

Ask EuroSafe Imaging Tips & Tricks

CT Working Group

Iterative Reconstruction Algorithms

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Dose Reduction in CT



- Dose reduction in CT, while maintaining image quality, is one of the major concerns of the scientific community.
- Manufacturers have contributed to reach this goal by developing technologies, such as automatic exposure control, noise reduction filters and automatic kV selection.
- Tube current reduction is the most common parameter used to reduce dose, but it also increases image noise.
- Recently, iterative reconstruction algorithms have re-emerged with the potential of radiation dose optimization by lowering image noise.
- Iterative reconstruction (IR) algorithms are used instead of the filtered backprojection (FBP) reconstruction commonly used in CT.



Iterative Reconstruction algorithm



MODEL BASED

ITFRATIVE

FBP

ITERATIVE IMAGE FILTER

HYBRID-STATISTICAL ITERATIVE

TRADITIONAL RECONSTRUCTION -SENSITIVE TO NOISE AND ARTEFACTS NOISE REDUCTION THROUGH IMAGE FILTERING - COMPROMISE BETWEEN NOISE & SPATIAL RESOLUTION

NOISE STATISTICS MODELLING ON RAW-DATA - LESS NOISY IMAGES NOISE STATSITCS , PHYSICS, OBJECT AND SYSTEM OPTICS RAW DATA DOMAIN -*MOST ACCURATE, BUT* DIFFERENT IMAGE TEXTURE



- MORE DOSE OR MORE NOISE
- FASTER RECONSTRUCTION TIME

- LESS DOSE OR LESS NOISE
- SLOWER RECONSTRUCTION TIME

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Iterative Reconstruction (IR) - VENDORS





- MORE DOSE OR MORE NOISE
- FASTER RECONSTRUCTION TIME

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How do IRs work?



- Each vendor proposes an IR algorithm with particular charcteristics
- The user has to select the strength of the algorithm for all the hybrid-statistical IRs
 → The higher the strength, the lower the noise
- No strengh selection for MBIR

ITERATIVE ALGORITHM NAME	STRENGTH INFLUENCE
ASIR, ASIR-V (GE)	10 (0-100%)
iDOSE (Philips)	1-7
SAFIRE, ADMIRE (Siemens)	1-5
AIDR 3D (CANON)	1-3



The figure displays an example from one vendor using FBP (1) and Admire, with 5 different IRs increasing in strength (2-6).



IR algorithms - performance



Vendor	Algorithm name	Type of algorithm	Reconstruction speed	Artifact reduction	Noise reduction
GE Healthcare	ASIR (Adaptive Statistical Iterative Reconstruction)	Hybrid	+	+	++
	Veo (MBIR)	Model-based	_	++	+++
	ASIR-V	Hybrid	+	+	++
Philips Healthcare	iDose ⁴	Hybrid	+	+	++
	IMR (iterative model reconstruction)	Model-based	_	++	+++
Siemens Healthineers	IRIS (iterative reconstruction in image space)	Image domain	++	_	+
	SAFIRE (sinogram-affirmed iterative reconstruction)	Hybrid	+	+	++
	ADMIRE (advanced modeled iterative reconstruction)	Model-based	_	++	+++
Canon Healthcare	AIDR3D (adaptive iterative dose reduction 3D)	Hybrid	+	+	++
	FIRST (forward projected model-based iterative re- construction solution)	Model-based	_	++	+++

Table 1 Different iterative reconstruction algorithms from the major vendors

- minimal; + average; ++ fast/strong; +++ very strong

Willemink, M.J. & Noël, P.B. Eur Radiol (2019) 29: 2185. https://doi.org/10.1007/s00330-018-5810-7



Pros and cons



Pros

- Noise and artefact reduction
- Better image quality or lower dose acquisitions

Cons

- Long computation time for model based IR
- Texture change in the images, which appear more "blocky and pixelated" or "smoothed"
- Spatial resolution is not always improved



Clinical Practice with ADMIRE (Siemens)



- 52% noise reduction can be used to lower dose by the same percentage
- 19 s for on average 296 images of an abdominal CT





Clinical Practice with AIDR 3D (Canon)



- Abdomen/pelvis CT of the same patient repeated after 1 month with AIDR 3D
- Dose reduction was 67%





Clinical Practice with IMR (Philips)





Low dose acquistion at 20 mAs is possible, if combined with an IR algorithm.

This effect is particulary evident with IMR.









Best compromise between image quality and dose (1 mSv) in thoracic aorta CT angiography.

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CONCLUSION



- IRs can subatantially reduce noise
- IRs increase image quality of low dose protocols
- IRs have limitations, such as texture changes ("blocky and pixelated" or "smoothed" appearance)
- IRs do not always improve spatial resolution
- Some IR algorithms require long computational time
- IRs are vendor specific and not standardized



References



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