Medical Imaging Research Laboratory
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Improved Quantitative evaluation of Cardiac perfusion using bayesian and spatio-temporal approaches : accuracy and reproducibility against conventional post-processing techniques on digital and clinical data

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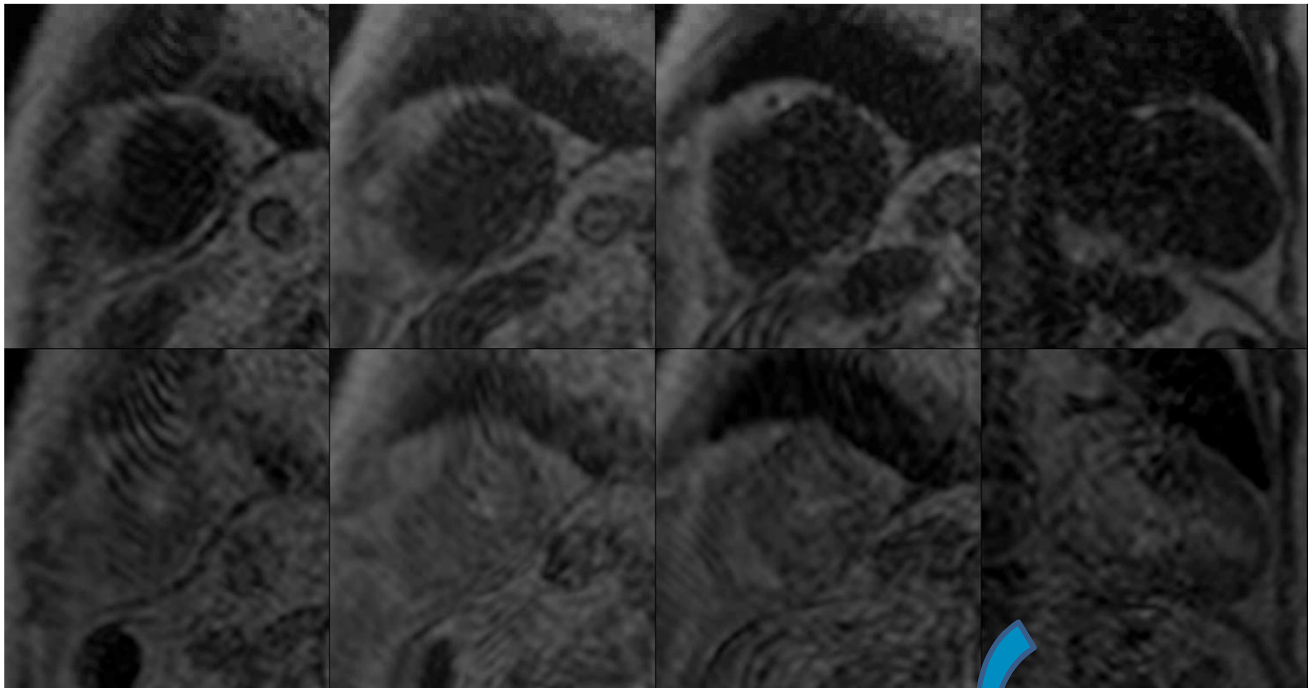
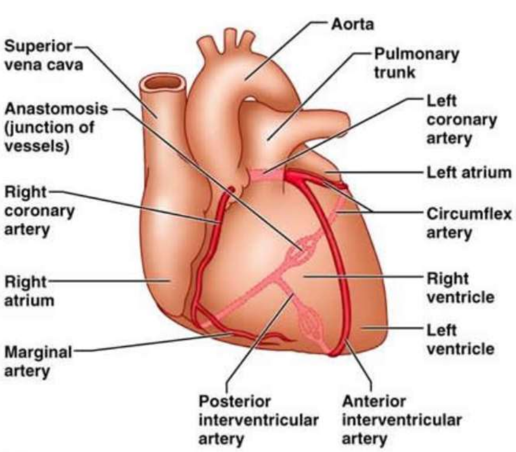
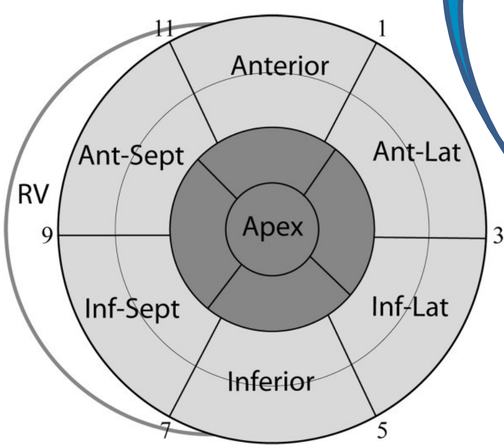
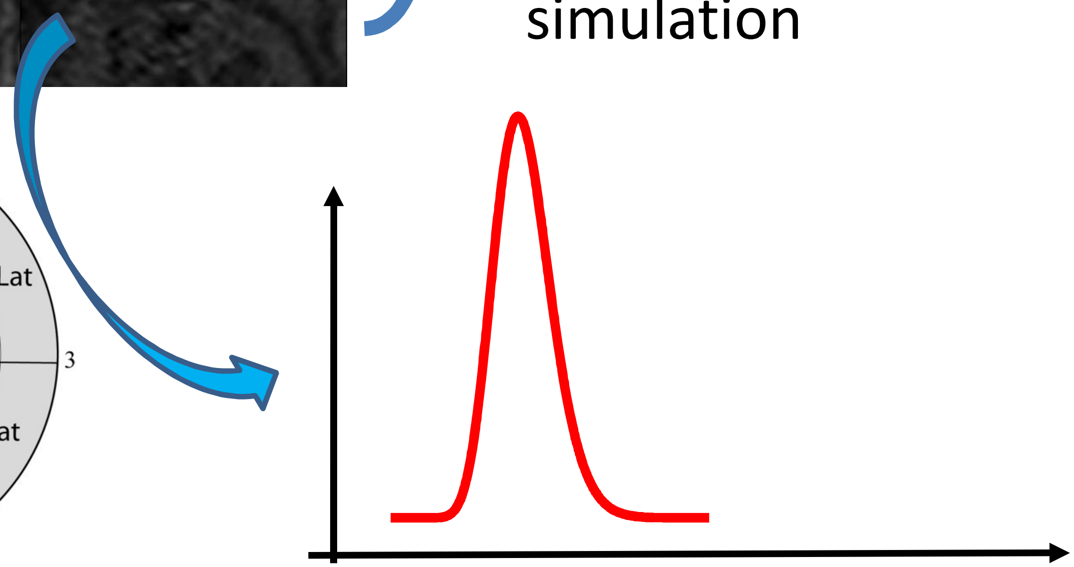
Background & Purpose



