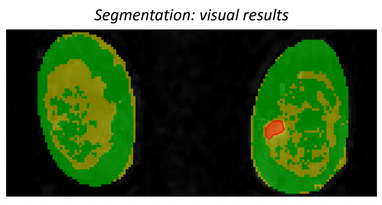


Spatio-Temporal features on an ideal TIC curve



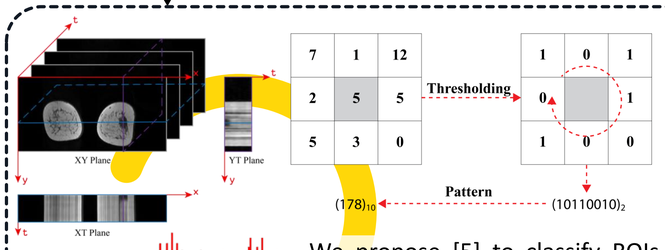
We achieve a pixel-by-pixel **segmentation** (by classification) by means of spatio-temporal features (ReMAX, TTP, AUC, WiS, WoS) [1].

Segmentation: visual results



Author	Accuracy	Sensitivity	Specificity
Our proposal	**98.70**	**71.56**	**98.94**
Torricelli et al.	98.69	25.80	99.49
Fusco et al.	86.99	90.97	86.99
Pixel-Based on RE	86.59	75.44	86.64

ROI Classification

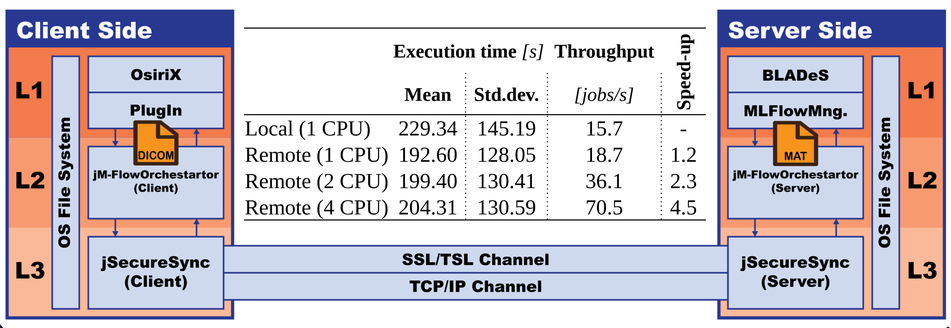


Local Binary Pattern (LBP) provides a very efficient set of features by thresholding the neighbourhood of each pixel and considering the result as a binary number. The binary numbers are interpreted as a **local pattern** and an **histogram** of the occurrences for the patterns is calculated.

We propose [5] to classify ROIs with LBP features for 3D volumes: **Three Orthogonal Planes (LBP-TOP)** considers three orthogonal planes: XY, XT and YT, and concatenates histograms.

Author	Methodology	Accuracy	Sensitivity	Specificity
Our proposal	LBP-TOP + Random Forest	**84.6**	**80.0**	**90.9**
Fusco et al.	Dynamic features + Naive Bayes	65.4	80.0	45.5
	Morphological features + Decision Tree	65.4	53.3	81.8
	Dynamic & Morph. features + Multiple Classifier System	69.2	86.7	45.5
Glaßer et al.	Morphological & Clinical features + Decision Tree	61.5	93.3	18.2

Framework for remote processing of huge amount of data [2, 6]



	Execution time *[s]*		Throughput	Speed-up
	Mean	Std.dev.	*[jobs/s]*	
Local (1 CPU)	229.34	145.19	15.7	-
Remote (1 CPU)	192.60	128.05	18.7	1.2
Remote (2 CPU)	199.40	130.41	36.1	2.3
Remote (4 CPU)	204.31	130.59	70.5	4.5

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Future Works

Future works will treat, carefully, every stage of the CAD system for breast DCE-MRI. Specifically:

- Testing new breast-mask extraction algorithms;
- Test different datasets (Pascale & USF collaborations);
- Explore new "habitat-based" features (USF collaboration);
- Develop new textural features for jointly spatial and temporal analysis;
- Prediction of the treatment outcome (USF collaboration);
- Further improve the performances of the QI for the data-driven selection of MCTs.

References & Publications

[1] S. Marrone, G. Piantadosi, R. Fusco, A. Petrillo, M. Sansone and C. Sansone, "Automatic lesion detection in breast DCE-MRI" in International Conference on Image Analysis and Processing (ICIAP), pp. 359-368, 09-13 Dec 2013, Naples, Italy, 2013.

[2] G. Piantadosi, S. Marrone, M. Sansone and C. Sansone, "A secure OsiriX plug-in for detecting suspicious lesions in breast DCE-MRI", in 13th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP), pp. 217-224, 18-20 Dec 2013, Vietri sul Mare, Italy, 2013.

[3] S. Marrone, G. Piantadosi, R. Fusco, A. Petrillo, M. Sansone, and C. Sansone, "A novel model-based measure for quality evaluation of image registration techniques in DCE-MRI" in IEEE 27th International Symposium on Computer-Based Medical Systems (CBMS), pp. 209-214, 27-29 May 2014, New York IEEE, 2014.

[4] G. Piantadosi, S. Marrone, R. Fusco, A. Petrillo, M. Sansone, and C. Sansone, "Data-driven selection of motion correction techniques in breast DCE-MRI" in IEEE International Symposium on Medical Measurements and Applications (MeMeA), IEEE, 07-09 May 2015, Turin, Italy, 2015.

[5] G. Piantadosi, R. Fusco, A. Petrillo, M. Sansone and C. Sansone, "LBP-TOP for volume lesion classification in breast DCE-MRI" in International Conference on Image Analysis and Processing (ICIAP), 07-11 Sep 2015, Genova, Italy, 2015.

[6] G. Piantadosi, S. Marrone, M. Sansone and C. Sansone, "A secure, scalable and versatile multi-layer client–server architecture for remote intelligent data processing" in Journal of Reliable Intelligent Environments (JRIE), 1 (2-4), 173-187, Dec 2015.