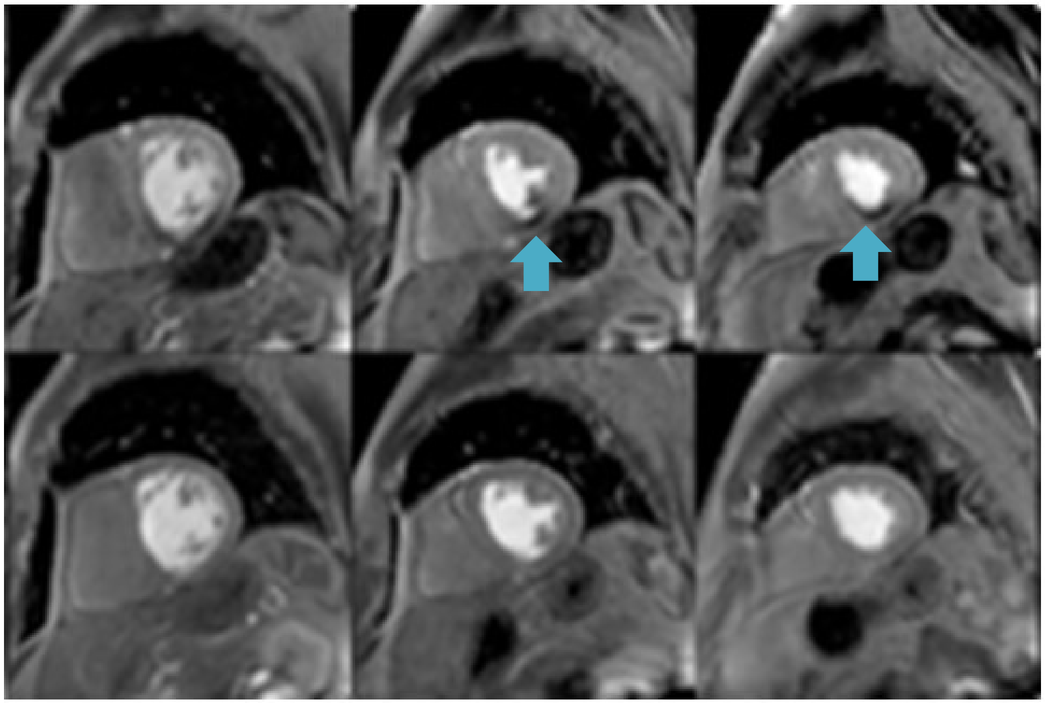
- **Dynamic acquisition** during contrast agent first pass
- **Pharmacological stress** ~ effort simulation



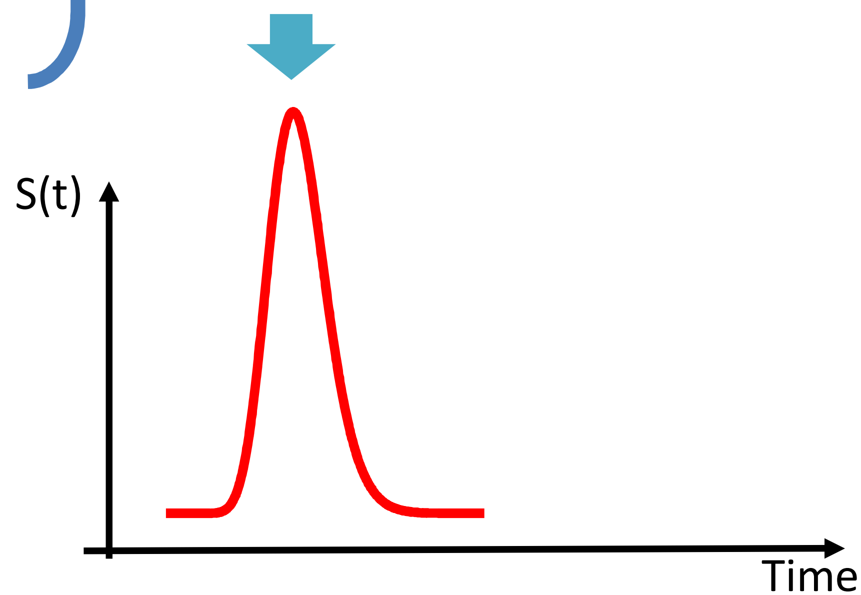


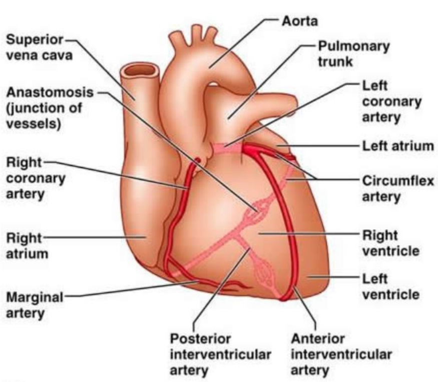


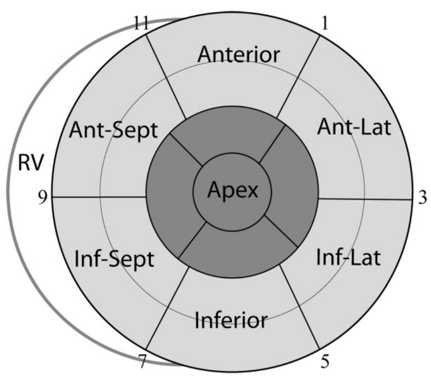
Background & Purpose



- **Contrast enhancement's visual analysis**
- Perfusion defect location



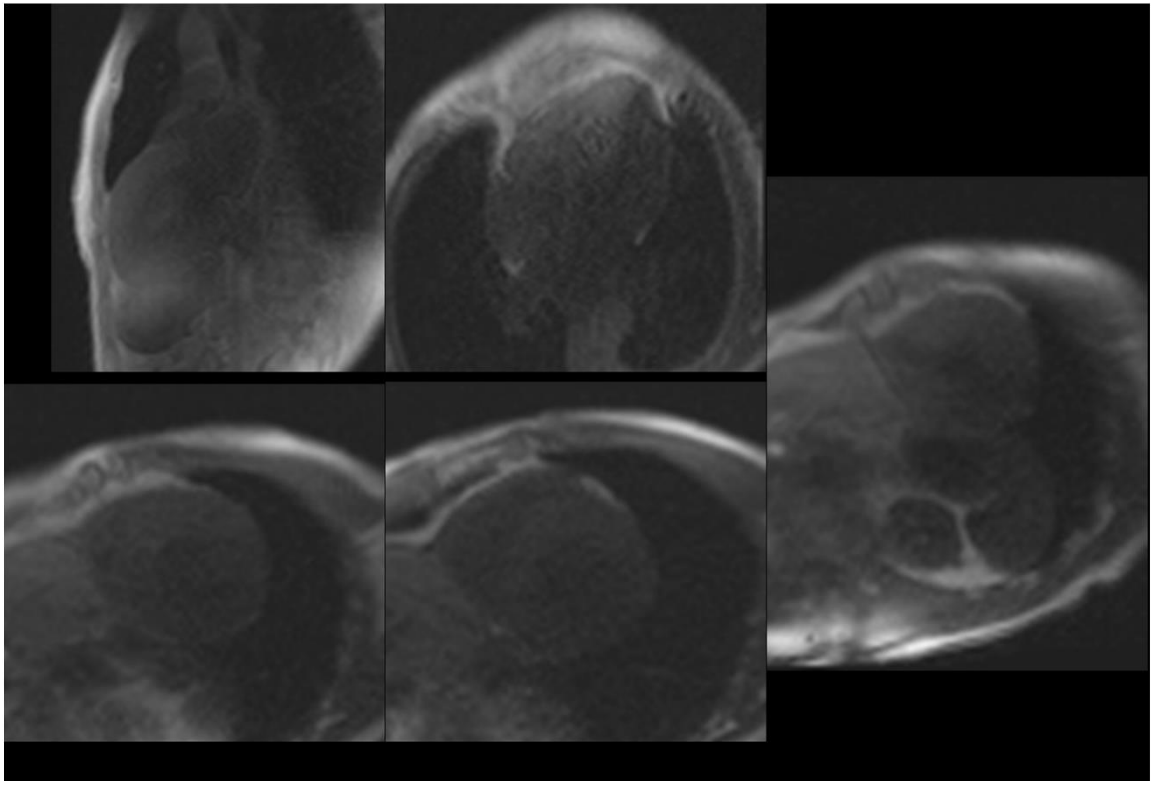




Background & Purpose

Visual analysis is insufficient :

- Case of general perfusion defect / triple vessel flow reduction
- No possibility for :
  - ✓ Patient follow up
  - ✓ Patient care statement
  - ✓ Therapy quantification



Perfusion needs Quantification indexes

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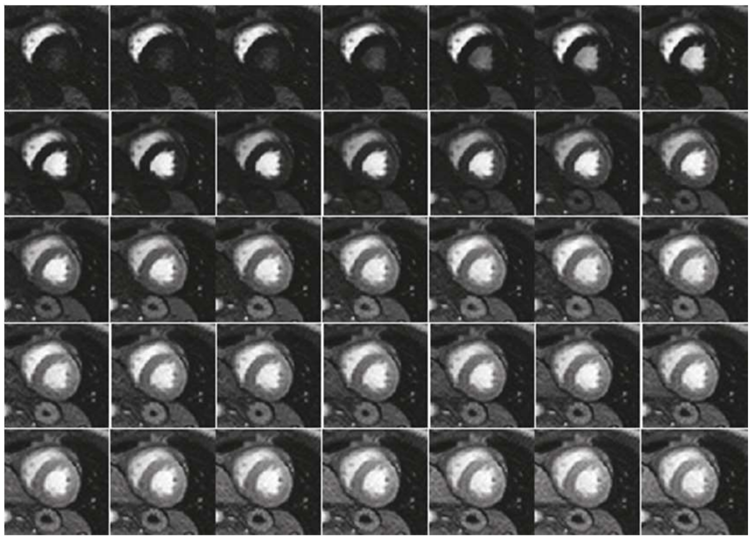
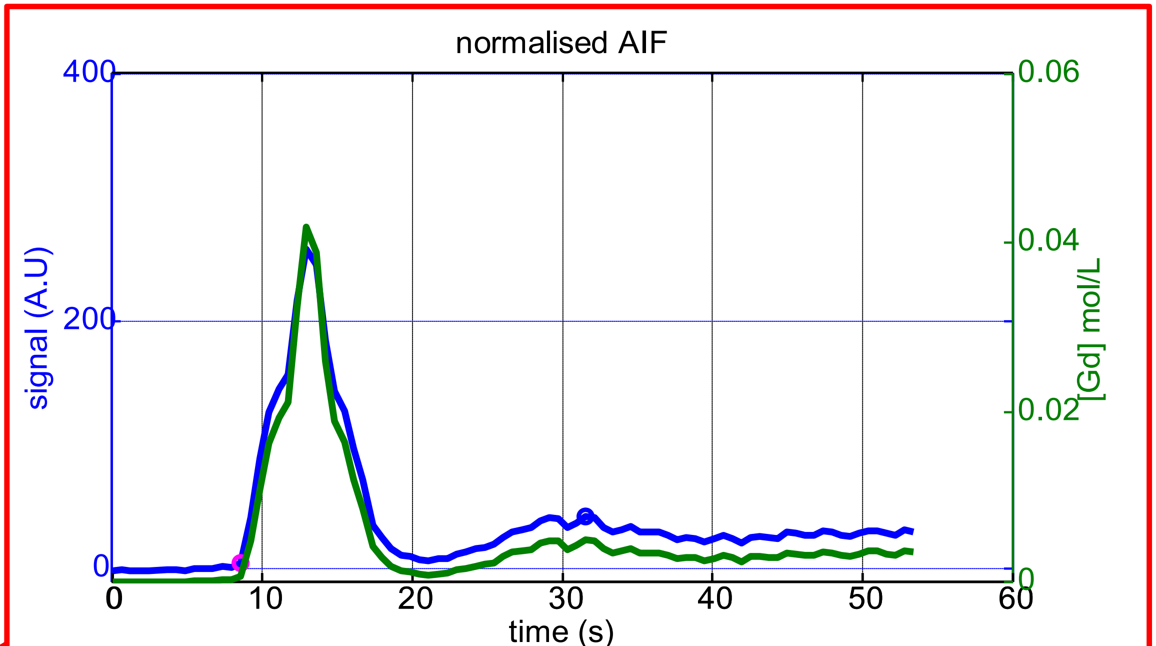
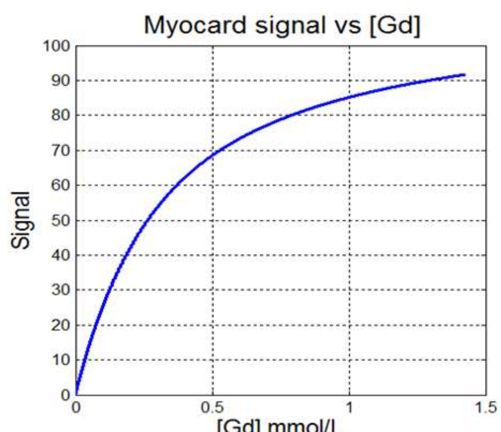
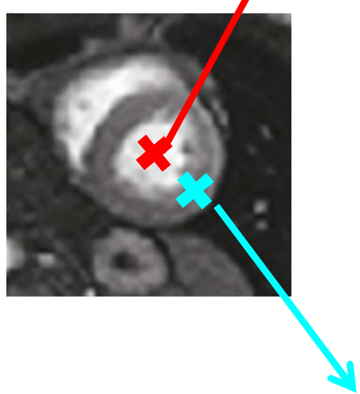
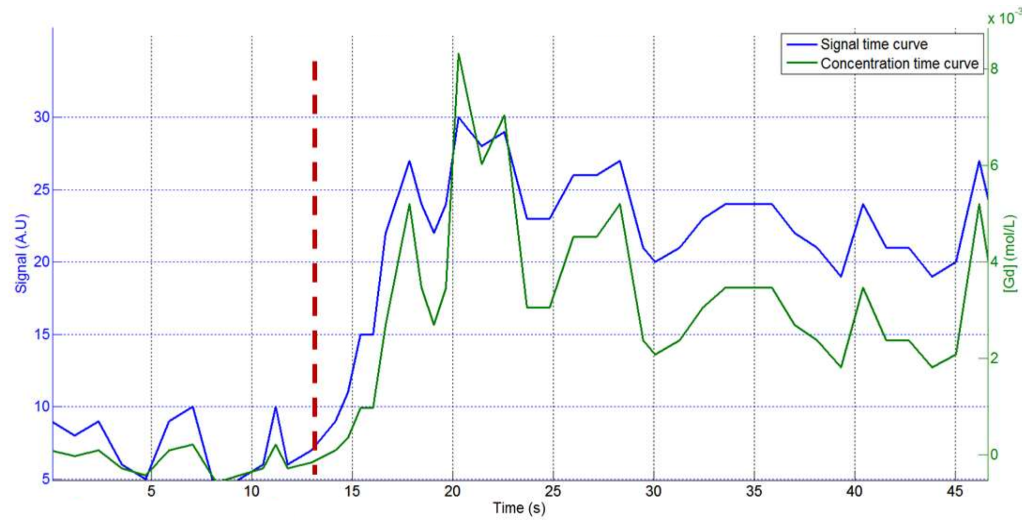
Signal to [Contrast Agent]









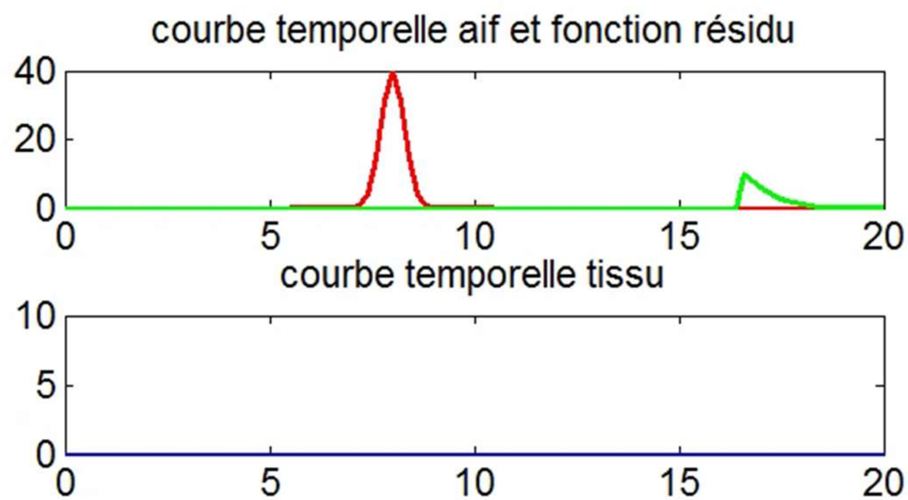


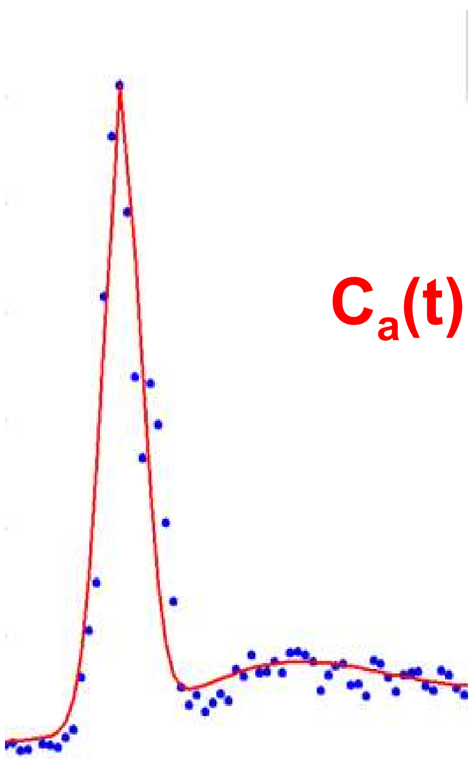
$$\frac{1}{T1} = \frac{1}{T1_{tissue}} + r1_{Gd} * [Gd]$$

M. J.-Herold Quantification of myocardial perfusion by cardiovascular magnetic resonance Journal of Cardiovascular Magnetic Resonance 2010

Background & Purpose

Quantification principle





AIF

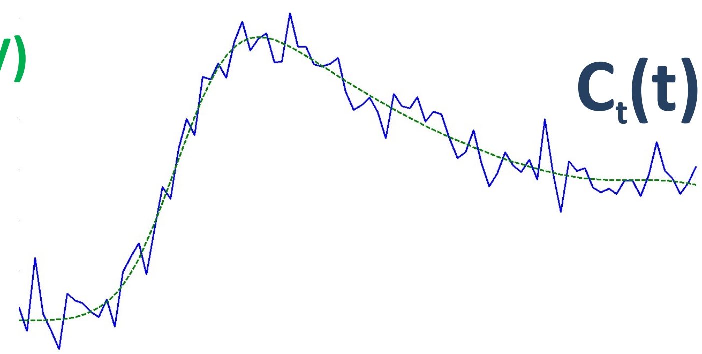
$\otimes$

R(t, MBF, MBV)

?

residue

=



tissue CTC

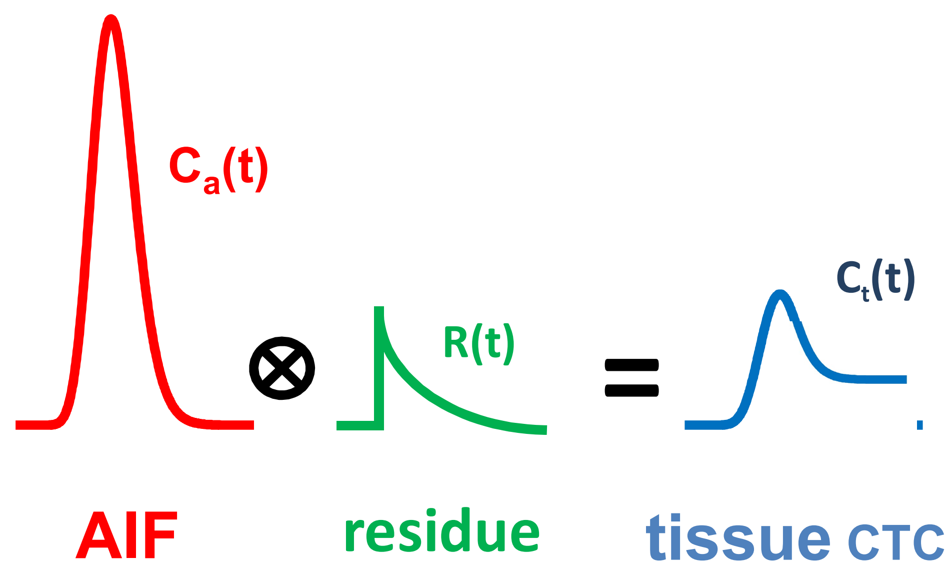
Background & Purpose

Model independent analysis

- Numerical resolution
- Noise sensitive
- Results are methods dependents

Evaluation of myocardial Blood flow and plasmatic volume

$$\Delta t \begin{bmatrix} C_a(t_0) & 0 & \cdots & 0 \\ C_a(t_1) & C_a(t_0) & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ C_a(t_{N-1}) & C_a(t_{N-2}) & \cdots & C_a(t_0) \end{bmatrix} \times \begin{bmatrix} R(t_0) \\ R(t_1) \\ \vdots \\ R(t_{N-1}) \end{bmatrix} = \begin{bmatrix} c(t_0) \\ c(t_1) \\ \vdots \\ c(t_{N-1}) \end{bmatrix}$$

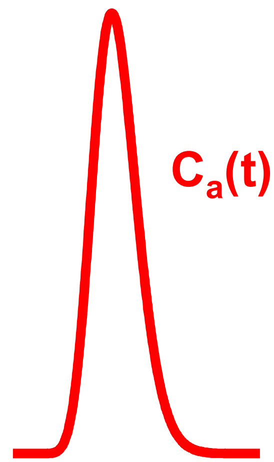


Background & Purpose

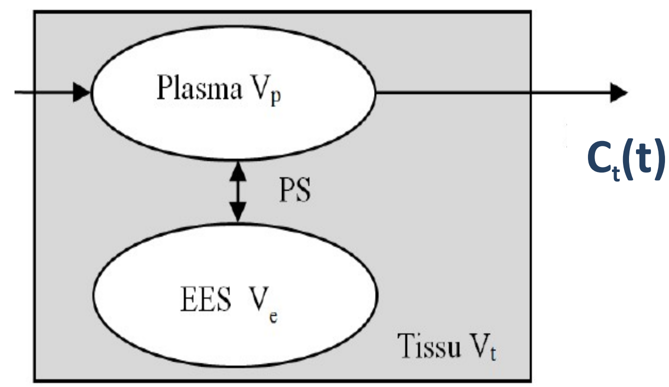
Parametric approach

- Parametrical modeling of residue function
- Parameters adjustments to fit concentration time curves
- Decreasing number of parameters
  => risk of estimation error
- Increase of parameter number
  => risk of instability

Evaluation of myocardial Blood flow and plasmatic volume



AIF



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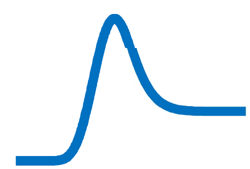
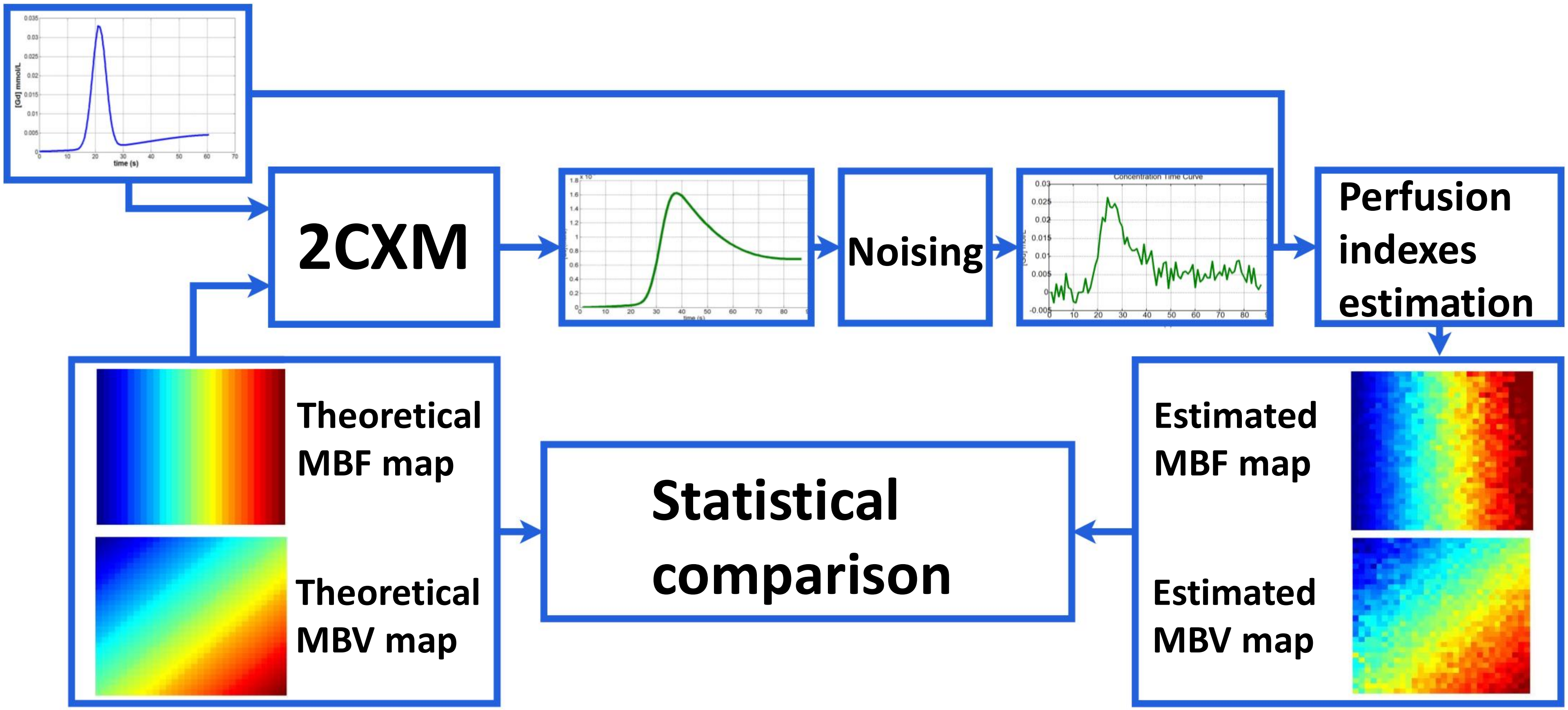


tissue CTC

Method

Generation of a digital phantom from 2 compartment exchange modeling (2CXM)



Method

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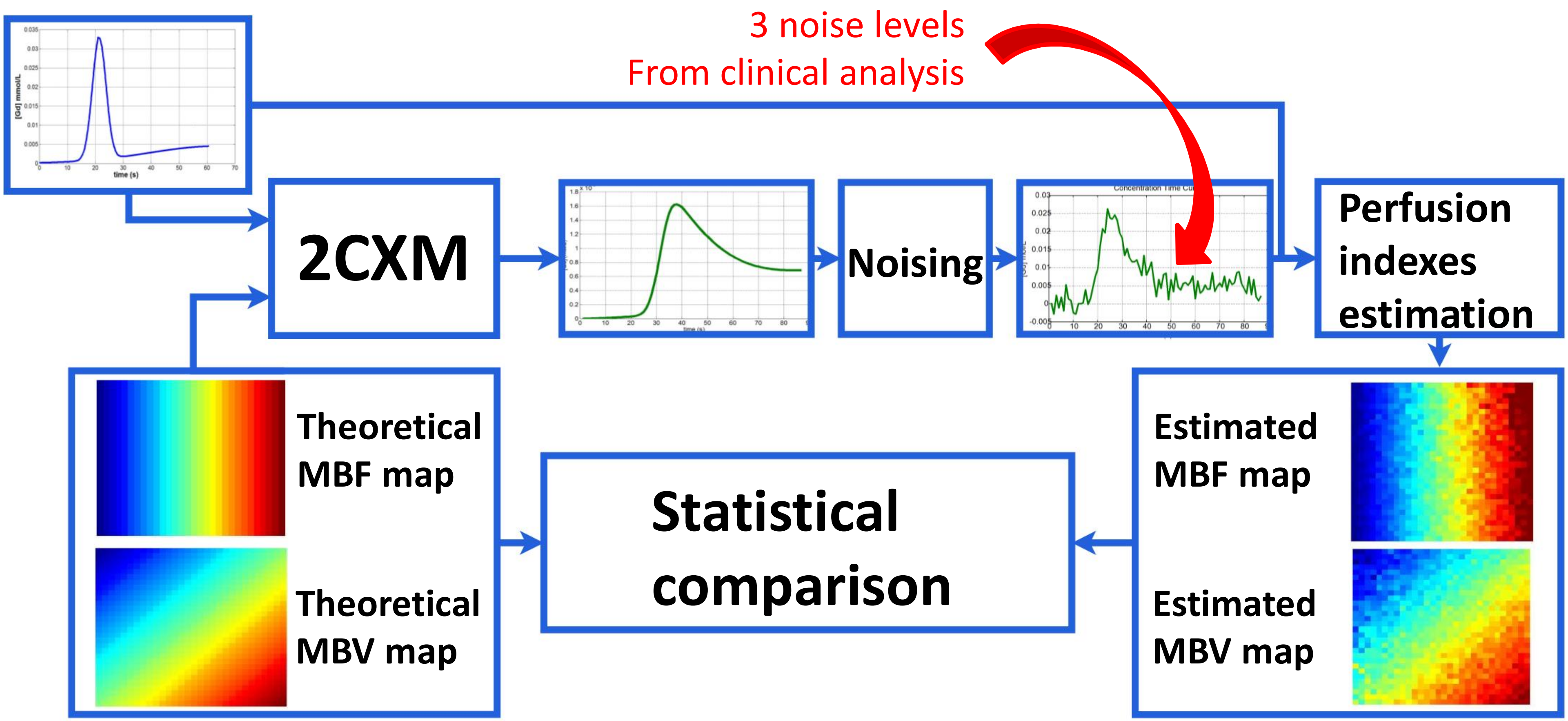
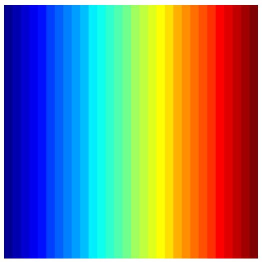
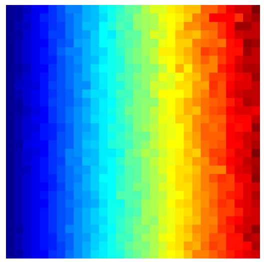
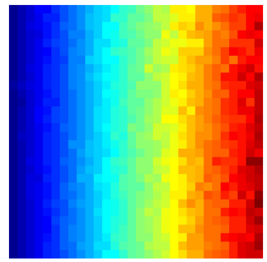
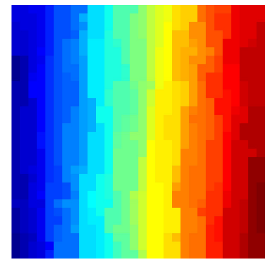
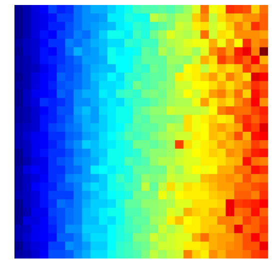
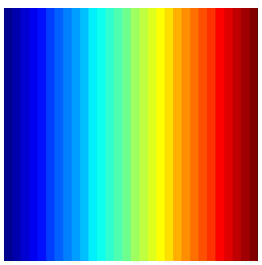
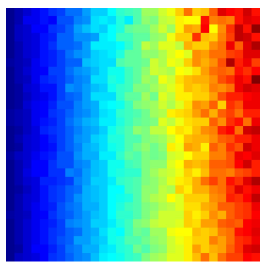
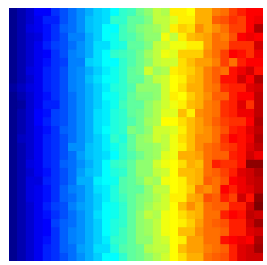
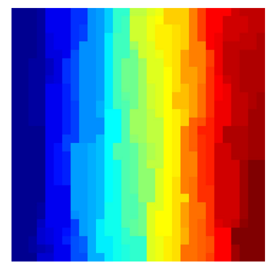
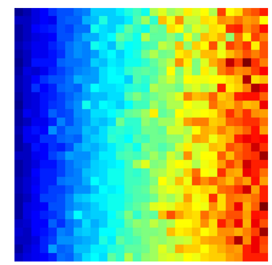
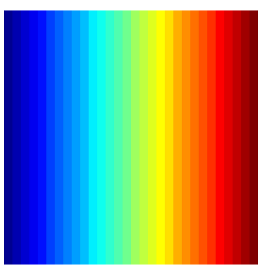
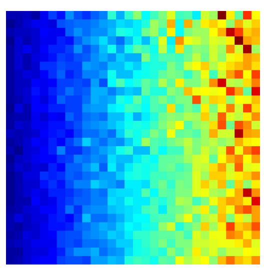
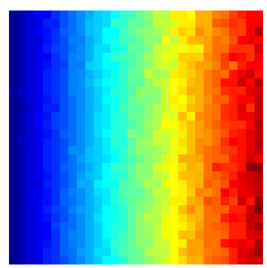
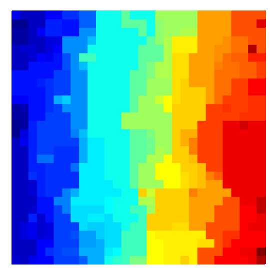
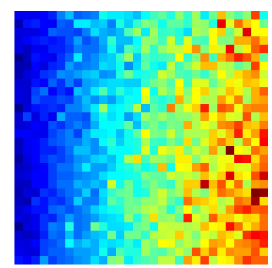


Results

MBF	phantom	Fermi	Bayésien	Spatio-Temporel	oSVD
Myocard					
segment					
voxel					

Results

Correlation (r^2) MBF	Fermi	Bayesian	Spatio-temporal	OSVD
Myocard	0.998	0.996	0.992	0.989
Segment	0.991	0.989	0.989	0.960
Voxel	0.940	0.951	0.969	0.887

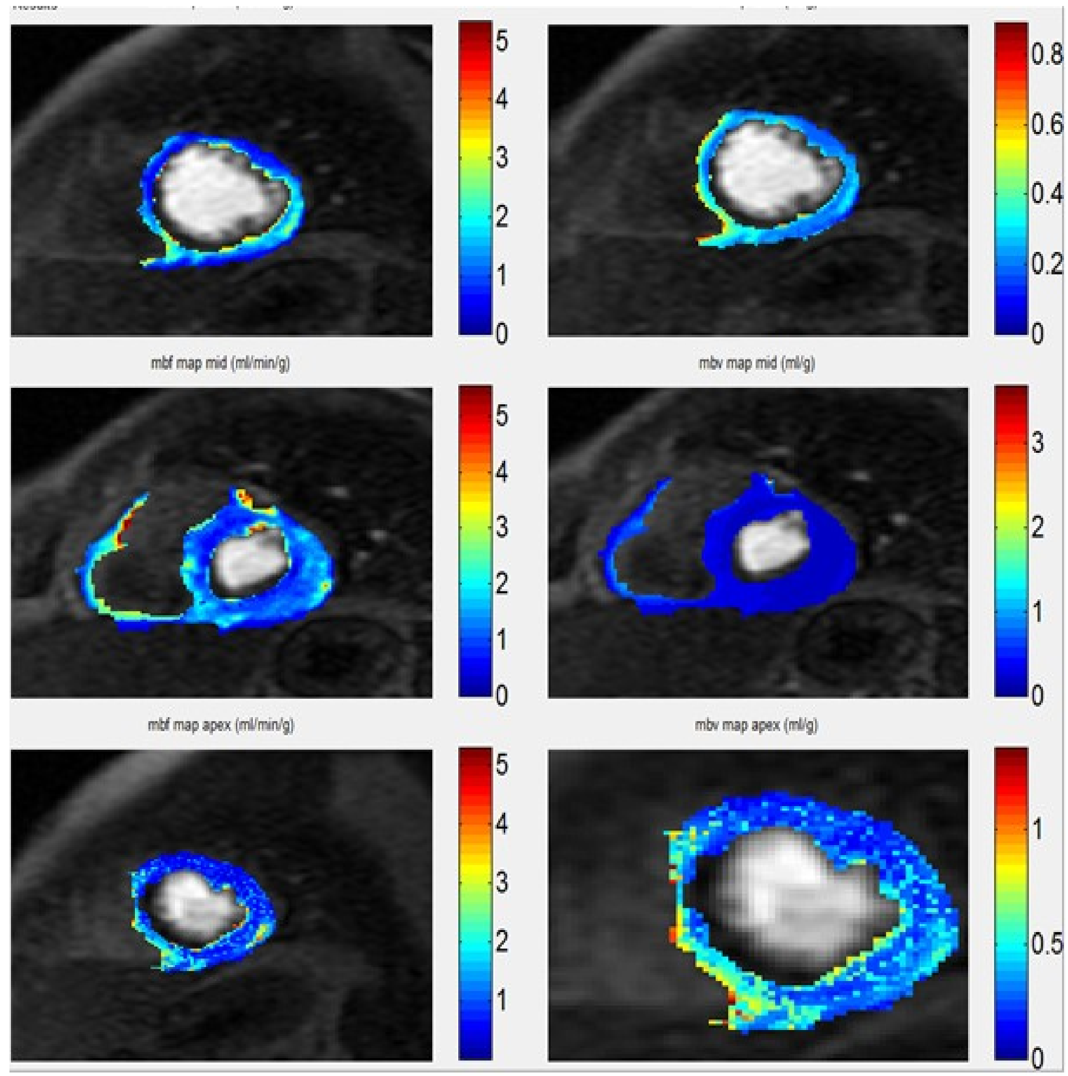
SSE MBF	Fermi	Bayesian	Spatio-temporal	OSVD
Myocard	0.053	0.067	0.085	0.093
Segment	0.1	0.1	0.099	0.13
Voxel	0.27	0.18	0.15	0.22

Discussion et Conclusions

- oSVD needs denoising pretreatment before being used in a cardiovascular context
- **Bayesian and spatio-temporal are robust and suitable for heart perfusion**
- Hard to evaluate real spatio-temporal performances on the digital phantom as is was designed

Perspectives

- Clinical application
- Pre-treatment with classification of suffering areas
- Digital phantom design for further spatio-temporal evaluation



Thank you for your attention

We would like to thank the Labex PRIMES for financial support

Background & Purpose

oSVD method

Tracer Arrival Timing-Insensitive Technique for Estimating Flow in MR Perfusion-Weighted Imaging Using Singular Value Decomposition With a Block-Circulant Deconvolution Matrix

Ona Wu,[1*] Leif Østergaard,[2] Robert M. Weisskoff,[3] Thomas Benner,[1] Bruce R. Rosen,[1] and A. Gregory Sorensen[1]

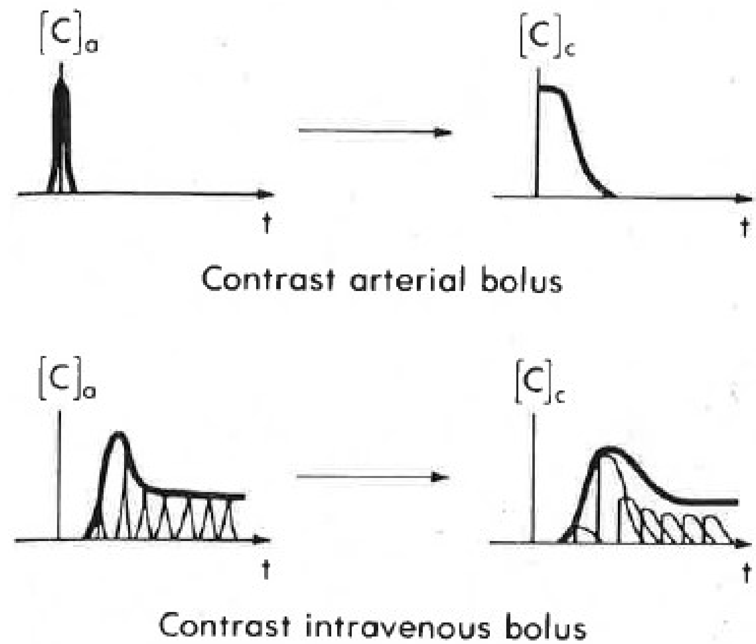
$$\begin{bmatrix} c(t_0) \\ c(t_1) \\ \vdots \\ c(t_{N-1}) \end{bmatrix} = \Delta t \begin{bmatrix} C_a(t_0) & 0 & \cdots & 0 \\ C_a(t_1) & C_a(t_0) & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ C_a(t_{N-1}) & C_a(t_{N-2}) & \cdots & C_a(t_0) \end{bmatrix} \times \begin{bmatrix} R(t_0) \\ R(t_1) \\ \vdots \\ R(t_{N-1}) \end{bmatrix} \cdot F_t.$$

Background & Purpose

Linear Shift Invariant modeling

Tissue Mean Transit Time from Dynamic Computed Tomography by a Simple Deconvolution Technique

LEON AXEL, PHD, MD



Medical Physics
The International Journal of Medical Physics Research and Practice

Magnetic resonance quantification of the myocardial perfusion reserve with a Fermi function model for constrained deconvolution

Michael Jerosch-Herold, Norbert Wilke, Arthur E. Stillman, and Robert F. Wilson

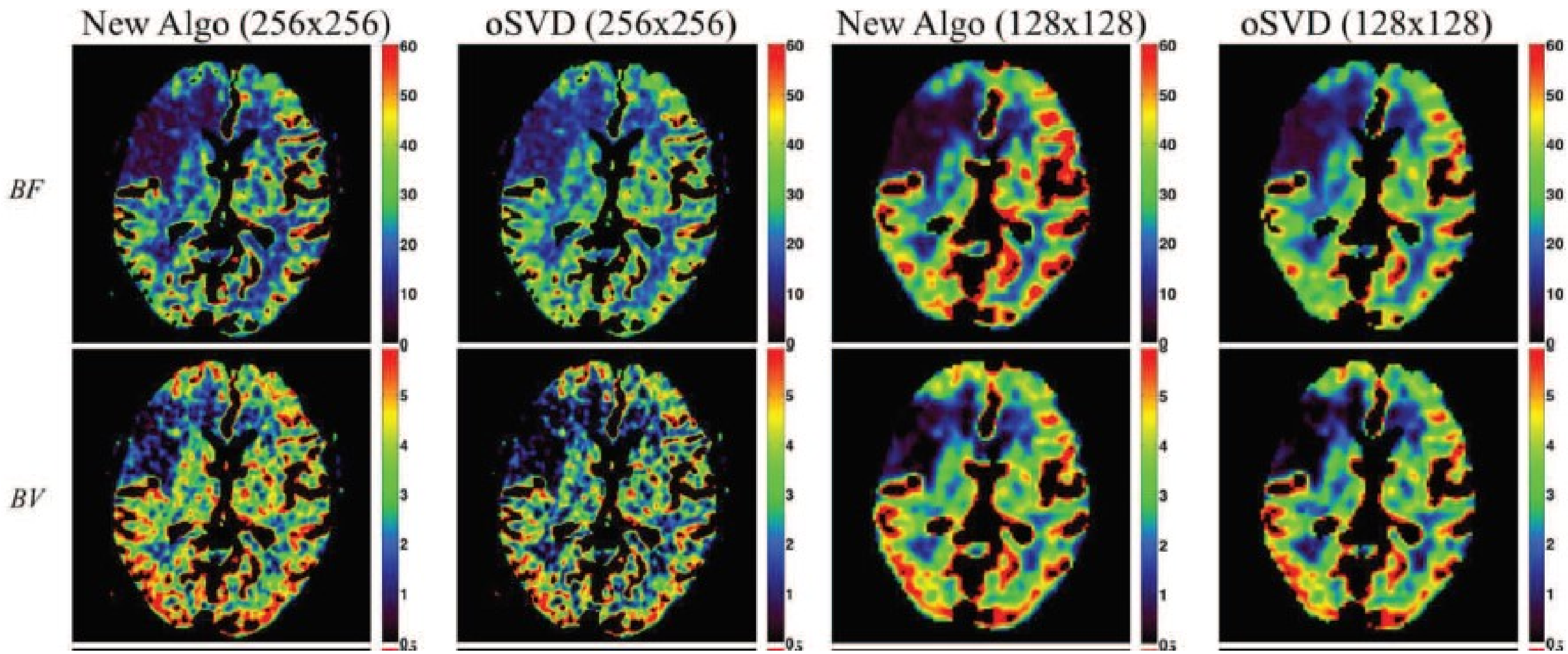
$$R_F(t) = \frac{A}{[\exp[(t-\mu)/k]+1}.$$

Background & Purpose

IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 31, NO. 7, JULY 2012 1381

Bayesian Hemodynamic Parameter Estimation by Bolus Tracking Perfusion Weighted Imaging

Timothé Boutelier*, Koshuke Kudo, Fabrice Pautot, and Makoto Sasaki



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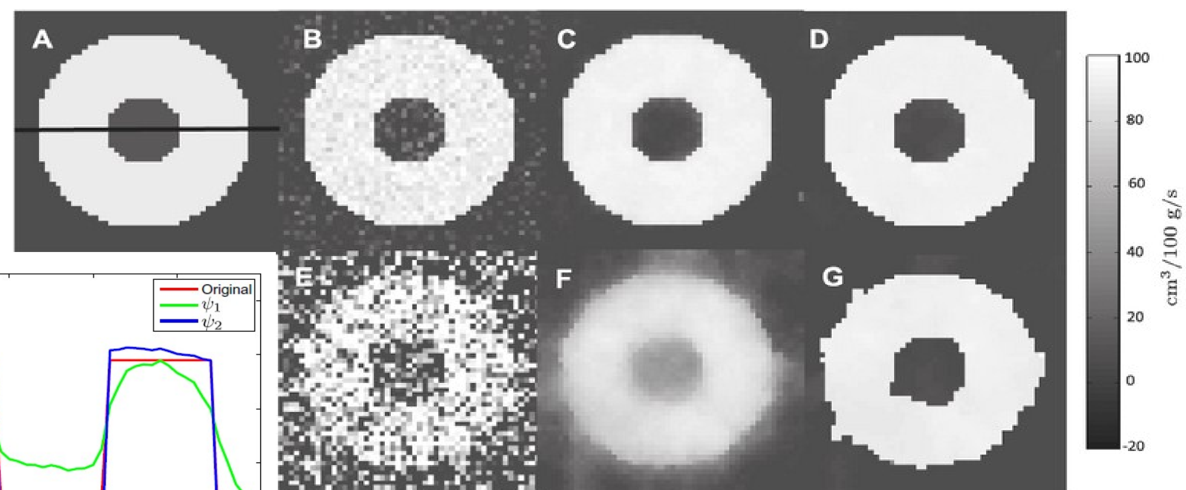
Background & Purpose

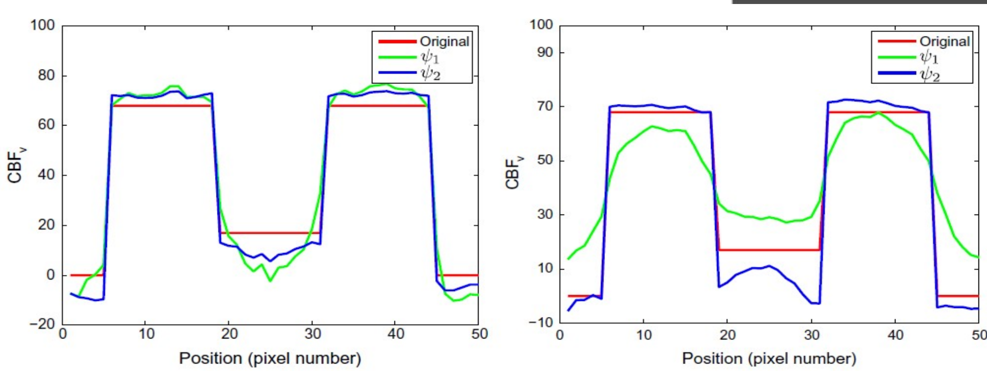
A 3-D spatio-temporal deconvolution approach for MR perfusion in the brain

Carole Frindel *, Marc C. Robini, David Rousseau

Université de Lyon, CREATIS; CNRS UMR5220; Inserm U1044; INSA-Lyon; Université Lyon 1, France
INSA Lyon, 7 Avenue Jean Capelle, 69621 Villeurbanne, France

Medical Image Analysis 18 (2014) 144–160





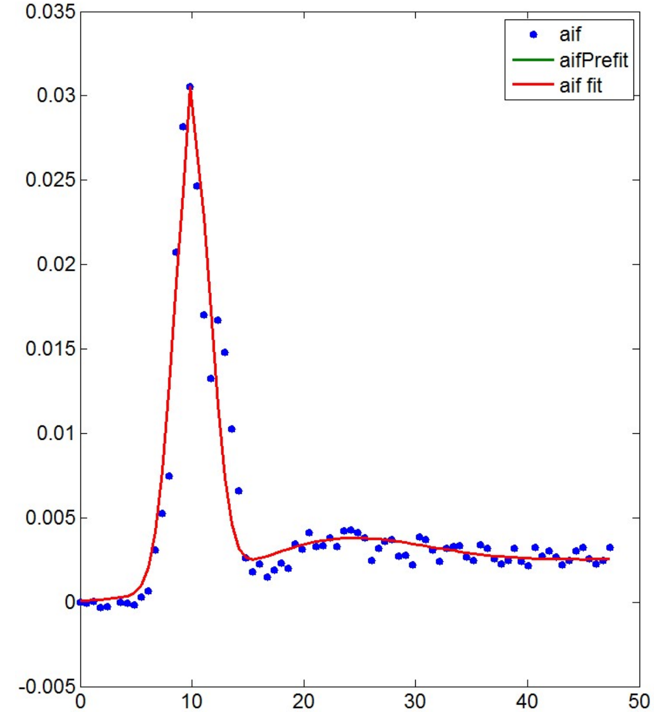
(A) SNR = 22.60 dB

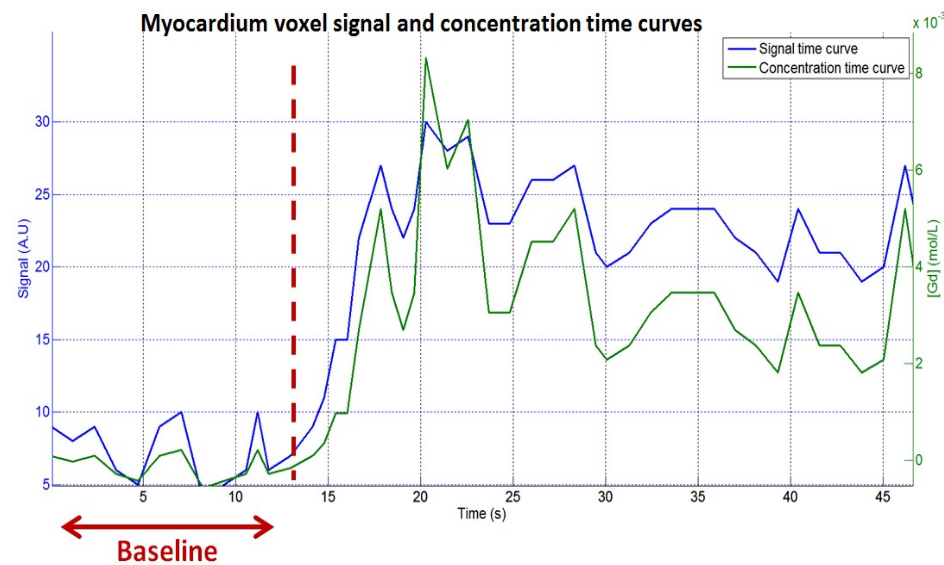
(B) SNR = 2.5 dB

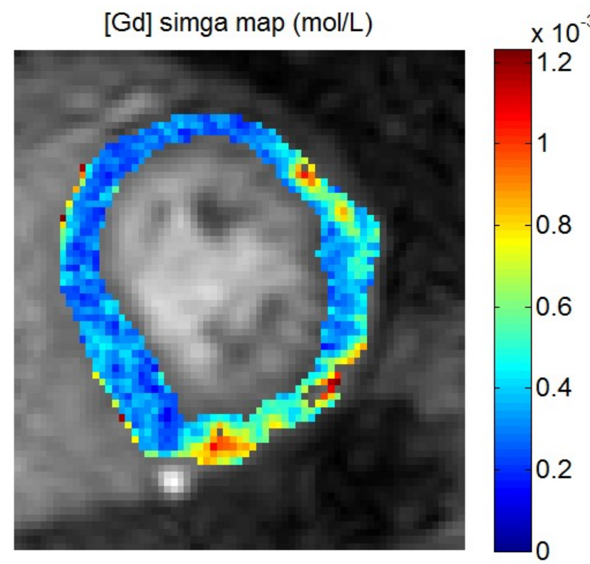
Method

Clinical dataset analysis for accurate digital phantom design

- Noise features
- AIF features (baseline, time to peak, $[CA]_{pk}$







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